# **BALTIMORE COUNTY PUBLIC SCHOOLS**

Creating a Culture of Deliberate Excellence 6901 N Charles Street, Building "E" Towson, MD 21204

**Division of Business Services** 

Department of Fiscal Services An Affirmative Action Employer Office of Purchasing

# SOLICITATION AND SPECIFICATIONS

For

NEW SCHOOL CONSTRUCTION – LANSDOWNE ELEMENTARY SCHOOL DEMOLITION OF LANSDOWNE ELEMENTARY SCHOOL

# Volume 2 of 2 DIVISIONS 21 - 33

PRE-BID:	December 1, 2016 @ 10:00 AM Baltimore County Public Schools Department of Physical Facilities 9610 Pulaski Park Drive, Suite 213 Baltimore, MD 21220
RETURN TO:	BALTIMORE COUNTY PUBLIC SCHOOLS Office of Purchasing RE: MBU-516-17 Attn: Melvin E. Burley, Purchasing Agent 6901 N Charles Street, Building "E" Towson, MD 21204
BID NUMBER:	<u>MBU-516-17</u>
BID ISSUED DATE:	<u>November 17, 2016</u>
DUE DATE:	<u>December 15, 2016</u>
DUE TIME:	NO LATER THAN 2:00 PM (Eastern Time Zone)
PUBLIC OPENING:	December 15, 2016, (10 minutes after due time) Conference Room 6901 N Charles Street, Building "E" Towson, MD 21204

Baltimore County Public Schools reserves the right to waive informalities, to reject all bids, and to reissue this bid at its option, and does not make an obligation to purchase by issuing this bid.

Failure to plainly identify as a "SEALED BID" on the outside of the return envelope may result in premature opening of the envelope and bid.

Project Manager: Douglas Mullins - Phone: (443) 809-9239 - FAX: (410) 887-6314 E-mail: <u>pmullins@bcps.org</u>

# **BALTIMORE COUNTY PUBLIC SCHOOLS**

Creating a Culture of Deliberate Excellence 6901 Charles Street, Building "E"

Towson. MD 21204

**Division of Business Services** 

Office of Purchasing

# 00100 NOTICE TO CONTRACTORS

Department of Fiscal Services

The Board of Education of Baltimore County invites Contractors to bid on the **NEW SCHOOL CONSTRUCTION – LANSDOWNE ELEMENTARY SCHOOL and the DEMOLITION OF THE EXISTING LANDSDOWNE ELEMENTARY SCHOOL** [commodity code 90927], under solicitation number **MBU-516-17 (PSCP#03.105.17 LPC)**. The cost for this work is projected to fall within Contract Cost Group **H: OVER \$15 MILLION.** Procurement questions can be emailed to **Melvin E. Burley**, Purchasing Agent at mburley2@bcps.org or they may be faxed to his attention at 410-887-7831. Verbal questions will not be taken.

Contractors proposing to bid may order contract documents after 2:00 PM beginning <u>Thursday, November 17,</u> <u>2016</u>, through <u>www.bcps.org</u>.Click on the "Our System" tab at the top right of the aforementioned web address, click on "Offices," click on "Purchasing Office," click on "Bid Board" on the left, and then click on the "Invitation to Bid." Solicitation documents can be ordered electronically or picked-up in person from Gardens Reprographics (419 Saint Paul Place, Baltimore, MD 21202. Hours: Monday through Friday 8 – 5. Phone: 410-539-2763).

A Pre-Bid meeting for this procurement is scheduled for <u>December 1, 2016 at 10:00 AM</u> at the Office of Physical Facilities, 9610 Pulaski Park Drive, Suite 213, Baltimore, MD 21207.

# The last day for written questions is December 6, 2016 and the final Addendum will issued by December 8, 2016.

Sealed bids will be received until <u>Thursday December 15, 2016, no later than 2:00 PM</u> in the Office of Purchasing at Baltimore County Public Schools Office of Purchasing, located at 6901 N Charles Street, Building "E", 1<sup>st</sup> Floor, Towson, MD 21204. A public bid opening will be held approximately 10 minutes after the due date and time for this solicitation.

- All bidders shall be pre-qualified by Baltimore County Department of Public Works (BCDPW) Classification "I", BUILDINGS, Category 1, NEW BUILDING CONSTRUCTION
- AND Classification "I", BUILDINGS, Category 7, DEMOLITION, prior to the date of bid opening.

# A copy of the pre-qualification certificate of the contractor shall be included with their proposal/bid.

# Certified Minority Business Enterprises are encouraged to respond to this solicitation notice.

The contractor or supplier who provides materials, supplies, equipment and/or services for this construction project shall attempt to achieve the specific overall MBE goal of 29 percent (29%) established for this project. All prime contractors, including certified MBE firms, when submitting bids or proposals as general or prime contractors, are required to attempt to achieve this goal from certified MBE firms. The sub goals established for this project are 7 percent (7%) from African American-owned businesses and 4 percent (4%) from Asian–owned businesses. The bidder or offeror is required to submit with its bid or proposal a completed Attachment A - Certified MBE Utilization and Fair Solicitation Affidavit and Attachment B - MBE Participation Schedule, as described in the solicitation documents.

The Board of Education of Baltimore County reserves the right to reject any or all proposals and to waive informalities.

By Order of the Board of Education of Baltimore County

**Purchasing Manager** 

## TABLE OF CONTENTS [CONTINUED]

# **DIVISION 21 TO DIVISION 33**

## **DIVISION 00 – BIDDING AND CONTRACT REQUIREMENTS**

#### **DIVISION 21 – FIRE SUPPRESSION**

## SECTION TITLE

210101	FIRE SUPPRESSION GENERAL PROVISIONS
210500	COMMON WORK RESULTS FOR FIRE SUPPRESSION
211000	WATER-BASED FIRE-SUPPRESSION SYSTEM

#### **DIVISION 22 – PLUMBING**

SECTION	TITLE
220101	PLUMBING GENERAL PROVISIONS
220500	COMMON WORK RESULTS FOR PLUMBING
220501	EXCAVATION AND FILL FOR PLUMBING WORK
220502	SLEEVES AND PLATES FOR PLUMBING PIPING
220503	ACCESS DOORS FOR PLUMBING PIPING AND EQUIPMENT
220505	EQUIPMENT CONNECTION FOR PLUMBING
220506	CURBS AND FLASHINGS FOR PLUMBING EQUIPMENT
220507	FIRESTOPPING FOR PLUMBING WORK
220509	PLUMBING EXPANSION SYSTEM
220513	COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT
220519	METERS AND GAGES FOR PLUMBING PIPING
220523	GENERAL-DUTY VALVES FOR PLUMBING PIPING
220529	HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
220548	VIBRATION CONTROL SUPPORTS FOR PLUMBING
220700	PLUMBING INSULATION
220719	PLUMBING PIPING INSULATION
221116	DOMESTIC WATER PIPING
221119	DOMESTIC WATER PIPING SPECIALTIES
221123	DOMESTIC WATER PUMPS
221316	SANITARY WASTE AND VENT PIPING
221319	SANITARY WASTE PIPING SPECIALTIES
221413	STORM DRAINAGE PIPING
221423	STORM DRAINAGE PIPING SPECIALTIES
221429	SUMP PUMPS
223300	ELECTRIC DOMESTIC WATER HEATER
224200	INSTITUTIONAL PLUMBING FIXTURES

#### **DIVISION 23 – HEATING VENTILATING AND AIR CONDITIONING**

# SECTION TITLE

230100	OPERATION AND MAINTENANCE OF HVAC SYSTEMS
230101	HVAC GENERAL PROVISIONS
230500	COMMON WORK RESULTS FOR HVAC

230501	EXCAVATION AND FILL FOR HVAC WORK
230502	SLEEVES AND PLATES FOR HVAC PIPING
230503	ACCESS DOORS FOR HVAC PIPING AND EQUIPMENT
230505	EQUIPMENT CONNECTIONS FOR HVAC PIPING AND EQUIPMENT
230506	CURBS AND FLASHINGS FOR HVAC PIPING AND EQUIPMENT
230507	FIRESTOPPING FOR HVAC WORK
230508	HVAC PIPING SPECIALTIES
230509	HVAC EXPANSION SYSTEM
230513	COMMON MOTORS REQUIREMENTS FOR HVAC EQUIPMENT
230519	METERS AND GAGES FOR HVAC PIPING
230523	GENERAL-DUTY VALVES FOR HVAC PIPING
230529	HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
230548	VIBRATION CONTROL SUPPORTS FOR HVAC
230593	TESTING, ADJUSTING AND BALANCING
230700	HVAC INSULATION
230713	DUCT INSULATION
230716	HVAC EQUIPMENT INSULATION
230719	HVAC PIPING INSULATION
230800	MECHANICAL SYSTEMS COMMISSIONING
230901	AUTOMATIC TEMPERATURE CONTROL SYSTEM
230902	CONTROL SYSTEMS WIRING
230905	CONTROL PANELS
230907	CONTROL DAMPERS
230908	CONTROL VALVES
230913	INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
230923	DIRECT DIGITAL BUILDING SYSTEMS CONTROL
230995	BUILDING AUTOMATION SYSTEM COMMISSIONING
232113	HYDRONIC PIPING
232116	GROUND HEAT EXCHANGER PIPING SYSTEM
232123	HVAC PUMPS
232300	REFRIGERANT PIPING
232500	HVAC WATER TREATMENT
233113	METAL DUCTS
233300	DUCT ACCESSORIES
233400	HVAC FANS
233713	DIFFUSERS, REGISTERS, AND GRILLES
233723	ROOF-MOUNTED GRAVITY VENTILATORS
234100	PARTICULATE AIR FILTRATION
237200	ENERGY RECOVERY AND DEDICATED OUTDOOR AIR UNITS
238127	DUCTLESS SPLIT-SYSTEM UNITS
238128	VARIABLE-REFRIGERANT-VOLUME MULTIZONE SYSTEM
238146	WATER-SOURCE HEAT PUMP UNITS
238238	ELECTRIC-RESISTANCE TERMINAL UNITS

# **DIVISION 26 – ELECTRICAL**

# SECTION

Τ	ľ	Ι	ΊLΕ	

260101	ELECTRICAL GENERAL PROVISIONS
260500	COMMON WORK RESULTS FOR ELECTRICAL
260501	EXCAVATION AND FILL FOR ELECTRICAL WORK
260507	FIRESTOPPING FOR ELECTRICAL WORK
260519	WIRES AND CABLES

260521	WIRING CONNECTIONS
260526	GROUNDING AND BONDING
260528	EQUIPMENT FOUNDATIONS
260533	CONDUITS
260534	BOXES
260541	LOW-VOLTAGE SERVICE ENTRANCE
260544	UNDERGROUND DUCTS AND UTILITY STRUCTURES
260553	IDENTIFICATION FOR ELECTRICAL SYSTEMS
260800	ELECTRICAL SYSTEMS COMMISSIONING
260923	STAND-ALONE LIGHTING CONTROL DEVICES
260933	CENTRAL DIMMING CONTROLS
260936	NETWORKED MODULAR DIMMING CONTROLS
262200	LOW-VOLTAGE TRANSFORMERS
262413	SWITCHBOARDS
262416	PANELBOARDS
262550	GENERATOR DOCKING STATION
262716	CABINETS AND ENCLOSURES
262726	WIRING DEVICES
262800	LOW-VOLTAGE CIRCUIT PROTECTIVE DEVICES
262813	FUSES
262914	ENCLOSED MOTOR CONTROLLERS
262923	VARIABLE FREQUENCY DRIVES
263213	GENERATORS, WEATHER-PROTECTED
263600	TRANSFER SWITCHES
264113	LIGHTNING PROTECTION FOR STRUCTURES
264313	SURGE PROTECTIVE DEVICES
265100	INTERIOR LIGHTING
265600	EXTERIOR LIGHTING

# **DIVISION 27 – COMMUNICATIONS**

<u>SECTION</u>	TITLE
270000	GENERAL COMMUNICATIONS PROVISIONS
270500	COMMON WORK FOR COMMUNICATIONS
271500	DATA, VOICE AND VIDEO SYSTEMS
275123	PUBLIC ADDRESS AND INTERCOMMUNICATIONS SYSTEM
275200	LOCAL SOUND SYSTEM
275250	GROUNDING AND BONDING FOR COMMUNICATIONS
275800	CONDUIT AND BACKBOXES FOR COMMUNICATIONS SYSTEMS
276000	TELEPHONE AND CATV UTILITY SERVICE PROVISIONS

# **DIVISION 28 – ELECTRONIC SAFETY AND SECURITY**

# SECTION TITLE

280101	ELECTRON	NIC SAFE	TY AN	ID SECURITY G	ENERAL F	ROVIS	SIONS
280500	COMMON	WORK	FOR	ELECTRONIC	SAFETY	AND	SECURITY
SYSTEMS							

280513 SYSTEMS	CONDUCTORS AND CABLES FOR SAFETY AND SECURITY
281300	ACCESS CONTROL
281600	INTRUSION ALARM
282300	VIDEO SURVEILLANCE SYSTEM
283100	FIRE DETECTION AND ALARM SYSTEMS
285200	GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY SYSTEM
285800	CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY SYSTEM

# **DIVISION 31 – EARTHWORK**

#### SECTION

<u>TITLE</u>

311000	SITE CLEARING
312300	EXCAVATING AND FILLING
312314	GEOTHERMAL TRENCHES AND BOREHOLES
312500	SEDIMENT CONTROL
313213.16	CEMENT SOIL STABILIZATION
316000	RAMMED AGGREGATE PIERS FOR GROUND IMPROVEMENT

#### **DIVISION 32 – EXTERIOR IMPROVEMENTS**

<u>SECTION</u>	TITLE		
321200			
323100	CHAINLINK FENCES AND GATES		
329000 329100	PLANTING MAINTENANCE OF TURF AND PLANTS		

#### **DIVISION 33 – UTILITIES**

#### SECTION

# TITLE

331000	WATER UTILITIES
333000	SANITARY SEWERAGE UTILITIES
334000	STORM DRAINAGE UTILITIES

#### END OF PROJECT TABLE OF CONTENTS

# **SECTION 21 01 01 - FIRE-SUPPRESSION GENERAL PROVISIONS**

# PART 1 - GENERAL

#### 1.11 SUMMARY

- A. General provisions and requirements for all fire-suppression work.
- 1.14 RELATED SECTIONS
  - A. Requirements of this section generally supplement requirements of Division 01.
  - B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.

## 1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.
- 1.25 SYSTEM DESCRIPTION
  - A. The full set of Contract Documents applies to work of Division 21.
  - B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
  - C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
  - D. Except as required otherwise in Division 01, promptly obtain and pay for, including all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
  - E. Fire-suppression work of this project includes, as a brief general description, the following:
    - 1. New wet pipe fire suppression system.
    - 2. The project includes commissioning under the direction of a Commissioning Agent (CxA).
    - 3. The project will be LEED certified.
  - F. See Division 01 for requirements related to LEED certification, commissioning, Owner's occupancy of the premises, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

## 1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 21 specifications.
- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in the article "Substitutions," below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
  - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
  - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

# 1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 21 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
  - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
  - 2. Will provide the same warranty for the substitution as for the specified product.
  - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
  - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
  - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.

- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

# 1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project and of representative manufacture. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
  - 1. Furnish: Supply item
  - 2. Install: Mount and connect item
  - 3. Provide: Furnish and install.
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturers' instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent before starting any work which may be affected by this decision.

# 1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.
- D. Coordinate location and elevation of all piping, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractor's assistants shall include a competent mechanical foreman, who shall be on the premises at all times to check, layout, coordinate and superintend the installation of work. The foreman shall establish all grades and lines relative to the work before starting, and be responsible for the accuracy thereof.

# 1.30 SUBMITTALS

- A. Manufacturers' and subcontractors' lists:
  - 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.
- B. Shop drawings and product data:
  - 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of shop drawings and product data for every item of equipment. Shop drawings or product data will not be considered until manufacturers' lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
  - 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.

- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electrical items furnished as items associated with fire-suppression items but not specifically described in the fire-suppression item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the fire-suppression item by identification specification paragraph.
- 5. Product data sheets shall be 8.5-inches by 11-inches cut sheets for operating and maintenance manual.
- C. Submit at least three copies of the results of every test required under any section in this division.
- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.
  - 1. Include project name, address, name and phone number of owner's representative, and project type and size.
- E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

# 1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

# 1.35 CONTRACT CLOSEOUT SUBMITTALS

- A. Project record documents:
  - 1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:
    - a. Contract drawings.
    - b. Specifications.
    - c. Addenda.
    - d. Change orders and other modifications to the Contract.
    - e. Reviewed shop drawings, product data, and samples.
  - 2. Maintain record documents separate from documents used for construction.

- 3. Record information concurrent with construction progress.
- 4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:
  - a. Manufacturer's name and product model and number.
  - b. Product options, substitutions, or alternates utilized.
  - c. Changes made by addenda and modifications.
- 5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:
  - a. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
  - b. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
  - c. Field changes of dimension and detail.
  - d. Details not on original Contract Drawings.
- 6. Submit documents as specified in Division 01.
- B. Operation and maintenance data:
  - 1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
  - 2. Binders: Three-ring binders with vinyl-covered hard covers. Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
  - 3. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS," and title of project. Print on spine of binder "O & M INSTRUCTIONS." If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
  - 4. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
  - 5. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
  - 6. Part 1: Directory, listing names, addresses, and telephone numbers of fire protection engineers; Contractor; fire-sprinkler subcontractors; and major equipment suppliers.
  - 7. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
    - a. Significant design criteria and similar performance charts.
    - b. List of equipment, including operating weight of each piece.
    - c. Parts list for each component, including recommended spare parts list.
    - d. Operating instructions.
    - e. Maintenance instructions for equipment and systems.
    - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

- g. Valve charts, including locations of flow fittings.
- 8. Part 3: Project documents and certificates, including the following:
  - a. Shop drawings and product data.
  - b. Photocopies of certificates.
  - c. Photocopies of warranties and guarantees.
  - d. Test reports: Copies of the results of all tests required under all sections of specifications.
- 9. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
- 10. Submit final volumes revised, within ten days after final inspection.
- 11. Submit DVD optical disc storage media specified in Section 21 05 00.

# 1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor that may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
  - 1. The fire protection, electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
  - 2. The National Electric Code, NFPA 70 (NEC).
  - 3. The National Fire Protection Association Code. (NFPA).

# 1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless otherwise specified in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply. Products shall be certified by manufacturers to meet the requirements of referenced standards.
  - 1. American National Standards Institute (ANSI)
  - 2. ASME International (ASME)
  - 3. American Society for Testing and Materials (ASTM)
  - 4. American Water Works Association (AWWA)
  - 5. International Code Council (ICC)
  - 6. Manufacturer's Standardization Society of the Valve and Fittings Industry Inc. (MSS)
  - 7. National Electrical Code, NFPA 70 (NEC)
  - 8. National Electrical Manufacturer's Association (NEMA)

- 9. National Fire Protection Association (NFPA)
- 10. The Occupational Safety and Health Act (OSHA)
- 11. Underwriters Laboratory Inc. (UL)
- 12. Maryland Occupational Safety and Health Act (MOSHA)

# 1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.

# 1.54 PROTECTION

- A. Control dust resulting from construction work to prevent its spread beyond the immediate work area, and to avoid creation of a nuisance.
  - 1. Do not use water to control dust. Use drop cloths or other suitable barriers.
  - 2. In areas where dirt or dust is produced as a result of the work, sweep daily, or more often as required.
  - 3. Provide walk-off mats at entries and replace them at regular intervals.
  - 4. Construct dust partitions, where indicated on the drawings or as required.
  - 5. Seal off all return air registers and other mechanical systems to prevent dust from entering.
- B. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
  - 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
  - 2. Protect finished work from damage, defacement, staining, or scratching.
  - 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
  - 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
  - 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- C. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract Sum.
- D. Protect work stored in place and supplies stored in the building.
  - 1. Store materials and products, subject to damage from moisture, in dry locations. If necessary, provide in protective wraps or covers.
  - 2. Store plastics, other materials, and products subject to damage from heat or cool at manufacturer's recommended temperatures.
- E. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

# 1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

# 1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
  - 1. Promptly notify the Architect in writing.
  - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

# 1.80 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties specified in individual sections.
- B. During the correction period, the Contractor shall promptly correct any work found to be not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- D. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- E. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

# 1.85 COMMISSIONING

A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.

B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

# PART 2 - PRODUCTS

Not used.

# PART 3 - EXECUTION

# 3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of pipes and appurtenances. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.
- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

# 3.14 TEMPORARY FACILITIES

A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

# 3.40 PROGRESS MEETINGS

- A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
- B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

# **END OF SECTION**

# SECTION 21 05 00 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

#### PART 1 - GENERAL

#### 1.11 SUMMARY

Basic material and equipment required for the fire-suppression piping work as indicated on the drawings and specified in Division 21.

Other requirements applicable to more than one section of Division 21.

Identification of fire-suppression systems and equipment.

#### 1.14 RELATED SECTIONS

- A. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
- B. Project and special warranties: Division 01 and Section 21 01 01.
- C. Operation and Maintenance Manuals: Division 01 and Section 21 01 01.
- D. Painting: Division 09.

#### 1.21 DEFINITIONS

Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.

Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.

- 1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
- 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.

DN: Dimension Nominale, nominal pipe size in millimeters, in accordance with the metric system for construction, Systeme Internationale (SI).

NPS: Nominal pipe size in inches, in accordance with standard U.S. designations for manufactured pipe. Pipe sizes do not change when projects are designed and built in metric units; each size has a consistent name (nominal dimension) in each system.

#### 1.26 DESIGN REQUIREMENTS

The drawings and system performances have been designed based on using the particular manufacturer's products specified and scheduled on the drawings.

Products of other manufacturers that are listed under the article "Acceptable Manufacturers," or permitted as "equal," are permitted provided:

- 1. Product shall meet the specifications.
- 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.

Do not propose products with dimensions or other characteristics different from the design basis product that render their use impractical, or cause functional fit, access, or connection problems.

The contract drawings are generally diagrammatic and do not indicate all fittings or offsets in pipe, all access panels, or other specialties required.

Install pipe exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining proper clearances for access at all parts requiring servicing.

Install pipe a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.

No pipe shall be run below the head of a window or door.

Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

## 1.30 SUBMITTALS

Comply with Division 01 and Section 21 01 01.

Shop drawings:

Schedule of welding and brazing procedures proposed for each piping system included in the project.

# LEED submittal:

Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For composite wood, documentation indicating no added urea formaldehyde.

Product data for Credit IEQ 4.1: For adhesives and sealants applied within the building waterproofing envelope, documentation including printed statement of VOC contents in g/L.

Product data for Credit IEQ 4.2: For paints and coatings applied within the building waterproofing envelope, documentation including printed statement of VOC content in g/L.

Certifications: Proof of operator and testing agency personnel qualifications as required for welding and brazing in the article "Quality Assurance" below.

Test reports: Field test results for each piping system as specified in Part 3 below.

## 1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the plumbing, mechanical, electrical, building, fire, health and safety, and other applicable codes and regulations of the state, county or city in which the work is performed.
- B. Welding procedures and operator qualifications for structural welding: AWS D1.1, Structural Welding Code Steel, electric arc process.
- C. Welding, brazing, and soldering procedures and operator qualifications for building systems piping:
  - 1. AWS D10.9, Qualification of Welding Procedures and Welders for Piping and Tubing.
  - 2. ASME B31.9, Building Services Piping.
- D. Qualifications of independent testing laboratory personnel:
  - 1. Welding inspectors: AWS QC1, Certification of Welding Inspectors.
- E. Electrical control panels, equipment, materials and devices provided or installed as work of Division 21 shall bear UL label or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70 (NEC). Provide testing, if required, without addition to the contract sum.
- F. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media format for video and audio production and editing.
- G. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.

#### 1.85 COMMISSIONING

A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractors' and subcontractors' responsibilities are described in Division 01.

# PART 2 - PRODUCTS

#### 2.10 MATERIALS

- A. General piping techniques, testing, identification, painting, and operating instructions specified in this section apply to products specified in other sections of Division 21.
- B. Weldolets and thredolets: Fittings designed for installing branches on piping, with either welded or threaded connection to branch; conforming to ASTM A 234.
- C. Pipe jointing compound:
  - 1. Polytetrafluoroethylene (PTFE) pipe thread tape, "Teflon."

- 2. Pipe cement and oil.
- D. Adhesives, sealants, paints and coatings applied within the building waterproofing envelope: Comply with low-emitting requirements in Section 01 61 16.
- E. Composite wood: Contain no added urea formaldehyde.

# 2.21 IDENTIFICATION DEVICES AND MATERIALS

- A. Stenciling materials:
  - 1. Stencils: Manufactured standard stencils prepared for required applications, conforming to ANSI A13.1 for color and size of legend letters, including arrows showing direction of flow.
  - 2. Paint: Exterior type enamel, colors conforming to ANSI A13.1, or black.
- B. Equipment identification tags:
  - 1. Laminated plastic with adhesive back, white core and black outer layers, which, when engraved, will produce white letters and numerals on a black background.
  - 2. Tags installed on curved surfaces shall be aluminum or brass.
- C. Valve tags: Brass, 1.5 inch (40 mm) in diameter with black-filled numbers not less than 0.25 inch (6 mm) high, complete with brass attachment chains.
- D. Ceiling identification tags: Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number.

# PART 3 - EXECUTION

# 3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

- A. Manufacturers' instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturers' instructions and recommendations applicable to the project conditions.
  - 1. Immediately notify Architect if a difference or discrepancy is found between manufacturers' instructions and the drawings or specifications.

# 3.22 PIPE INSTALLATION

- A. Remove burrs resulting from cutting pipe or from any other operation.
- B. Threaded connections:
  - 1. Cut threads full and clean.
  - 2. Apply specified pipe jointing compound or tape on male threads only.
- C. Thoroughly clean pipe and fittings before they are installed, and keep them clean until the acceptance of the completed work. Cap or plug the ends of the lines so as to prevent earth and other debris from entering during construction.

- D. Black steel piping NPS 2.5 (DN 65) and larger shall be welded; NPS 2 (DN 50) and smaller shall be threaded, except as required otherwise in a particular section.
- E. Do not weld galvanized piping.
- F. Use welding fittings, tees, wyes, reducers, eccentric reducers, and caps as required. Branches at least two nominal pipe sizes less than the main may be made with "Weldolets" or "Thredolets" installed with full size opening in larger pipe and in accordance with manufacturer's printed instructions. Flanges shall be welded neck or slip-on pattern of class to suit the valves or equipment connections. Flanges shall have machine bolts with hex nuts and washers.

# 3.25 INTERFACE WITH OTHER PRODUCTS

- A. Where it is necessary to run pipes through walls, provide finished, permanent, waterproof installation complete with inserts, sleeves, supports or hangers, seals, and other appurtenances as required. Do not pierce, cut, or notch any footing or other structural member.
- B. Waterproofing and dampproofing of the building shall be unharmed by the installation of the work. Where pipe has to pierce waterproofing or dampproofing, including outside walls, the penetration shall be made watertight. Waterproofing damaged or destroyed shall be repaired or replaced with new waterproofing.

# 3.59 IDENTIFICATION

- A. General: Do not apply identification until insulation and finish painting work is complete.
- B. Equipment:
  - 1. Stencil equipment with minimum two-inch (50-mm) -high letters or provide identification tags. Clearly identify function, equipment served, and area served.
  - 2. Firmly fasten each identification tag to its appropriate piece of equipment with drive screws, sheet metal screws, or rivets. Do not interfere with operation of, or damage the item being marked.
- C. Piping:
  - 1. Mark by stenciling.
  - 2. Mark to identify service with arrows showing direction of flow. Apply markings near building walls where pipes enter or leave an accessible space and in intermediate locations so that markings are no more than 30 feet (9 m) apart. They shall be readily visible to a person standing on the floor.
  - 3. Fully identify all piping installed as work of the project.
  - 4. Mark pipe with letters of height and with colors as required by OSHA and conforming to ANSI A13.1.
  - 5. Identify every gage, and control device.
  - 6. Provide valve tags for all valves. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.
- D. Ceiling identification tags: Provide on the access door or, in suspended ceilings, on the ceiling

support adjacent to the device.

1. Valves: Identify with the same number shown on the valve tag.

#### 3.61 PIPING TESTS

- A. Notify Owner at least one day prior to the actual test.
- B. Test before pipes are concealed or insulated. Test the piping in sections as the work progresses, so as not to delay progress of the building construction. Furnish pumps and gages required for testing.
- C. Conduct piping tests before connecting equipment that would be subject to damage from the test pressure. Replace piping or fittings found defective with new material.
- D. Bracing and supporting: Adequately brace and support piping during the test, so that no movement, displacement, or damage results from the application of the test pressure.
- E. Test the piping systems for not less than four hours to fulfill the conditions in the Piping Systems Test Schedule at the end of this section.
- F. Documentation of tests: Prepare a test report for each portion of piping tested, identified by service, material, location, and pipe size. Include these items:
  - 1. Date of test.
  - 2. Starting and completion times.
  - 3. Initial test pressure.
  - 4. Final test pressure.
  - 5. Problems or leaks detected.
  - 6. Corrective actions taken.
  - 7. Record of successful completion of testing.
  - 8. Name, title, and signature of person conducting test.

#### 3.75 CLEANING AND PAINTING

- A. Cleaning: Clean piping and equipment. Where items are to be painted, clean and prepare surfaces for painting.
- B. Painting: Coordinate painting with requirements of Division 09. Paint the items identified below to be painted. Use paint materials and systems specified in Division 09.
- C. Items to be painted:
  - 1. Items identified below to have protective coating.
  - 2. Items furnished with manufacturer's prime coat.
  - 3. Mechanical rooms:
    - a. Piping.
    - b. Non-galvanized hangers and supports.
- D. Items not to be painted: Stainless steel and equipment furnished with manufacturer's finish.

- E. Paint piping in mechanical rooms: Paint piping using colors in accordance with ANSI A13.1 and as coordinated with the owner.
  - 1. Galvanized steel: One coat of primer recommended for galvanized surfaces and one coat of glossy alkyd enamel.
  - 2. Ferrous metal: One coat of primer recommended for ferrous metal and one coat of glossy alkyd enamel.
- F. Paint systems for exposed piping: Primer compatible with the substrate, whether steel, galvanized steel, insulation jacket, or other material; one coat or two, if required to cover, to match adjacent surfaces in color and texture.

# 3.81 OPERATING INSTRUCTIONS (DEMONSTRATION)

- A. Furnish the necessary technicians, skilled workers, and helpers to operate all the fire-suppression systems and equipment of the entire project for one 8-hour day.
- B. Where specified in technical sections, provide longer periods required for specialized equipment.
- C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of all systems and equipment.
  - 1. Instructions by manufacturer's technical representative for each type of system shall include the performance of the recommended preventive maintenance procedures for that equipment.
- D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by instructors and Owner personnel.
- E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.
- F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Architect.

#### 3.90 SCHEDULES

A. Piping Systems Test Schedule:

SYSTEM	TEST PRESSURE PSIG (kPa)	ALLOWABLE DROP	MEDIUM
Sprinkler water and fire line	200 (1370)	None	Water

# **END OF SECTION**

# SECTION 21 10 00 - WATER-BASED FIRE-SUPPRESSION SYSTEM

## PART 1 - GENERAL

#### 1.10 SUMMARY

- A. This section includes the following fire suppression systems inside the building:
  - 1. Wet pipe sprinkler systems.
- 1.14 RELATED SECTIONS
  - A. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
  - B. Project and special warranties: Division 01 and Section 21 01 01.
  - C. Operation and Maintenance Manuals: Division 01 and Section 21 01 01.
  - D. Painting: Division 09.
  - E. Piping materials and joining requirements: Section 21 05 00.
  - F. Requirements for firestopping: Section 22 05 07.
  - G. Backflow preventers: Section 22 11 19.

#### 1.21 DEFINITIONS

- A. AHJ: Authority having jurisdiction, typically the fire marshal.
- B. CPVC: Chlorinated polyvinyl chloride plastic.
- C. CR: Chlorosulfonated polyethylene synthetic rubber.
- D. PE: Polyethylene plastic.
- E. Registered fire protection engineer:
  - 1. Registered professional engineer in Maryland.
  - 2. Bachelor's degree in fire protection engineering and no less than two years experience working in fire protection; or Bachelor's degree in engineering and no less than 4 years experience working in fire protection; or other combination of qualifications satisfactory to the AHJ.
- F. Underground service-entrance piping: Water service piping installed below grade in earth.

# 1.25 SYSTEM DESCRIPTIONS

A. Wet pipe sprinkler system: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

# 1.26 DESIGN REQUIREMENTS

- A. Design the system by the hydraulic calculation method. Base data for calculations are shown on the drawings. Obtain, from the local fire authority having jurisdiction, flow readings from the fire hydrant closest to the project.
- B. Locations of service connection, mains and risers, zones, and minimum required Hazard Classifications are shown on drawings.
- C. Contractor's attention is called to provisions of NFPA 13 for large open Light Hazard areas where the mains must be sized for Ordinary Hazard. This situation can occur where movable partitions are used. Coordinate locations of sprinklers and piping with elevator equipment and requirements of local elevator inspection authorities.
- D. Contractor's attention is called to Memorandum 01-88-206 from the Maryland State Fire Marshal which states; "elevator shafts and elevator mechanical rooms shall be equipped with an automatic fire suppression system ... within buildings which are .... Sprinklered ... with an automatic sprinkler system at the top and bottom of the elevator shaft and within the elevator machine room." Coordinate locations of sprinklers and piping with elevator equipment and requirements of local elevator inspection authority.
- E. Do not include area reductions for quick response sprinklers installed in light or ordinary hazard locations, allowed by NFPA, unless approved by both the insurance carrier and the Owner.

# 1.27 PERFORMANCE REQUIREMENTS

A. Standard piping system component working pressure: Listed for at least 175 psig (1200 kPa).

# 1.30 SUBMITTALS

- A. Product data: Include copy of UL report verifying each product's UL listing for Fire Protection Service.
  - 1. Piping materials, including dielectric fittings, flexible connections, and sprinkler specialty fittings.
  - 2. Pipe hangers and supports.
  - 3. Valves, including listed fire protection valves, unlisted general duty valves, and specialty valves and trim.
  - 4. Each type of sprinkler, escutcheon, and guard. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
  - 5. Fire department and backflow preventer test connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.

- 6. Alarm devices, including electrical data.
- B. Shop drawings: Diagram power, signal, and control wiring.
- C. Fire hydrant flow test report.
- D. Approved sprinkler piping drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations.
- E. Field test reports and certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping".
- F. Welding certificates.
- G. Field quality control test reports.
- H. Operation and maintenance data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.
- 1.40 QUALITY ASSURANCE
  - A. Installer qualifications:
    - 1. Installer's responsibilities include designing, fabricating, and installing fire suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
      - a. Engineering responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
  - B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
  - C. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:
    - 1. NFPA 13, "Installation of Sprinkler Systems."
    - 2. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."
    - 3. NFPA 230, "Fire Protection of Storage."
  - D. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label directly on the pipe indicating compliance.

# 1.42 REGULATORY REQUIREMENTS

A. Backflow preventers shall be installed by a licensed plumber. Coordinate fire suppression system piping installation with domestic water piping installation.

# 1.49 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

# 1.91 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Sprinkler cabinets, sprinklers, and wrench: Finished, wall-mounting, steel cabinet with hinged cover, with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler on project.

# PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Available manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, manufacturers specified.

# 2.20 ABOVEGROUND PIPE AND FITTINGS

- A. Pipe: Metal, rigid types permitted by NFPA 13, UL listed and FM approved, suitable for specified fittings.
- B. Fittings: Compatible with pipe, types permitted by NFPA 13, UL listed and FM approved.
  - 1. Exceptions: Compression fitting shall be mechanical coupling for grooved pipe only; other compression types are not permitted.
- C. Flexible stainless steel sprinkler connections: UL listed, FM approved, manufactured by either Victaulic or Flexhead Industries.
- D. Hangers and supports: UL approved, supporting piping from above, black steel conforming to NFPA 13.

# 2.22 SPRINKLER SPECIALTY FITTINGS

- A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig (1200-kPa) minimum working-pressure rating, and made of materials compatible with piping.
- B. Sprinkler drain and alarm test fittings: Cast or ductile iron body; with threaded or locking lug inlet and outlet, test valve, and orifice and sight glass.

- C. Sprinkler inspector's test fitting: Cast or ductile iron housing with threaded inlet and drain outlet and sight glass.
- D. Drop-nipple fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.

# 2.23 LISTED FIRE-PROTECTION VALVES

- A. Manufacturers:
  - 1. Crane Co.; Crane Valve Group; Crane Valves
  - 2. Crane Co.; Crane Valve Group; Jenkins Valves
  - 3. Hammond Valve
  - 4. McWane Inc.; Kennedy Valve Div.
  - 5. Milwaukee Valve Co.
  - 6. Mueller Company
  - 7. NIBCO
  - 8. Potter-Roemer; Fire Protection Div.
  - 9. Reliable Automatic Sprinkler Co., Inc.
  - 10. Stockham
  - 11. Tyco Fire Protection
  - 12. Victaulic Co. of America
- B. Valves shall be UL listed or FM approved, with 175-psig (1200 kPa) minimum pressure rating.
  - 1. Valves where required by NFPA 13 to be supervised shall be capable of being locked open with a guarded-shackle padlock equal to Master Lock No. 37.
- C. Gate valves: Equal to NIBCO F-607-0, NPS 2.5 through 12 (DN 65 through 300), iron body, OS&Y bolted bonnet, solid wedge, 175 pounds WWP.
- D. Butterfly valve: Lug type, equal to NIBCO LD3510-2, NPS 2 through 12 (DN 65 through 300), with gear operator, wheel, and flag, 175 pounds WWP.

# 2.24 SPECIALTY VALVES

- A. Sprinkler system control valves: UL listed or FM approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig (1200-kPa) minimum pressure rating.
- B. Alarm check valves: Equal to Tyco Model AV-1-300 in combination with Model RC-1 retarding chamber, bronze grooved seat with O-ring seals, and trim set for external bypass; clapper assembly mounted in valve body with a hinge pin plug and dual springs.
- C. Automatic ball drip valves: Equal to Elkhart No. 701, NPS 0.75 (DN 20), cast brass, ball check device with threaded ends.
  - 1. Finish: Rough brass.
- D. Water solenoid valve: Normally closed type, one NPT, one inch orifice, PTFE seal, 120 volt coil, equal to Automatic Switch Co., ASCO 8210D4.

## 2.28 SPRINKLERS

- A. Sprinklers shall be UL listed or FMG approved, with 175-psig (1200-kPa) minimum pressure rating.
- B. Sprinkler types and categories:
  - 1. Provide quick-response type.
  - 2. Provide high-temperature heat-responsive elements where required.
  - 3. Open sprinklers: UL 199, without heat-responsive element.
    - a. Orifice: 0.5 inch (12.7 mm), with discharge coefficient K between 5.3 and 5.8.
    - b. Orifice: 0.53125 inch (13.5 mm), with discharge coefficient K between 7.4 and 8.2.
  - 4. Flexible stainless steel sprinkler connections: UL listed, FM approved, manufactured by Victaulic or Flexhead Industries.
  - 5. Extended coverage sprinklers are not acceptable.
- C. Sprinkler types, features, and options as indicated in Part 3.
- D. Sprinkler finishes: Chrome-plated, in areas with ceilings, and plain brass in other areas.
- E. Special coatings: Lead and corrosion-resistant paint.
- F. Sprinkler escutcheons: Chrome-plated for sidewall and ceiling mounting.
- G. Sprinkler guards: Wire cage type, including fastening device for attaching to sprinkler. Provide guards on sprinklers mounted in gymnasium mechanical rooms and where mounted 7.5 feet above floor and lower.
- H. Where required by the authority having jurisdiction, provide heat deflectors of proper size, painted to match surrounding area.

#### 2.32 FIRE DEPARTMENT CONNECTIONS

- A. Wall-type, fire department connection: UL listed, 175-psig (1200-kPa) minimum pressure rating; with corrosion resistant metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include 2.5 inch inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR & STANDPIPE," or "AUTO-SPKR."
  - 1. Type: Exposed, projecting, with two inlets and round escutcheon plate.
  - 2. Finish: Polished chrome plated.

# 2.33 ALARM DEVICES

A. Alarm device types shall match piping and equipment connections.

- B. Electrically operated alarm: UL 464, with 10-inch- (250-mm-) diameter, vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.
- C. Water flow indicator: UL listed, equal to Notifier Corporation Model WFD, electricalsupervision, paddle-operated-type, water-flow detector with 250-psig (1725-kPa) pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
- D. Valve supervisory switch: UL listed, equal to Notifier Model OSY2, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position with tamperproof cover that sends signal when removed.

# 2.34 PRESSURE GAGES

- A. Description: 4.5-inch- (115-mm-) diameter, dial pressure gage with range of 0 to 250 psig (0 to 1725 kPa) minimum .
  - 1. Water system piping: Include caption "WATER" on dial face.

# 2.35 SIGNAGE

A. Metal signs: Comply with NFPA 13 requirements.

# PART 3 - EXECUTION

# 3.02 EXAMINATION

- A. Examine walls and partitions for suitable thicknesses, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

# 3.05 PREPARATION

- A. Perform fire hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in Part 1 "Quality Assurance" Article.
- B. Report test results promptly and in writing.

# 3.20 PIPING APPLICATIONS, GENERAL

- A. Shop weld pipe joints where welded piping is indicated.
- B. Do not use welded joints for galvanized-steel pipe.

C. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.

# 3.21 JOINT CONSTRUCTION

- A. Refer to Section 21 05 00, Common Work Results for Fire Suppression, for basic piping joint construction.
- B. Threaded joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe with wall thickness less than Schedule 40.
- C. Twist locked joints: Insert plain end piping into locking lug fitting and rotate retainer lug one quarter turn.
- D. Grooved joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.
  - 1. Ductile iron pipe: Radius cut groove ends of piping. Use grooved end fittings and grooved end pipe couplings.
  - 2. Steel pipe: Square cut or roll groove piping as indicated. Use grooved end fittings and rigid, grooved end pipe couplings, unless otherwise indicated.
  - 3. Copper tube: Roll groove tubing. Use grooved end fittings and grooved end tube couplings.
- E. Dissimilar-metal piping joints: Construct joints using dielectric fittings compatible with both piping materials.
  - 1. NPS 2 (DN 50) and smaller: Use dielectric unions, couplings, or nipples.
  - 2. NPS 2.5 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.
  - 3. NPS 5 (DN 125) and larger: Use dielectric flange insulation kits.

# 3.22 WATER SUPPLY CONNECTION

- A. Connect fire suppression piping to building's interior water distribution piping. Refer to Division 22 Section "Domestic Water Piping" for interior piping.
- B. Install shutoff valve, pressure gage, drain, and other accessories indicated at connection to water distribution piping.

# 3.23 ABOVEGROUND PIPING INSTALLATION

- A. Install piping above the finished ceiling wherever ceilings occur. For bar joist construction, run the pipes between or threaded through bar joists, arranged so as to give clear path for ductwork, lighting fixtures, and appurtenances below joists and to permit possible clearance for future relocation of light fixtures and ductwork. Consult Finish Schedules on Architectural drawings. Do not install piping so that it blocks access doors or panels of ductwork, air handling equipment, or the space required for filter removal. Provide padlocks for valves.
  - 1. The finished ceilings shall not be erected until all fire protection piping has been installed, tested, and inspected.
  - 2. Hanger spacing shall conform to NFPA 13.

- B. System drains shall be piped to drain into service sinks, drains, or through wall to grade with all exterior fittings of brass. At low points in piping provide ball valves with hose nipples with vacuum breakers.
  - 1. Except as shown otherwise on drawings, drains 1.5 inches and larger shall be piped through wall to grade.
- C. Piping shall not penetrate beams.
- 3.25 VALVE INSTALLATION
  - A. Install listed fire-protection valves, specialty valves and trim, controls, and specialties according to NFPA 13, and authorities having jurisdiction.
  - B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.
  - C. Specialty valves:
    - 1. Alarm check valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain line connection.

# 3.26 SPRINKLER APPLICATIONS

- A. Installation in suspended ceilings:
  - 1. Locate sprinklers in the geometrical centers of acoustical panels. Provide pipe, fittings, and number of sprinklers to accomplish this, with no addition to the contract sum.
  - 2. Contractor option: In areas with suspended ceilings, the use of flexible commercial grade sprinkler connections in lieu of rigid piping swing-joint connections is acceptable.
- B. Adjustable recessed pendent: Areas with ceilings.
- C. Adjustable pendent: Areas with obstructions such as surface-mounted light fixtures.
- D. Upright: Areas without ceilings.
- E. Concealed, including cover plate: Where noted.
- F. Dry: Refrigerator and freezer.
- 3.28 SPRINKLER CABINET
  - A. Securely mount spare sprinkler cabinet to wall at location shown on the drawings.
- 3.31 FIRE DEPARTMENT CONNECTION INSTALLATION
  - A. Install wall type, fire department connections in vertical wall.
  - B. Install ball drip valve at each check valve for fire department connection.

# 3.32 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Connect fire suppression piping to water supply piping at backflow preventer. Include backflow preventer between potable water piping and fire suppression piping. Refer to Section 22 11 19 for backflow preventers.
- D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.
- E. Connect piping to specialty valves, specialties, fire department connections, and accessories.
- F. Electrical connections: Power wiring is specified in Division 26.
- G. Connect alarm devices to fire alarm.
- H. Ground equipment according to Section 26 05 26.
- I. Connect wiring according to Section 26 05 19.
- J. Tighten electrical connectors and terminals according to manufacturer's published torquetightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- 3.59 LABELING AND IDENTIFICATION
  - A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and in Section 21 05 00.

# 3.60 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. Leak test after installation:
    - a. Charging medium: water.
    - b. Test pressure and duration of test as required by NFPA 13 and Section 21 05 00.
    - c. Repair leaks and retest until no leaks exist.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - 3. Energize circuits to electrical equipment and devices.
  - 4. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" chapter.
  - 5. Coordinate with fire alarm tests. Operate as required.
  - 6. Verify that equipment hose threads are same as local fire department equipment.

- B. Report test results promptly and in writing to Architect and authorities having jurisdiction.
- C. Grooved pipe installation:
  - 1. Install grooved joints in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer, and shall be verified as suitable for the intended service.
  - 2. A factory-trained field representative (direct employee) of the mechanical joint manufacture shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products. A distributor's representative is not considered qualified to conduct the training.

# 3.75 CLEANING AND PROTECTION

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.
- C. Protect sprinklers from damage until Substantial Completion.

# 3.81 DEMONSTRATION

A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves. Refer to Division 01 and Section 21 01 01.

# **END OF SECTION**

# **SECTION 22 01 01 - PLUMBING GENERAL PROVISIONS**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. General provisions and requirements for all plumbing work.
- 1.14 RELATED SECTIONS
  - A. Requirements of this section generally supplement requirements of Division 01.
  - B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
  - C. Fire suppression system requirements: Division 21.

#### 1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

#### 1.25 SYSTEM DESCRIPTION

- A. The full set of Contract Documents applies to work of Divisions 21 and 22.
- B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
- C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
- D. Except as required otherwise in Division 01, promptly obtain and pay for, including all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
- E. Plumbing work of this project includes, as a brief general description, the following:
  - 1. Sanitary and vent systems.
  - 2. Domestic cold and hot water systems.
  - 3. Storm water system
  - 4. Radon venting system.
  - 5. Condensate systems.
  - 6. The project includes commissioning under the direction of a Commissioning Agent (CxA).
  - 7. The project will be LEED certified.

F. See Division 01 for requirements related to LEED certification, commissioning, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

# 1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Divisions 21 and 22 specifications.
- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in the article "Substitutions," below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
  - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
  - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

# 1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 22 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
  - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
  - 2. Will provide the same warranty for the substitution as for the specified product.
  - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
  - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
- 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.
- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

## 1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project and of representative manufacture. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
  - 1. Furnish: Supply item
  - 2. Install: Mount and connect item
  - 3. Provide: Furnish and install.
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturer's instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent before starting any work which may be affected by this decision.

## 1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate plumbing work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.
- D. Coordinate location and elevation of all piping, ductwork, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractor's assistants shall include a competent foreman, who shall be on the premises at all times to check, lay out, coordinate and superintend the installation of work. The foreman shall establish all grades and lines relative to the work before starting, and be responsible for the accuracy thereof.

## 1.30 SUBMITTALS

- A. Manufacturers' and subcontractors' lists:
  - 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.
- B. Shop drawings and product data:
  - 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of shop drawings and product data for every item of equipment. Shop drawings or product data will not be considered until manufacturers' lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
  - 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract

documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.

- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electrical items furnished as items associated with mechanical items but not specifically described in the mechanical item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the mechanical item by identification specification paragraph.
- 5. Product data sheets shall be 8.5-inch by 11-inch cut sheets for operating and maintenance manual.
- C. Submit at least three copies of the results of every test required under any section in this division.
- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.
  - 1. Include project name, address, name and phone number of owner's representative, and project type and size.
- E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

## 1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

## 1.35 CONTRACT CLOSEOUT SUBMITTALS

- A. Project record documents:
  - 1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:
    - a. Contract drawings.
    - b. Specifications.
    - c. Addenda.
    - d. Change orders and other modifications to the Contract.

- e. Reviewed shop drawings, product data, and samples.
- 2. Maintain record documents separate from documents used for construction.
- 3. Record information concurrent with construction progress.
- 4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:
  - a. Manufacturer's name and product model and number.
  - b. Product options, substitutions, or alternates utilized.
  - c. Changes made by addenda and modifications.
- 5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:
  - a. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
  - b. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
  - c. Field changes of dimension and detail.
  - d. Details not on original Contract Drawings.
- 6. Submit documents as specified in Division 01.
- B. Operation and maintenance data:
  - 1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
  - 2. Lubrication charts: Prepare lubrication charts for each piece of mechanical equipment that requires grease or oil.
    - a. Include the following:
      - 1) Types of lubricants required.
      - 2) Locations of lubrication points.
      - 3) Frequency of lubrication.
    - b. Provide one extra set of lubrication charts mounted in plastic covers, besides those required in Operating and Maintenance Manuals.
  - 3. Binders: Three-ring binders with vinyl-covered hard covers. Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
  - 4. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", and title of project. Print on spine of binder "O & M INSTRUCTIONS". If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
  - 5. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.

- 6. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
- 7. Part 1: Directory, listing names, addresses, and telephone numbers of mechanical engineers; Contractor; mechanical subcontractors; and major mechanical equipment suppliers.
- 8. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
  - a. Significant design criteria, including pump curves and similar performance charts.
  - b. List of equipment, including operating weight of each piece.
  - c. Parts list for each component, including recommended spare parts list.
  - d. Operating instructions.
  - e. Maintenance instructions for equipment and systems.
  - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
  - g. Valve charts, including locations of flow fittings.
- 9. Part 3: Project documents and certificates, including the following:
  - a. Shop drawings and product data.
  - b. Water balance reports.
  - c. Photocopies of certificates.
  - d. Photocopies of warranties and guarantees.
  - e. Test reports: Copies of the results of all tests required under all sections of specifications.
- 10. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
- 11. Submit final volumes revised, within ten days after final inspection.
- 12. Submit DVD optical disc storage media specified in Section 22 05 00.

## 1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
  - 1. The plumbing, mechanical, electrical, building, fire, and safety codes of the state and county in which the work is being performed.

### 1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply.
  - 1. Air Conditioning and Refrigeration Institute (ARI)
  - 2. American Association State Highway and Transportation Officials (AASHTO)
  - 3. American National Standards Institute (ANSI)
  - 4. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
  - 5. ASME International (ASME)
  - 6. American Society for Testing and Materials (ASTM)
  - 7. American Society of Sanitary Engineering (ASSE)
  - 8. American Water Works Association (AWWA)
  - 9. International Code Council (ICC)
  - 10. Manufacturer's Standardization Society of the Valve and Fittings Industry Inc. (MSS)
  - 11. National Electrical Code, NFPA 70 (NEC)
  - 12. National Electrical Manufacturer's Association (NEMA)
  - 13. National Fire Protection Association (NFPA)
  - 14. National Sanitary Foundation (NSF)
  - 15. National Standard Plumbing Code (NSPC)
  - 16. The Occupational Safety and Health Act (OSHA)
  - 17. Piping and Drainage Institute (PDI)
  - 18. Underwriters Laboratory Inc. (UL)
  - 19. Maryland Occupational Safety and Health Act (MOSHA)

#### 1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.

#### 1.54 **PROTECTION**

- A. Control dust resulting from construction work to prevent its spread beyond the immediate work area, and to avoid creation of a nuisance.
  - 1. Do not use water to control dust. Use drop cloths or other suitable barriers.
  - 2. In areas where dirt or dust is produced as a result of the work, sweep daily, or more often as required.
  - 3. Provide walk-off mats at entries and replace them at regular intervals.
  - 4. Construct dust partitions, where indicated on the drawings or as required.
  - 5. Seal off all return air registers and other mechanical systems to prevent dust from entering.
- B. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.

- 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
- 2. Protect finished work from damage, defacement, staining, or scratching.
- 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
- 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
- 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- C. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract Sum.
- D. Protect work stored in place and supplies stored in the building.
  - 1. Store materials and products subject to damage from moisture in dry locations. If necessary, protect in wraps or covers.
  - 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- E. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

## 1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

## 1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
  - 1. Promptly notify the Architect in writing.
  - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

## 1.80 WARRANTY

A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties specified in individual sections.

- B. During the correction period, the Contractor shall promptly correct any work found to be not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. When use of the permanent equipment has been permitted for temporary heating or ventilation of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

## 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

## PART 2 - PRODUCTS

Not used.

## PART 3 - EXECUTION

## 3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of pipes, ducts and appurtenances. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.

- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.
- 3.14 TEMPORARY FACILITIES
  - A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.
- 3.40 PROGRESS MEETINGS
  - A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
  - B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

#### 3.82 COMMISSIONING

A. Comply with requirements of "Commissioning" in Part 1 above.

## **SECTION 22 05 00 - COMMON WORK RESULTS FOR PLUMBING**

### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Basic material and equipment required for the mechanical equipment and piping work as indicated on the drawings and specified in Divisions 21 and 22.
- B. Other requirements applicable to more than one section of Divisions 21 and 22.
- C. Identification of mechanical systems and equipment.

#### 1.14 RELATED SECTIONS

- A. Division 01 includes sections specifying requirements for LEED rating, and commissioning.
- B. Project and special warranties: Division 01 and Section 22 01 01.
- C. Operation and Maintenance Manuals: Division 01 and Section 22 01 01.
- D. Painting: Division 09.

#### 1.21 DEFINITIONS

- A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.
- B. Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
  - 1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
  - 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.
- C. DN: Dimension Nominale, nominal pipe size in millimeters, in accordance with the metric system for construction, Systeme Internationale (SI).
- D. NPS: Nominal pipe size in inches, in accordance with standard U.S. designations for manufactured pipe. Pipe sizes do not change when projects are designed and built in metric units; each size has a consistent name (nominal dimension) in each system.

## 1.26 DESIGN REQUIREMENTS

A. The drawings and system performances have been designed based on using the particular manufacturer's products specified and scheduled on the drawings.

- B. Products of other manufacturers that are listed under the article "Acceptable Manufacturers", or permitted as "equal," are permitted provided:
  - 1. Product shall meet the specifications.
  - 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.
- C. Do not propose products with dimensions or other characteristics different from the design basis product that render their use impractical, or cause functional fit, access, or connection problems.
- D. The contract drawings are generally diagrammatic and do not indicate all fittings or offsets in pipe, all access panels, or other specialties required.
  - 1. Install pipe exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining proper clearances for access at all parts requiring servicing.
  - 2. Install pipe a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.
  - 3. No pipe shall be run below the head of a window or door.
    - a. Equipment, ducts, and pipes installed in areas without a suspended ceiling shall be as tight to structure as possible, but at least above a height of 6'-8", unless otherwise noted.
  - 4. Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

## 1.30 SUBMITTALS

- A. Comply with Division 01 and Section 22 01 01.
- B. Shop drawings:
  - 1. Showing proposed expansion design.
  - 2. Schedule of welding and brazing procedures proposed for each piping system included in the project.
- C. LEED submittal:
  - 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For adhesives and sealants, include printed statement of VOC content.
  - 2. Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For wood products such as plywood equipment backboards, include printed statement of non-urea-formaldehyde component present in material.
  - 3. Product data for Credit IEQ 4.2: For paints and coatings applied within the building waterproofing envelope, documentation including printing statement of VOC content in g/L.

- D. Certifications: Proof of operator and testing agency personnel qualifications as required for welding and brazing in the article "Quality Assurance" below.
- E. Test reports: Field test results for each piping system as specified in Part 3 below.

## 1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the plumbing, mechanical, electrical, building, fire, health and safety, and other applicable codes and regulations of the state and county in which the work is performed.
  - 1. Product specifications herein may not necessarily meet all regulations for the limit on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.
- B. Welding procedures and operator qualifications for structural welding: AWS D1.1, Structural Welding Code Steel, electric arc process.
- C. Welding, brazing, and soldering procedures and operator qualifications for building systems piping:
  - 1. AWS D10.9, Qualification of Welding Procedures and Welders for Piping and Tubing.
  - 2. ASME B31.9, Building Services Piping.
  - 3. Copper Development Association "Copper Tube Handbook."
  - 4. Safe Drinking Water Act.
- D. Qualifications of independent testing laboratory personnel:
  - 1. Welding inspectors: AWS QC1, Certification of Welding Inspectors.
- E. Electrical control panels, equipment, materials and devices provided or installed as work of Division 15 shall bear UL label or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70 (NEC). Provide testing, if required, without addition to the contract sum.
- F. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media format for video and audio production and editing.
- G. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.
- H. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.
- I. Products shall contain no urea-formaldehyde content.

## 1.85 COMMISSIONING

A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01.

## PART 2 - PRODUCTS

## 2.10 MATERIALS

- A. General piping techniques, testing, identification, painting, and operating instructions specified in this section apply to products specified in other sections of Divisions 21 and 22.
- B. Weldolets and thredolets: Fittings designed for installing branches on piping, with either welded or threaded connection to branch; conforming to ASTM A 234.
- C. Solder: Free of lead, antimony, and zinc. No solder containing lead is permitted.
  - 1. Tin 95.5 percent, copper 4 percent, and silver 0.5 percent; equal to "Silvabrite 100" manufactured by Engelhard Corporation.
  - 2. Tin, copper, bismuth, and silver; equal to "Oatey Silver" manufactured by Oatey.
- D. Flux: Meeting requirements of NSF 61.
- E. Pipe jointing compound:
  - 1. Polytetrafluoroethylene (PTFE) pipe thread tape, "Teflon."
  - 2. Pipe cement and oil.
  - 3. For sanitary piping overhead of food storage, preparations, and serving and dining areas: Litharge and glycerin.
- F. Adhesives, sealants, paints, and coatings applied within the building waterproofing envelope: Comply with low-emitting requirements in Section 01 61 16.
- G. Composite wood: Contain no added urea formaldehyde.

## 2.11 MATERIALS FOR UNDERFLOOR INSTALLATION

- A. Pipe: Copper tubing, ASTM B 88, Type L soft drawn, no joints under floor.
- B. Conduit: Schedule 40 PVC pipe, size to accommodate copper tubing and insulation.
- C. Insulation: Flexible elastomeric, as specified in Section 15081, Pipe Insulation.
- D. Firestopping caulk: Equal to Three M CP 25 WB, intumescent caulk, which, under heat, expands to five times its original volume, creating a char which can withstand flames and smoke for at least three hours.

## 2.21 IDENTIFICATION DEVICES AND MATERIALS

A. Stenciling materials:

- 1. Stencils: Manufactured standard stencils prepared for required applications, conforming to ANSI A13.1 for color and size of legend letters, including arrows showing direction of flow.
- 2. Paint: Exterior type enamel, colors conforming to ANSI A13.1, or black.
- B. Equipment identification tags:
  - 1. Laminated plastic with adhesive back, white core and black outer layers, which, when engraved, will produce white letters and numerals on a black background.
  - 2. Tags installed on curved surfaces shall be aluminum or brass.
- C. Valve tags: Brass, 1.5 inch (40 mm) in diameter with black-filled numbers not less than 0.25 inch (6 mm) high, complete with brass attachment chains.
- D. Ceiling identification tags: Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number.

## 2.23 DATE-SENSITIVE EQUIPMENT

- A. Date-sensitive equipment: Systems, equipment, or components which use or process date and time data in order to perform their functions.
- B. Each item of date-sensitive equipment used in the project shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

## PART 3 - EXECUTION

## 3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

- A. Manufacturer's instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturer's instructions and recommendations applicable to the project conditions.
  - 1. Immediately notify Architect if a difference or discrepancy is found between manufacturer's instructions and the drawings or specifications.

## 3.20 INSTALLING PIPING UNDER FLOOR SLAB

- A. Install conduit.
- B. Insulate copper tubing and insert in conduit.
- C. Where piping rises through floor, cut conduit and insulation flush with floor.
- D. Fill annular spaces with firestopping caulk. Use fiberglass insulation as backing.

## 3.22 PIPE INSTALLATION

- A. Remove burrs resulting from cutting pipe or from any other operation.
- B. Threaded connections:
  - 1. Cut threads full and clean.
  - 2. Apply specified pipe jointing compound or tape on male threads only.
- C. Thoroughly clean pipe and fittings before they are installed, and keep them clean until the acceptance of the completed work. Cap or plug the ends of the lines so as to prevent earth and other debris from entering during construction.
- D. Provide for expansion and contraction of piping and connections so that no strain or breakage will occur. Provide anchors and guides of approved design where shown on drawings and where necessary to allow for proper expansion and contraction. At the time of installation, expansion loops shall be cold sprung to one-half of the calculated expansion.
- E. Provide for draining all parts of water piping systems and apparatus by installing a valved hose connection at every low point.
- F. Use welding fittings, tees, wyes, reducers, eccentric reducers, and caps as required. Branches at least two nominal pipe sizes less than the main may be made with "Weldolets" or "Thredolets" installed with full size opening in larger pipe and in accordance with manufacturer's printed instructions. Flanges shall be welded neck or slip-on pattern of class to suit the valves or equipment connections. Flanges shall have machine bolts with hex nuts and washers.
- G. Each connection from risers to equipment shall contain at least three elbows or expansion joints. Connections shall be so arranged that movement in piping due to expansion and contraction will not be transmitted to the equipment.
- H. Install unions and flanges in the piping at each item of equipment, so as to provide easy removal of the equipment, valve.

## 3.23 COPPER TUBING FOR WATER INSTALLATION

- A. Solder joints for copper tubing: Clean ends of tubing and inside of fitting ends thoroughly with emery cloth before applying flux.
- B. Make flare joints in copper tubing with proper size flaring tool and in accordance with manufacturer's recommendations.
- C. Provide isolation fittings between copper and steel piping to prevent electrolysis.
- D. Cut pipe with a tubing cutter or fine-tooth saw. Cuts made with a saw shall be true and square, and the end shall be filed smooth with a fine-tooth file. Remove all marks and burrs with sandpaper.

## 3.24 PLASTIC PIPING INSTALLATIONS

- A. Cut pipe true and square with a fine-tooth saw and file the end smooth with a fine-tooth file. Remove all saw marks and burrs with sandpaper.
- B. Clean connecting surfaces of both pipe and fitting with methyl ethyl ketone or acetone.
- C. Apply solvent cement liberally with clean brush, first to fitting and then to pipe (outer surface and end). Lap cement a minimum of 0.25 inch (6 mm) over depth of fitting.
- D. Join pipe and fitting to full depth of fitting, giving fitting at least one-quarter turn on pipe to distribute cement.
- E. Pipe and fitting shall show a small fillet or bead completely around pipe without any voids, or fitting shall be cut out and new fitting made up and installed. Allow a minimum of 48 hours drying time for each joint.

#### 3.25 INTERFACE WITH OTHER PRODUCTS

- A. Where it is necessary to run pipes through walls, provide finished, permanent, waterproof installation complete with inserts, sleeves, supports or hangers, seals, and other appurtenances as required. Do not pierce, cut, or notch any footing or other structural member.
- B. Waterproofing and dampproofing of the building shall be unharmed by the installation of the work. Where pipe has to pierce waterproofing or dampproofing, including outside walls, the penetration shall be made watertight. Waterproofing damaged or destroyed shall be repaired or replaced with new waterproofing.

## 3.59 IDENTIFICATION

- A. General: Do not apply identification until insulation and finish painting work is complete.
- B. Equipment:
  - 1. Stencil equipment with minimum two-inch (50-mm) -high letters or provide identification tags. Clearly identify function, equipment served, and area served.
  - 2. Firmly fasten each identification tag to its appropriate piece of equipment with drive screws, sheet metal screws, or rivets. Do not interfere with operation of, or damage the item being marked.
- C. Piping:
  - 1. Mark by stenciling.
  - 2. Mark to identify service with arrows showing direction of flow. Apply markings near building walls where pipes enter or leave an accessible space and in intermediate locations so that markings are no more than 30 feet (9 m) apart. They shall be readily visible to a person standing on the floor.
  - 3. Fully identify all piping installed as work of the project.
  - 4. Mark pipe with letters of height and with colors as required by OSHA and conforming to ANSI A13.1.

- 5. Identify every thermometer, gage, and control device.
- 6. Provide valve tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.
- D. Ceiling identification tags: Provide on the access door or, in suspended ceilings, on the ceiling support adjacent to the unit.
  - 1. Valves: Identify with the same number shown on the valve tag.

## 3.61 PIPING TESTS

- A. Notify Owner at least one day prior to the actual test.
- B. Test before pipes are concealed or insulated. Test the piping in sections as the work progresses, so as not to delay progress of the building construction. Furnish pumps and gages required for testing.
- C. Conduct piping tests before connecting equipment that would be subject to damage from the test pressure. Replace piping or fittings found defective with new material.
- D. Bracing and supporting: Adequately brace and support piping during the test, so that no movement, displacement, or damage results from the application of the test pressure.
- E. Interior sanitary and storm drainage piping:
  - 1. Before connection of the plumbing fixtures and before connection to the sewer, cap or plug the entire sanitary, condensate, and storm drainage piping systems of the building.
  - 2. Test following the methods of testing required by the plumbing code, and no less than the duration and pressures required in the Schedule of Piping Systems Tests.
  - 3. Where pipes are in trenches, leave the trenches open until the completion of the test.
- F. Test exterior gravity sanitary and storm sewer piping by the exfiltration method. Backfill over sewers to a minimum depth of two feet of cover prior to tests. Plug the lower manhole, filling the section between manholes with water and measuring the drop in water level in the upper manhole. Furnish water for testing, and maintain it at levels directed by the Architect, for a period of at least 24 hours. Repair or replace all visible leaks and all defects to meet the maximum allowable leakage shown in the Sewer Piping Test Schedule at the end of this section.
- G. Test the piping systems for not less than four hours to fulfill the conditions in the Piping Systems Test Schedule at the end of this section.
- H. Documentation of tests: Prepare a test report for each portion of piping tested, identified by service, material, location, and pipe size. Include these items:
  - 1. Date of test.
  - 2. Starting and completion times.
  - 3. Initial test pressure.
  - 4. Final test pressure.
  - 5. Problems or leaks detected.

- 6. Corrective actions taken.
- 7. Record of successful completion of testing.
- 8. Name, title, and signature of person conducting test.

## 3.75 CLEANING AND PAINTING

- A. Cleaning: Clean all piping and equipment. Where items are to be painted, clean ready for painting.
- B. Painting: Coordinate painting with requirements of Division 09. Paint the items identified below to be painted. Use paint materials and systems specified in Division 09.
- C. Items to be painted:
  - 1. Items identified below to have protective coating.
  - 2. Items furnished with manufacturer's prime coat.
  - 3. Mechanical rooms:
    - a. Insulation and uninsulated steel: Piping, pumps, tanks, and vessels.
    - b. Non-galvanized hangers and supports.
  - 4. Piping exposed in finished spaces, insulated and uninsulated.
- D. Items not to be painted: Copper, stainless steel, and equipment furnished with manufacturer's finish.
- E. Paint systems in mechanical rooms: Paint piping using colors in accordance with ANSI A13.1.
  - 1. Galvanized steel: One coat of primer recommended for galvanized surfaces and one coat of glossy alkyd enamel.
  - 2. Ferrous metal: One coat of primer recommended for ferrous metal and one coat of glossy alkyd enamel.
  - 3. Items protected with bituminous coating or rust-inhibitive primer: Finish coat of compatible glossy enamel.
- F. Paint systems for exposed piping: Primer compatible with the substrate, whether steel, galvanized steel, insulation jacket, or other material; one coat or two, if required to cover, to match adjacent surfaces in color and texture.

## 3.81 OPERATING INSTRUCTIONS (DEMONSTRATION)

- A. Furnish the necessary technicians, skilled workers, and helpers to operate all the mechanical systems and equipment of the entire project for two 4- hour days. Sessions shall occur on consecutive days.
- B. Where specified in technical sections, provide longer periods required for specialized equipment.
  - 1. Session requiring time periods exceeding four-hours shall occur on multiple days. All single sessions shall not exceed a four-hour time period.

- C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of all systems and equipment.
  - 1. Instructions by manufacturer's technical representative for each type of equipment shall include the performance of the recommended preventive maintenance procedures for that equipment.
- D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by instructors and Owner personnel.
- E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.
- F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Architect.

## 3.90 SCHEDULES

SYSTEM	TEST PRESSURE PSIG (kPa)	ALLOWABLE DROP	MEDIUM
Domestic water service and exterior water piping	150 (1030)	None	Water
Interior domestic water, cold & hot, and recirculated	125 (860)	None	Water
Air conditioning condensate drain	4.3 (30)**	None	Water
Sanitary waste	4.3 (30)**	None	Water
Storm	4.3 (30)**	None	Water

A. Piping Systems Test Schedule:

\*\* Where piping is above food service area, test pressure shall be 11 psig (76 kPa).

## SECTION 22 05 01 - EXCAVATION AND FILL FOR PLUMBING WORK

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Trenching, backfilling, and compacting for mechanical work underground inside the building and extending five feet beyond exterior building walls, and outside the building as shown on drawings.
- 1.14 RELATED SECTIONS
  - A. Cutting and patching: Division 01 and Section 22 05 01.
  - B. Repairing pavements: Division 02.
  - C. Piping: Sections 22 11 16, 22 13 16, and 22 14 13.
- 1.20 REFERENCES
  - A. ASTM D 1557: Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbs/cu ft (2700 kN-m/cu m).
- 1.30 SUBMITTALS
  - A. General: Submit in accordance with Division 01 and Section 22 01 01.
  - B. Shop drawings: At the same scale as the contract drawings, showing field verified locations of utilities and proposed detailed trenching plan.
  - C. Product data:
    - 1. Warning tape
  - D. Certifications: Test reports showing that compaction meets specified requirements.

#### PART 2 - PRODUCTS

#### 2.10 MATERIALS

- A. Backfill: Earth materials, free from perceptible amounts of wood, debris, or topsoil, free of frost at the time of placement, and not containing marl or other elements which tend to stay in a plastic state.
- B. Underground warning tape: Polyethylene 0.004 inch (0.102 mm) thick for metallic lines, and for non-metallic lines polyethylene both sides with metallic lining, six inches (152 mm) wide.
  - 1. Colors: In accordance with APWA and AASHTO standards.
  - 2. Markings: Repeated continuously along the entire length, legend appropriate for line being identified.

## 2.12 EQUIPMENT

A. Mechanical tampers for compacting backfill: Capable of exerting a blow equal to 250 pounds per square foot (12 kPa) of area of the tamping face.

## PART 3 - EXECUTION

### 3.05 PREPARATION

- A. Contact local utility company underground information service (BGE Miss Utility) before beginning excavation outside buildings.
- B. The general locations of underground utilities are indicated on the drawings and are not to be assumed to be accurate or complete. Before beginning work, field check the area with the most accurate instruments available, such as Fisher Labs' Pipe and Cable Locators.

## 3.20 INSTALLATION

- A. Perform all excavating, trenching, sheeting, shoring, backfilling, and compacting required for the proper installation of the work.
- B. Where obstructions are encountered, obtain written approval and make necessary changes in line, grade or location.
- C. Protect existing utilities from damage during excavation and backfilling. Repair damaged new or existing work at no addition to the contract sum. Bracing, shoring and other protection of existing utilities is part of this work.
- D. Do not damage or remove existing shrubs or trees including their root systems, without prior notification to the Architect.
- E. Provide temporary roadways over trenches with railings and other safeguards, including amber blinker lamps or other warnings for night use.
- F. Note the depths of footings. In cases where piping is in close proximity to or below footings and where the natural earth under footings is disturbed, after the line is installed the voids shall be filled up to bottoms of such footings with solid concrete.

## 3.25 TRENCHING

- A. Excavations outside and within building footprint shall generally follow the routes indicated on the drawings. Stockpile topsoil separately for later replacement. Excavations shall be of sufficient depths to provide, unless indicated otherwise on the drawings, a minimum cover (top of pipe) as follows or as noted on drawings.
  - 1. Water piping: 36 inches (900 mm).
  - 2. Sewer lines: 30 inches (750 mm).

- B. Trenches shall be of necessary depth and width for the proper laying of pipe with a minimum of 8 inches (205 mm) on each side of the joint.
  - 1. The sides shall be as nearly vertical as practicable. Unless local regulations are more strict, trenches 4 ft. (1220 mm) and deeper shall have shored sides as required by OSHA trenching regulations.
  - 2. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for each section of pipe on undisturbed soil at every point along its entire length, except for bell holes and for the proper sealing of the pipe joints.
  - 3. No greater length of trench shall be left open, in advance of the completed structure placed in it, than can be completed in that day's operation.
  - 4. Except where rock is encountered, do not excavate below the depths required. Where rock excavation is required, excavate to a depth of at least 6 inches (150 mm) below the trench depth and fill the overdepth with compacted crusher run or bank run stone or sand. Unauthorized overdepths in excavation shall be backfilled with crushed stone, slag or gravel, thoroughly compacted.
  - 5. Whenever wet or otherwise unstable soil is encountered, it shall be removed to the depth and extent directed, and the trench backfilled to the proper grade with crushed stone, slag or gravel.
- C. Should springs be encountered within the work area, or soft soil conditions at the elevations required for load bearing, immediately notify the Architect and do not place any portion of the work on such surfaces until instructions are received.
- D. Furnish and maintain pumps, flumes, gutters, and appurtenances if required to keep the excavations free from water. Water shall be directed to a point remote from building operations, shown on the approved shop drawing.

## 3.26 BACKFILL

- A. Place no backfill until the adjacent construction or the utility to be covered has been inspected, tested, and approved.
- B. Installing underground warning tape: Install in backfill above exterior buried lines not encased in concrete. Select legend and color appropriate for type of line. Install metallic lined tape for non-metallic lines. Install approximately 12 inches (305 mm) below grade.
- C. Plumbing systems backfill:
  - 1. Backfill and compact in six-inch (150-mm) layers up to spring line of the pipe. The installations shall then be inspected and tested.
  - 2. Following inspection, backfill in six-inch (150-mm) layers, each compacted, until the pipe has a cover of not less than one foot (305 mm). Place the remainder of the backfill material in the trench in eight-inch (200-mm) compacted layers.
  - 3. Excavations improperly backfilled shall be reopened, then refilled and compacted to the required grade and compaction, and smoothed off.
  - 4. Open trenches across roadways or other areas to be paved shall be backfilled as specified above, except that the entire depth of trench shall be backfilled in six-inch (150-mm) layers, and each layer shall be mechanically compacted.

- 5. Completed work shall have uniform graded surface, in accordance with the surface and grade indicated on the drawings.
- D. Structure backfill: Do not backfill against structures with cement mortar joints until the mortar is at least twelve hours old.

## 3.27 COMPACTION

- A. Test in accordance with the requirements of ASTM D 1557.
- B. Compact under slabs, roads, and sidewalks to a 95 percent density.
- C. Compact unpaved areas to a 90 percent density.
- D. Backfill and compact trench in unpaved areas to within 4 inches (102 mm) of existing grade. Furnish and install compacted select topsoil for the final layer to finish even with existing grade. Remove surplus earth and rake unpaved areas for final planting.
- E. Take particular care in compaction of earth under joints of HVAC piping.

### SECTION 22 05 02 - SLEEVES AND PLATES FOR PLUMBING PIPING

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Sleeves and escutcheon plates for piping systems.
- B. Mechanical seals for piping penetrations.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Sleeves, plates, sealants, and mechanical penetration seals.
- C. LEED Submittals: For sealants applied within the building waterproofing envelope, documentation including printed statement of VOC content in g/L

#### PART 2 - PRODUCTS

- 2.10 SLEEVES, PLATES, AND ACCESSORIES
  - A. Steel sleeves: Schedule 40 black steel pipe, ASTM A 53.
  - B. Copper sleeves: Type L, ASTM B 88 hard drawn.
  - C. Cast-iron sleeves: Extra heavy, equal to product of U.S. Pipe Co. with mechanical seals.
  - D. Plastic sleeves: Schedule 40 PVC, ASTM D 1785.
  - E. Sealing compound in walls and floors: Equal to the following:
    - 1. Bare and insulated pipes carrying fluids 150 degrees F (65 degrees C) and below: Sika Corporation "Sikaflex la."
    - 2. Bare and insulated piping carrying fluids 151 degrees F (66 degrees C) and above: Dow Corning Corporation "790 Silicone."
  - F. Floor, wall and ceiling plates: Stamped or cast brass, hinged type as pipe size requires. Plates shall have chrome finish.
  - G. Mechanical penetration seals: Equal to PSI "Link-Seal Modular Seals" or Calpico Sealing Link "LINX". Seals shall be modular mechanical type, consisting of interlocking synthetic links shaped to continuously fill the annular space between the pipe and wall opening. Bolt and nut fasteners for the seals shall be stainless steel for units used in penetrations below grade.

## PART 3 - EXECUTION

### 3.20 INSTALLING SLEEVES

- A. Install sleeves for piping, or piping with insulation continuous through sleeve, passing through walls, partitions, beams, or slabs.
  - 1. Exception: Where steel pipe penetrates a steel beam that is not part of a fire- or smokerated assembly, no sleeve is required.
- B. Do not cut, drill, or burn structural steel for installation of piping without specific instructions from the Architect.
- C. Locations in nonfire-rated construction:
  - 1. Install steel sleeves for penetrations of steel, iron, and insulated piping.
  - 2. Install copper sleeves for penetrations of uninsulated copper tubing and piping.
  - 3. Install plastic sleeves for penetrations of plastic piping. Plastic piping and sleeves are not permitted in ceiling spaces used as HVAC system plenums, nor in shafts used for building HVAC air distribution.
- D. Locations in floors and fire-rated construction: Sleeves used in piping penetrations through firerated construction shall be an acceptable component of the through-penetration firestop assembly as specified in Section 22 05 07, Firestopping for Plumbing Work.
  - 1. Where firestop assembly is UL listed, sleeve material shall be as directed in the listing.
  - 2. Where other specified approval and acceptance is required, sleeve shall be as described in the approved assembly.
- E. Install sleeves through walls and partitions flush with finished surfaces.
- F. Sleeves through floors shall extend 0.375 inch (10 mm) above top of finished floor and be finished neat and level. Sleeves through mechanical or equipment room floors shall extend one inch (25 mm) above finished floor. Provide projecting sleeves with anchor clips to prevent them from being loosened and knocked down in the floor construction.
- G. Sleeves for penetrations in kitchen and food service areas shall finish 0.375 inch (10 mm) above floor or flush with wall surfaces and be neatly pointed up to fit snugly against floor or wall materials. Seal space between pipe and sleeve with waterproof sealant or fire barrier as required, and finish even with wall or floor with a light pouring of molten lead.
- H. Sleeves for insulated piping with vapor barrier shall be large enough to pass piping and insulation.
- I. Seal spaces between sleeves and pipe, or pipe insulation, in nonrated walls, with mineral wool.
- J. Penetrations in exterior masonry or concrete walls and foundations:
  - 1. Sleeves: Cast iron, or in cast concrete may be core drilled.
  - 2. Above and below grade: Mechanical penetration seal, at outside face of wall.

## 3.25 INSTALLING PLATES

- A. Piping passing through interior walls, partitions, floors, and ceilings in exposed locations shall be fitted with wall, floor, and ceiling plates of size and depth to conceal sleeves. Secure plates firmly in place with set screws.
- B. Do not install floor or wall plates on pipes in the kitchen and food service areas.

#### SECTION 22 05 03 - ACCESS DOORS FOR PLUMBING PIPING AND EQUIPMENT

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Access doors for concealed plumbing specialties requiring maintenance or manual operation.
- 1.14 RELATED SECTIONS
  - A. Valves: Section 22 05 23.
  - B. Specialties: Section 22 11 19.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Each type of access door.
- 1.80 WARRANTY
  - A. For floor access door, in addition to general project warranty, provide manufacturer's standard five-year warranty against defects in material or workmanship.

#### PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Wall and ceiling access doors:
  - 1. Acudor Products Inc.
  - 2. Cesco Products Company
  - 3. Karp Associates, Inc.
  - 4. Milcor, Inc.
  - 5. Zurn Industries
- B. Floor access doors:
  - 1. Acudor Products, Inc.
  - 2. Bilco Company
  - 3. Milcor

#### 2.21 WALL AND CEILING ACCESS DOORS

- A. Doors: Provide Milcor model listed, or similar type and equal quality by another acceptable manufacturer.
- B. Types:

- 1. Fire-rated where occurring in fire-rated walls.
- 2. Style M stainless steel where occurring in masonry or ceramic tile surfaces.
- 3. Style DW where occurring in drywall construction.
- C. Sizes: As required for access to the particular device, but no less than 16 by 16 inches (405 by 405 mm), unless noted otherwise on drawings.
- D. Finish: Brushed stainless steel.

#### 2.22 FLOOR ACCESS DOORS

- A. Equal to Acudor Products, Inc., single-leaf angle frame door designed for installation in concrete slab.
- B. Nominal door size (WxH): 24 by 24 inches (610 by 610 mm).
- C. Material: Aluminum door and frame; stainless steel hinges and hardware.
- D. Door: 1/4-inch smooth aluminum plate reinforced for live load of 150 pounds/sq. ft. Extruded edging is welded to door panel, providing a 1/8-inch recess to accept carpet tiles or vinyl tiles.
- E. Frame: Angle frame fabricated from aluminum extrusion with integral 1-inch anchor flange on three sides and welded anchor straps on the hinge side.
- F. Hinge: Extruded aluminum hinges are welded to inside of door panel and pivot on stainless steel pins.
- G. Device: Door panel to open to 90 degrees, locking door in open position, and allowing for easy control when closing door panel.
- H. Latch: Stainless steel slamlock with a fixed inside handle, removable outside handle, and removable threaded plug.
- I. Finish: Mill finish with bituminous coating applied to exterior frame.

## 2.70 LABELS

A. Minimum lettering size: 0.5 inch (13 mm) high.

## PART 3 - EXECUTION

#### 3.20 INSTALLATION

- A. Provide access doors in walls and inaccessible ceilings for plumbing devices, valves, and other concealed specialties that require manual operation or maintenance.
- B. Access door locations and sizes shown on drawings.

C. Coordinate installation of floor access door with concrete work specified in Division 03.

## **SECTION 22 05 05 - EQUIPMENT CONNECTIONS FOR PLUMBING**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Equipment connections for plumbing, to food service and Owner-provided equipment.
- 1.14 RELATED SECTIONS
  - A. Piping connections: Section 22 01 01.
  - B. Rough-in dimensions and lists of accessories: Suppliers of equipment specified in other divisions.
  - C. Schedule of roughing-in and connections: Drawings.
  - D. Wiring connections: Section 26 05 21.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Any product required for connection but not specified in other sections.

### 1.40 QUALITY ASSURANCE

- A. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
  - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
  - 2. NSF/ANSI 61.
- B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

## PART 2 - PRODUCTS

## 2.10 MATERIALS

- A. Traps NPS 2 (DN 50) and larger shall be galvanized cast iron P traps. NPS 1.5 (DN 40) P traps shall have cleanout plug and chrome finish. Those concealed within base cabinets of equipment may be rough brass.
- B. Solids interceptor (sediment trap): Zurn Series Z-1180, as specified in Section 22 42 00.

- C. Shutoff valves for plumbing fixtures:
  - 1. Rough brass, equal to Nibco Inc. No. 726-LF.
  - 2. Exposed: Chrome-plated, equal to Chicago Faucet Co. No. 45-LKABCP.

## PART 3 - EXECUTION

### 3.20 INSTALLATION

- A. Rough in and connect to plumbing equipment. Install valves, balancing cocks, thermometer wells, gage tappings, control valves, air vents, traps, strainers, drains, and appurtenances as shown on diagrams on drawings and specified under other sections of the specifications.
- B. Rough in and connect to food service, owner-supplied, sinks, and other equipment requiring water, drain, or other piping connections, that is specified, furnished and set in place in other divisions or listed in the Schedule of Roughing-in and Connections on the drawings.
  - 1. Faucets, drains, trim, and necessary vacuum breakers, solenoid valves, flow control fittings supplied with the sinks and equipment are specified herein or under other divisions.
  - 2. Rough-in dimensions and list of accessories shall be provided by the equipment supplier.
- C. Install the faucets, drains, trim, and accessories and provide necessary supply stops, P traps, and shock absorbers with necessary fittings to make a complete and satisfactory installation of every item of equipment.
- D. Provide water supply shutoff valves, and unions at each item of equipment. Where exposed adjacent to chromium-finished piping, the water shutoff valves shall be chromium plated.

#### SECTION 22 05 06 - CURBS AND FLASHINGS FOR PLUMBING PIPING AND EQUIPMENT

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Rooftop pipe support assemblies, pipe boot assemblies, and flashing devices for plumbing items penetrating roof.
- 1.14 RELATED SECTIONS
  - A. Rough carpentry: Division 06.
  - B. Piping: Section 22 13 16.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 22 01 01.
  - B. Shop drawings: Rooftop pipe supports assemblies, pipe boots, flashing assemblies and devices showing compatibility with roof membrane, insulation, and slope, and configuration for the supported piping and piping penetrations of roof.
  - C. Product data: Each type of manufactured unit, accessory, and accessory material.

#### PART 2 - PRODUCTS

#### 2.20 PENETRATIONS OF SINGLE PIPE OR VENT

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by another manufacturer.
- B. Boot for water piping through flat roof: Equal to Elmdor/Stoneman. 1100-4, 4-lb (1.8 kg per 0.09 sq. m) lead flashing assembly, 8-inch (205-mm) skirt; top counterflashing fitting and waterproofing compound.
- 2.72 ROOFTOP PIPE SUPPORT SYSTEM
  - A. Equal to Caddy "Pyramid ST" Series PSF UV-stabilized, polyethylene, polypropylene, and hotdip galvanized strut-based support, 10 inches minimum strut length by 4.8 inches in height.
  - B. Provide manufacturer's standard pipe clamps and accessories designed for strut system, as required for size, material, and configuration of air-conditioning condensate lines across roof.

## PART 3 - EXECUTION

### 3.20 INSTALLATION, GENERAL

- A. Plumbing vent shall extend 8 inches (205 mm) above finished roof. Clamp devices shall be tightly sealed to vent. Space between vent hub and pipe shall be lightly caulked with lead to provide for movement in piping.
- B. Flashing of roofing felts into clamping devices of roof drains and sleeves through roof, and flashing and counterflashing of pipe curb assemblies and of roof rails and curbs shall be as specified under Division 07.

## 3.22 INSTALLING ROOFTOP PIPE SUPPORT SYSTEM

- A. Where air-conditioning condensate lines cross roof from equipment to drain, support on rooftop support system.
- B. Use clamps and fasteners compatible with piping.
- C. Follow manufacturer's instructions.

## SECTION 22 05 07 - FIRESTOPPING FOR PLUMBING WORK

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Through-penetration firestopping in fire-rated construction.
- B. Through-penetration smoke-stopping in smoke partitions.
- 1.14 RELATED SECTIONS
  - A. Sections specifying requirements for LEED rating are specified in Division 01.
  - B. Sleeves and plates: Section 22 05 02.

## 1.20 REFERENCES

- A. Underwriters Laboratories
  - 1. UL Fire Resistance Directory
  - 2. UL 1479: Through Penetration Firestops.
- B. American Society for Testing and Materials Standards:
  - 1. ASTM E 814: Standard Test Method for Fire Tests of Through-Penetration Firestops.

#### 1.21 DEFINITIONS

- A. Assembly: Particular arrangement of materials specific to given type of construction described in referenced documents.
- B. Barriers: Time-rated fire walls, smoke barrier walls, time-rated ceiling/floor assemblies and structural floors.
- C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.
- D. Penetration: Opening or foreign materials passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.
- E. Sleeve: Metal fabrication or pipe section extending through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.
- F. System: Specific products and applications, classified and numbered by the rating agency to close specific barrier penetrations.

### 1.25 SYSTEM DESCRIPTION

- A. Design requirements
  - 1. Fire-rated construction: Maintain barrier and structural floor fire resistant ratings including resistance to cold smoke at all penetrations.
  - 2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. LEED submittal:
  - 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For penetration firestopping, including printed statement of VOC content and chemical components.
- C. Product data: Manufacturer's specifications and technical data including the following:
  - 1. Detailed specification of construction and fabrication.
  - 2. Manufacturer's installation instructions.
- D. Shop drawings: Submit firestop assemblies and devices for all openings and through penetrations in fire-rated construction. Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, plus the following specific requirements.
  - 1. Details of each proposed assembly identifying intended products and applicable rating agency classification.
  - 2. Manufacturer or manufacturer's representative shall provide qualified engineering judgments and drawings relating to conditions where rated assemblies do not exist.
- E. Quality control submittals: Statement of qualifications.
- F. Applicators' qualifications statement: List past projects indicating required experience.
- G. Certifications: Letters or forms showing acceptance by local authorities for systems without acceptance by a rating agency.

#### 1.40 QUALITY ASSURANCE

- A. Products and assemblies shall be tested and labeled by an independent, nationally recognized testing and labeling authority.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installer's qualification: Firm experienced in installation or application of systems similar in complexity to those required for this project, plus the following:

- 1. Acceptable to or licensed by manufacturer, state, or local authority where applicable.
- 2. At least 2 years' experience with systems.
- 3. Successfully completed at least 5 projects of comparable scale, using these systems.
- D. Local and state regulatory requirements: Obtain acceptance for proposed assemblies not conforming to specific rating agency classifications or rated assemblies.
- E. Materials shall have been tested to provide fire rating at least equal to that of the construction in which they are to be installed.
- F. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.

## 1.50 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
  - 1. Deliver products in original unopened packaging with legible manufacturer's identification.
  - 2. Coordinate delivery with scheduled installation date, allow minimum storage at site.
- B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

## 1.60 PROJECT CONDITIONS

- A. Verify existing conditions:
  - 1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
  - 2. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.
- B. Environmental requirements:
  - 1. Furnish adequate ventilation if using solvent.
  - 2. Furnish forced-air ventilation during installation if required by manufacturer.
  - 3. Keep flammable materials away from sparks or flame.
  - 4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
  - 5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

## 1.80 WARRANTY

A. General project warranty and correction period, as required in general conditions and Division 01, requires repair or replacement of materials or systems which fail in joint adhesion, co-adhesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, or general durability or appear to deteriorate in any other manner not clearly
specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated.

### PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers and products: Those listed in the UL Fire Resistance Directory for the UL System involved, or rated for the application by Warnock Hersey or by another acceptable rating agency.

#### 2.20 THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

- A. Provide systems or devices listed and labeled by a rating agency, and conforming to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance. The system shall be symmetrical for wall applications. Systems or devices shall be asbestos-free.
  - 1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system, or by the use of a separate product included as a part of the rated system or device, and designed to perform this function.

## 2.22 SMOKE-STOPPING AT SMOKE PARTITIONS

A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

### 2.70 ACCESSORIES

A. Fill, void or cavity materials and forming materials: Classified for firestopping use, or included in a rated firestopping assembly, by a rating agency.

### PART 3 - EXECUTION

### 3.02 EXAMINATION

- A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
  - 1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.
  - 2. Do not proceed until unsatisfactory conditions have been corrected.

### 3.05 PREPARATION

A. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

### 3.20 INSTALLATION

- A. Provide firestop devices or assemblies for every opening and penetration in floors or fire-rated construction.
- B. Install penetration seal materials in accordance with printed instructions of the rating agency and in accordance with manufacturer's instruction.
- C. Ensure an effective smoke barrier in each sealed penetration. Install smoke stopping as specified for firestopping.
- D. Protect materials from damage on surfaces subject to traffic.
- E. Where large openings are created in walls or floors to permit installation of pipes or other items, close unused portions of opening with firestopping material tested for the application.
- 3.60 FIELD QUALITY CONTROL
  - A. Examine penetration seals to ensure proper installation before concealing or enclosing them.
  - B. Keep areas of work accessible until inspection and acceptance by applicable authorities.
  - C. Before substantial completion, patch and repair firestopping cut or penetrated by other construction work.
- 3.70 ADJUSTING AND CLEANING
  - A. Clean up spills of liquid components.
  - B. Neatly cut and trim materials as required.
  - C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

### SECTION 22 05 09 - PLUMBING EXPANSION SYSTEM

### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Precharged bladder-type expansion tank for potable water system.
- B. High-capacity automatic air vent.
- 1.14 RELATED SECTIONS
  - A. Piping: Section 22 11 16.
  - B. Supports: Section 22 05 29.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 22 01 01.
  - B. Product data: Expansion tank and all accessories.
- 1.40 QUALITY ASSURANCE
  - A. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
    - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
    - 2. NSF/ANSI 61.
  - B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
  - C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

### PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified and scheduled products or comparable products by one of the following:
  - 1. Expansion tanks:
    - a. Taco
    - b. Amtrol, Inc.
    - c. Armstrong Pumps, Inc

- d. Bell and Gossett Domestic Pump Div of ITT
- e. Wessels

### 2.32 EXPANSION TANK FOR POTABLE WATER

- A. Pressurized bladder type tank, Taco PAX model number scheduled on the drawings, containing impermeable bladder which separates the air cushion from the system water. Operating temperature: 240 degrees F. maximum. Precharged to manufacturer's standard pressure.
- B. Shell: Welded steel, constructed, tested and stamped in accordance with ASME BPV for Unfired Pressure Vessels for a working pressure of 125 psi. Lined with protective coating.
- C. Bladder: Butyl rubber, flexible but not stretchable under working conditions, removable for inspection.
- D. FDA approval: Wetted components FDA-approved materials.
- E. Size and capacity: Shown on the drawings.
- F. Supports: For horizontal or vertical support on concrete equipment foundation, as diagramed on the drawings.
- 2.36 HIGH CAPACITY AUTOMATIC AIR VENT
  - A. As specified in Section 22 11 19, Domestic Water Piping Specialties. Float type vent, size and capacity recommended by manufacturer for tank and system.

### PART 3 - EXECUTION

### 3.21 INSTALLING EXPANSION TANKS

- A. Follow manufacturer's instructions and recommendations.
- B. Install piping and vents as diagramed on drawings.
- C. Install supports as shown on drawings.

### 3.81 OPERATING INSTRUCTIONS

A. As specified in Section 22 05 00, provide operating instructions.

### SECTION 22 05 13 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

A. Unless otherwise specified in a particular section or required for a particular application, motors shall conform to the following requirements, whether factory-installed or field-installed.

#### 1.14 RELATED WORK SPECIFIED ELSEWHERE

A. Pumps: Section 22 11 23.

#### 1.20 REFERENCES

- A. NEMA MG 1: Motors and Generators.
- B. NEMA MG 11: Energy Management Guide for Selection and Use of Single-Phase Motors.
- C. UL 508: Industrial Control Equipment.

#### 1.21 DEFINITIONS

- A. Energy efficient motor: Motor meeting the nominal and minimum efficiency levels listed for its horsepower and speed in Table 12-10 of NEMA MG 1.
- B. Nominal efficiency: Efficiency as defined in Table 12-8, Efficiency Levels, in NEMA MG 1, and identified on the motor nameplate.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Wiring diagrams required for the proper installation of plumbing equipment.
- C. Submit product data which verifies compliance with ASHRAE 90.1 or provide certified performance ratings by a qualified independent testing agency.

#### 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 22 05 00, Common Work Results for Plumbing.
- B. Plumbing equipment shall meet the energy performance requirements of ASHRAE 90.1.

### 1.44 REGULATORY REQUIREMENTS

A. Motors shall conform to the requirements of NEMA MG1 and applicable portions of the National Electric Code (NEC, NFPA 70).

### PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

#### A. Motors:

- 1. Baldor Electric Co.
- 2. Marathon
- 3. Rockwell
- 4. Siemens
- 5. A.O. Smith
- 6. Toshiba International

#### 2.20 BASIC MOTOR REQUIREMENTS

- A. Capacity: Each motor shall have sufficient capacity and torque to start, accelerate, and operate the machine it drives without exceeding the motor nameplate rating at the speed specified, or at any speed and load which may be obtained by the drive actually furnished.
- B. Starting: Each automatically controlled motor shall be capable of starting as frequently as the control sequence may demand. Motors not automatically controlled shall be capable of making no fewer than 4 starts per hour.
- C. Ratings: Motors shall be rated for continuous duty at 100 percent of rated capacity, and temperature rise shall be based on ambient temperature of 40 degrees C.
- D. Phase: Unless otherwise indicated, motors one-half horsepower and larger shall be polyphase and motors smaller than one-half horsepower shall be single-phase motors.
- E. Motor construction: Motors for pumps, unless specified otherwise in the equipment section, shall be open drip-proof NEMA design B construction.
- F. Efficiency: The term "energy efficient" is defined in the article "Definitions" in Part 1 above.
  - 1. Single-phase motors, alternating-current fractional horsepower, rated 1/20 to 1 horsepower, 250 volts or less: NEMA MG 11, types and efficiencies selected for their applications.

### 2.21 SINGLE-PHASE MOTORS

- A. Permanent split-capacitor or split-phase type.
- B. Bearings: Sealed, prelubricated ball-bearing type.

### PART 3 - EXECUTION

#### 3.81 OPERATING INSTRUCTIONS

A. As specified in Section 22 05 00, provide operating instructions.

### SECTION 22 05 19 - METERS AND GAGES FOR PLUMBING PIPING

### PART 1 - GENERAL

### 1.11 SECTION INCLUDES

- A. Meters and gages for plumbing systems.
- 1.14 RELATED SECTIONS
  - A. Pipe installation and testing: Section 22 05 00.
  - B. Valve tags and charts: Sections 22 05 00 and 22 05 23.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Shop drawings: Meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.
- C. Product data: For each type of meter, gage, device, and fitting specified.
  - 1. Scale range.
  - 2. Ratings.

### 1.40 QUALITY ASSURANCE

- A Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
  - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
  - 2. NSF/ANSI 61.
- B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

### PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Meters and gages:
  - 1. AMETEK; U.S. Gage
  - 2. Ashcroft; Dresser Instrument
  - 3. Miljoco Corporation

- 4. Taco, Inc.
- 5. H.O. Trerice Co.
- 6. Weiss Instruments
- 7. Weksler; Dresser Instrument

#### 2.11 THERMOMETERS

- A. General: Industrial, adjustable angle type, accurate to within plus or minus one percent of range span, baked enamel finish, blue reading organic liquid tube, glass or clear acrylic plastic window, dust and moisture tight.
  - 1. Scale size: 9 inches (230 mm).
  - 2. Graduation: To the scale shown on the drawings or of a scale so that the normal working temperature of the system is near the mid-point of the scale.
  - 3. Case: Cast aluminum.
- B. Pipe-mounted thermometers: Brass well, separable sockets.
  - 1. Where mounted in insulated piping, thermometers shall have six-inch (150-mm) stem length and sockets with 2.5-inch (64-mm) lagging extension necks. Where mounted in uninsulated piping, they shall have 3.5-inch (89-mm) stem lengths and sockets without lagging extension.
  - 2. Where thermometer wells only are required, provide separable socket with 2.5-inch (64-mm) lagging extension, fitted with attached chain and cap.

#### 2.12 PRESSURE GAGES

- A. Pressure gages shall be accurate to within plus or minus one percent of range span, silver brazed bronze bourdon-tube system, bronze movement, aluminum dial with white background, black graduations and numerals and adjustable pointer, bottom connected.
  - 1. Dial diameter: 6 inches (150 mm).
  - 2. Those installed adjacent to pumps or in pulsating locations shall be provided with pulsating dampeners or snubbers.
  - 3. Case: Cast aluminum or glass filled nylon.
- B. Graduation: To the scale shown on drawings or so pointer is nearly straight up at system normal working pressure.
- C. Gages shall be straight pressure type, except gages on suction side of pumps and inlet side of suction strainers shall be compound type.
- D. Gage cock (pressure gage isolation valve):
  - 1. Needle valve: Brass bar stock needle valve, equal to Weksler No. BBV4.
  - 2. Ball valve: Bronze, three-piece body, full port, with Type 316 stainless steel trim, 150 psi (1034 kPa) saturated steam, 600 psi (4137 kPa) non-shock cold water, oil, or gas, equal to Nibco 595 or 595-T-66-LF.

### 2.18 MECHANICAL SYSTEMS MAKEUP/FILL WATER METER

- A. Equal to Niagara Meters positive-displacement liquid meter for use in water system up to 100 degrees F (38 degrees C) or condensate system up to 225 degrees F (107 degrees C), size and capacity shown on drawings.
  - 1. Blind type transmitter reading in gallons.
- B. Materials: Epoxy-coated cast-iron case, bronze or stainless steel measuring chamber and brass internal gear train, Ryton disc, Ryton or carbon ball.
- C. Drive: Mechanical shaft from meter to register through O-ring seal. Use vertical extension on systems greater than 250 degrees F (121 degrees C).
- D. Impulse transmitter: Model R-11, electro-mechanical, totalizer value in gallons, magnetically activated reed switch with maximum rating of 3 Watts DC, 0.5 Amp, 250 VDC, SPDT to be used with building automation system.

### PART 3 - EXECUTION

#### 3.21 INSTALLING THERMOMETERS

- A. Pipe line thermometers shall be installed as indicated on the drawings.
- B. Furnish and deliver to Owner at final inspection, three additional pipe line thermometers as above specified, with 6-inch (152-mm) stem lengths, for use in the thermometer wells. Ranges shall be minus 40 to plus 110 degrees F (minus 40 to 43.3 degrees C); 20 to 120 degrees F (minus 6.7 to 48.9 degrees C), and 50 to 550 degrees F (10 to 287.8 degrees C).

### 3.22 INSTALLING PRESSURE GAGES

- A. Each gage connection shall have a gage cock. Connections to pipe lines shall be 0.5 inch (DN 15), with 0.5 inch (DN 15) by 0.25 inch (DN 8) reducer for valve, the assembly of sufficient length to clear insulation.
- B. Where gage cocks only are called for on drawings, provide the 0.5-inch (DN 15) connections to pipe line with reducer and the gage cock.
- C. Provide one compound and one straight pressure gage of appropriate scale to Owner at final inspection.

#### 3.26 INSTALLING WATER METER

A. Install in accordance with the manufacturer's recommendations.

#### SECTION 22 05 23 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Valves for various piping systems.
  - B. Chainwheel operators.
- 1.14 RELATED SECTIONS
  - A. Piping installation and testing: Section 22 05 00.
  - B. Piping systems: Sections 22 11 16, 22 13 16, and 22 14 13.
  - C. Automatically operating valves: Section 22 11 19.
  - D. Access doors: Section 22 05 03.
  - E. Automatic water temperature control valve for domestic hot water: Section 22 11 19.
  - F. Ice maker supply box: Section 22 42 00.
  - G. Valves in fire suppression systems: Division 21.

#### 1.20 REFERENCES

- A. ASME B16.10: Face-to-Face and End-to-End Dimensions of Valves.
- B. ASME B16.34: Valves Flanged, Threaded, and Welding End.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 22 01 01.
  - B. Product data: For each type of valve. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.
  - C. Maintenance data: For inclusion in operation and maintenance manual specified in Division 01 and Section 22 01 01. Include manufacturer's instructions for adjusting, servicing, disassembling, and repairing.
  - D. Valve charts: Furnish valve charts typed on 8.5 by 11-inch (216 by 279-mm) bond paper, showing locations of all manual and automatic control valves, and flow meters. Include:
    - 1. Number
    - 2. Location
    - 3. Service
    - 4. Function
    - 5. Area served

E. Valve numbering system shall be approved by the Owner prior to final submittal. Place one copy of approved chart in a plastic envelope and mount on wall where directed. Provide another copy for each of the Operating and Maintenance Manuals.

### 1.40 QUALITY ASSURANCE

- A. Ferrous valves shall conform to ASME B16.10 and B16.34 for dimension and design criteria.
- B. Copper alloy valves (brass and bronze) shall have no more than 15 percent zinc in the alloy.
- C Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
  - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
  - 2. NSF/ANSI 61.
- D. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- E. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

### PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Gate valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:
  - 1. Crane Co.
  - 2. Hammond Valve Co.
  - 3. Lunkenheimer Co.
  - 4. Milwaukee Valve Co.
  - 5. NIBCO
  - 6. Stockham Valve & Fittings
  - 7. Walworth Co.
- B. Ball valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:
  - 1. Apollo Valves
  - 2. Milwaukee Valve Co.
  - 3. NIBCO
  - 4. Stockham Valve & Fittings
  - 5. Victaulic Company of America
  - 6. Walworth Co.
  - 7. Watts Regulator Co.
- C. Check valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:

- 1. Combination Pump and Valve Co.
- 2. Mueller Steam Specialty
- 3. NIBCO
- 4. Victaulic Company of America
- D. Balancing valves for domestic hot water recirculation: Subject to compliance with requirements, provide the specified Bell & Gossett product or equal.
- E. Backwater valves: Subject to compliance with requirements, provide the specified swing check valves, or comparable products by one of the following:
  - 1. Zurn
  - 2. Ames Company, Inc.
  - 3. Jay R. Smith
  - 4. Jenkins Bros., a corporation
  - 5. Josam Manufacturing Co.
- F. Hose connections: Subject to compliance with requirements, provide the specified Zurn or NIBCO valves or comparable products by one of the following:
  - 1. Zurn
  - 2. NIBCO
  - 3. Josam Manufacturing Co.
  - 4. Crane Co.
- 2.20 VALVES
  - A. Gate valves:
    - 1. Valves NPS 6 (DN 150) through NPS 12 (DN 300); 250 psi WWP, outside screw and yoke, resilient wedge, epoxy coated interior and exterior, iron body construction. NIBCO F-607-RW, flanged.
  - B. Ball valves:
    - 1. Valves NPS 0.25 (DN 8) through NPS 2 (DN 50); 600 psi CWP, two-piece silicon bronze alloy body, full port, blowout-proof stem, PTFE seats, stainless-steel ball and stem. Extension handle for use in insulated piping. NIBCO T-685-66-LF or S-685-66-LF or S-FP-600A-LF, threaded or soldered ends.
    - 2. Valve NPS 2.5 (DN 65) through NPS 4 (DN100); 400 psi (27.6 Bar) non-shock cold working pressure, two-piece brass body full port, blowout-proof stem, PTFE seats, forged body and end cap, stainless-steel ball and brass system, NIBCO T-FP-600A-LF or S-FP-600A-LF, threaded or soldered ends.
  - C. Center-guided, spring-loaded silent-action type check valves:
    - 1. Valves NPS 0.375 (DN 10) through NPS 2 (DN 50); 250 psi CWP, bronze body, Teflon disk, stainless-steel stem and spring, NIBCO T-480-Y-LF or S-480-Y-LF, threaded or soldered ends.
  - D. Swing check valves:

- 1. Valves NPS 0.25 (DN 8) through NPS 3 (DN 80); 200 psi CWP, bronze, PTFE seat, renewable seat and disk, Y pattern, horizontal swing, NIBCO T-413-Y-LF or S-413-Y-LF, threaded or soldered ends.
- E. Balancing valves: NPS 3 (DN 80) and smaller: Calibrated balancing valve equal to Bell & Gossett Circuit Setter Plus.
  - 1. Materials: Low-lead brass body (<0.25 percent lead content), stainless-steel ball with carbon filled TFE seat rings.
  - 2. Pressure and temperature ports. Differential pressure readout ports across valve seat area.
  - 3. Ratings (NPT): Entire assembly 400 psi, 250 degrees F (2758 kPa, 121 degrees C).
  - 4. Flow element: Variable orifice flow meter.
  - 5. Adjustable pre-set balancing points with memory stop and isolation valve.
  - 6. Drain port: 1/4-inch NPT.
  - 7. Bi-directional design.
  - 8. Bellows type meter gage kit with case, provide one for use on the entire project.
- F. Backwater valves:
  - 1. Valves NPS 2 (DN 50) and larger installed below slab-on-grade: Zurn Z-1095, flapper type with cast-iron floor level cleanout and plug.

### 2.21 HOSE CONNECTIONS

- A. Hose connections, general: Every hose connection shall be provided with an ASSE 1052 backflow prevention device with two check valves, field testable, with outlet check valve capable of withstanding backpressure up to 125 psi (862 kPa).
  - 1. Where backflow prevention device is not integral with the hydrant or bibb, but added on, provide a hose connection backflow preventer equal to Woodford 37HD2, for freezing and non-freezing conditions, brass and stainless steel.
    - a. Bushing: Threaded, designed to prevent the attachment of a hose if the check valve device should be removed, with O ring.
    - b. Stop collar and stop screw: Stainless-steel, preventing unauthorized removal of the check valve device.
- B. Wall hydrants: Connection suitable for NPS 3/4 (DN 20) hose.
  - 1. Exterior walls: Non-freeze type with integral backflow preventer and automatic drain. Casing and interior parts bronze; box and hinged cover polished nickel bronze, cover marked "water." Key that unlocks cover operates hydrant. Equal to Zurn Z-1300, length as required for wall thickness.
  - 2. Interior walls, hot and cold water: Where connection to hot and cold water is shown on drawings, provide non-freeze type, flush design with locking cover; interior parts bronze; face and hinged cover polished nickel bronze. Equal to Zurn 1325.
- C. Hose bibbs: Compression type, with bronze body, stem, and bonnet, chrome-finished where exposed and rough brass where concealed, Class 125 WOG non-shock. Connection suitable for NPS 0.75 (DN 20) hose. Include integral vacuum breaker (if valve is disassembled, hose cannot be attached).

- Mounted on wall with concealed connection: Angle sillcock, equal to NIBCO Figure No.
  63. Provide with removable handle where bibb is accessible to the general public.
- 2. Connecting to exposed pipe: Drain valve, equal to NIBCO Figure No. 74.

### 2.70 CHAINWHEEL OPERATORS

- A. Manufacturers:
  - 1. Babbitt Steam Specialty Co.
  - 2. Roto Hammer Industries, Inc.
- B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
  - 1. Sprocket rim with chain guides: Ductile iron or cast iron, of type and size required for valve. Include zinc coating.
  - 2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
  - 3. Chain: Hot-dip, galvanized steel of size required to fit sprocket rim.
- C. Chain storage canisters: Non-corrosive canisters for storage of overhead chains, allow for chain loop release in a single downward movement.
  - 1. Canisters: Plastic, safety yellow or orange color, with perforated bottom for drainage and integral release handle, quick-release hooking mechanism and retention lanyard.
  - 2. Attach to each overhead chain loop with 6 feet minimum clearance below canister.
  - 3. Equal to Roto Hammer, Model CĤAW "Chain Away."

### 2.71 VALVE ACCESSORIES

- A. Service box for backwater valve: Fiberglass-reinforced polymer concrete, modular stacking units equal to Quazite "Composolite" PC style, manufacturer's standard gray, enclosures and cover rated to support no less than 8,000 lbs. over a 10 by 10-foot area.
  - 1. Size: No less than 17 by 30 inches (432 by 762 mm), depths and number of stacked units required for valve location.
  - 2. Cover: Locking, with two tamperproof stainless-steel bolts.
    - a. Nonskid surface.
    - b. Impressed logo: BWV.
    - c. Pull slot: 1 by 4 inches (25 by 102 mm).
  - 3. Base: Open (no base).
  - 4. Stone filter material: Uniform gradation, AASHTO M 43 size 67 or 7.

## PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Install valves to be readily accessible for operation and maintenance, and with ample clearance for turning handles or operators.
  - B. For valves in inaccessible locations, provide access doors as specified in a related section.
  - C. Identify valves as specified in Section 22 05 00, Common Work Results for Plumbing.

- 1. Provide tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.
- 2. Provide ceiling identification tags where valves are above an accessible suspended ceiling. Number shall correspond to tag number.
- D. Install chainwheel operators on valves NPS 4 (DN 100) and larger and more than 7 feet (2150 mm) above floor. Extend chains to 6 feet (1850 mm) above finished floor elevation.

#### 3.21 INSTALLING SHUTOFF AND BALANCING VALVES

- A. Install shutoff and balancing valves where indicated.
- B. Shutoff valves for water piping systems shall be as follows:
  - 1. Sizes NPS 4 (DN 100) and smaller: Ball valves.
  - 2. Sizes NPS 6 (DN 150) and larger: Gate valves.
- C. Balancing valves: Locate valve to provide 5 pipe diameters straight inlet and 2 pipe diameters straight outlet.
- 3.22 INSTALLING CHECK VALVES
  - A. Provide center-guided, spring-loaded silent-action type check valves in pumped lines, lines subject to pump pressure, and vertical lines.
  - B. Provide swing-type check valves in gravity lines or horizontal domestic water lines. Provide for backwater valves NPS 1.5 (DN 40) and smaller.
- 3.25 INSTALLING BACKWATER VALVES
  - A. Provide backwater valves in plumbing drainage piping where indicated.
  - B. Service box: Where shown on drawings, install service box with bottom unit resting on stone filter material no less than two inches deep.
    - 1. Follow box manufacturer's instructions, including installation of deep unit at bottom of stacked units.
- 3.26 INSTALLING HOSE CONNECTIONS
  - A. Drain valves: Provide interior hose bibbs, NPS 0.75 (DN 20) or size indicated on the drawings, at every low point of a water system, and where indicated.
  - B. Provide wall hydrants where indicated. In finished areas, locate units so that domestic water connection is concealed inside adjoining partition or furred space.

### SECTION 22 05 29 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Supports for piping systems and equipment.
  - B. Equipment foundations.
  - C. Pipe guides and anchors.
  - D. Accessories.
- 1.14 RELATED SECTIONS
  - A. Vibration control supports: Section 22 05 48.

#### 1.20 REFERENCES

- A. ASME B31.9: Building Services Piping.
- B. MSS SP-58: Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation.

#### 1.21 DEFINITIONS

- A. Definitions are from MSS SP-58, "Classification of Piping Systems."
- B. Hot Systems: Maximum operating (service) temperatures 120 degrees F (49 degrees C) and above.
- C. Ambient Systems: Maximum operating temperatures 60 to 119 degrees F (16 to 48 degrees C).
- D. Cold Systems: Maximum operating temperatures 59 degrees F (15 degrees C) and below.

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Provide manufacturer's literature showing compliance with specifications for each type of hanger, manufactured support, guide, and anchor, including fasteners and accessory materials.
  - 1. For supports and anchors used as components of fire protections systems, include certification of listing and label as required in "Quality Assurance" below.

#### 1.40 QUALITY ASSURANCE

A. Hangers, supports, guides, and anchors shall comply with the requirements of:

- 1. MSS SP-58.
- 2. ASME B31.9.
- B. Hangers and supports used as components of fire protection systems shall:
  - 1. Comply with NFPA 13.
  - 2. Be listed and labeled by a nationally recognized testing laboratory (NRTL) according to 29 CFR 1910.7

### PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Hangers
  - 1. Anvil International
  - 2. Carpenter and Paterson, Inc.
  - 3. PHD Manufacturing, Inc.
  - 4. National Pipe Hanger Corporation
- B. Support systems
  - 1. Anvil International
  - 2. Unistrut
  - 3. PHD Manufacturing, Inc.
- C. Thermal hanger shields
  - 1. Carpenter and Patterson, Inc.
  - 2. Pipe Shields, Inc.
  - 3. Rilco Manufacturing Co., Inc.
- D. Pipe guides
  - 1. Adsco
  - 2. Carpenter and Paterson, Inc.
  - 3. Metraflex Company
- E. Anchors
  - 1. Carpenter and Paterson, Inc.
  - 2. Metraflex Company
- 2.10 CONCRETE
  - A. Concrete shall be no less than 3000-lb (25,000 kPa) strength.
  - B. Reinforcement: 6 by 6 inch (150 by 150 mm) welded steel wire fabric, ASTM A 185.
- 2.11 GROUT

- A. Non-shrink grout: Premixed, consisting of non-metallic aggregate, cement, and water-reducing and plasticizing agents; capable of developing minimum compressive strength of 7,000 psi (48,000 kPa) in 28 days.
  - 1. Sonneborn-Rexnord "Sonogrout"
  - 2. L&M Construction Chemical Company "Crystex"
  - 3. US Grout Corporation "Five-Star Grout"

### 2.20 HANGERS AND SUPPORTS

- A. Types are identified by MSS type numbers in the article "Installing Pipe Hangers and Supports" below.
- B. Materials for hangers and clamps:
  - 1. For copper pipe: Copper plated.
  - 2. For steel, insulated, and cast-iron pipe: Galvanized in crawl spaces, tunnels, or wet areas; galvanized or factory-painted in other areas.
- C. Insulating-insert materials and protection shields:
  - 1. Insulation-insert material for cold piping: ASTM C 552, Type II cellular glass with 100psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862kPa) minimum compressive strength and vapor barrier. Insert thickness shall match adjacent piping insulation thickness.
  - Insulation-insert material for hot piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa); ASTM C 552, Type II cellular glass with 100-psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength. Insert thickness shall match adjacent piping insulation thickness.
  - 3. Insert and shield shall cover entire circumference of pipe.
  - 4. Insert length: Extend 2 inches (50 mm) beyond shield.
- D. Pipe covering protection saddle: Steel, meeting requirements of MSS SP-58 Type 39, with insulating material located in the space between saddle and pipe.
- E. Hanger rod nuts and washers shall be zinc-plated. Hanger rods shall be solid steel, all threaded, and zinc-plated.
- F. Channel: Slotted cold-rolled steel, equal to Grinnell PS 150 S, 12 gage with 0.406- by 3-inch (10 by 76-mm) slots on 4-inch (102-mm) centers.
- G. Wall- and floor-mounted supports: Structural support system equal to Grinnell "Power Strut."
- H. Structural shapes: ASTM A 36.
- I. Steel pipe: ASTM A 53, standard weight.
- J. Threaded rod: MSS SP-58.

### 2.22 FASTENERS

- A. Fasteners to concrete: Self-drilling type expansion shields or machine bolt drop-in anchors for drilled holes, equal to ITT Phillips Anchors "Red Head." Fasteners to ceilings shall be vibration and shock resistant. Load applied to fasteners shall not exceed 25 percent of manufacturer's stated load capacity in 3500 psi (24,000 kPa) concrete.
- B. Fasteners to drywall or cavity wall construction: Equal to ITT Phillips Anchors "Red Head" toggle bolts, with hollow wall drive anchors or nylon anchors as required.
- C. Fasteners to wood construction: Lag bolts.
- D. Bolts, nuts, and washers: ASTM A 307, or ASTM A 325 where high strength is required.

### 2.23 PIPE GUIDES

A. Pipe alignment guides shall be equal to Carpenter and Paterson Figure 1007 heavy-duty insulating type, consisting of a spider and a housing sleeve, constructed of minimum 0.375-inch-thick (9.5-mm) steel.

#### 2.24 PIPE ANCHORS

- A. Anchors shall be fabricated from structural steel conforming to ASTM A 36 as detailed on the drawings; shall conform to applicable ASME codes; and shall be capable of withstanding the forces imposed by the system on anchor points.
- B. Anchor pipe shoes: Gusseted, equal to Carpenter and Paterson Figure 1120.

### PART 3 - EXECUTION

### 3.20 INSTALLING PIPE HANGERS AND SUPPORTS

- A. Types and locations, refer to MSS SP-58:
  - Type 1 Clevis hanger:
    - 1. Non-steam Hot Systems NPS 0.5 (DN 15) through NPS 8 (DN 200).
    - 2. Ambient Systems and Cold Systems of all sizes.
  - Type 8 Riser clamp, steel for steel or cast-iron risers and stacks, copper plated for copper risers and stacks.
  - Type 10Copper plated adjustable swivel ring for uninsulated copper piping NPS 0.5<br/>(DN 15) through NPS 4 (DN 100). Use Type 1 for insulated pipe.
  - Type 18 Malleable iron concrete inserts for supporting hangers from concrete structure.
  - Type 20 Side beam clamp for attaching hanger rods to structural beams. Use proper size clamp to suit beam flange.

Type 23	C clamp for beams with maximum flange thickness of 0.75 inch (19 mm); for
	use with single pipes NPS 2 (DN 50) and smaller.

- Type 33Heavy welded steel bracket capable of supporting up to 3,000 lbs (1360 kg),<br/>with a Type 9 or Type 1 hanger, for piping along walls.
- Type 34Side beam bracket for storm water and sanitary lines running along walls or<br/>fastened to sides of wood beams, for pipe up to NPS 4 (DN 100).
- Type 37Adjustable pipe stanchion saddle with U-bolt and floor flange anchored to floor,<br/>for piping NPS 2 to 12 (DN 50 to 300) supported from floor.
- Type 39Pipe-covering protection saddle for use between roller-type hangers and Hot<br/>System piping.
- Type 40 Pipe-covering protection shield of proper size to fit insulation, between hanger and insulation:
  - 1. Size to fit pipe, between hanger and plastic piping.
  - 2. Include structural insulation insert between protection shield and pipe for piping NPS 2.5 (DN 65) and larger.
  - 3. Option: Instead of protection shield and structural insert, provide thermal hanger shield. For piping NPS 4 (DN 100) and larger on rollers, include steel weight distribution plate.
- Type 44 Cast-iron roll, steel roll rod, provided with steel chair, bolts, and hex nuts, for pipe in racks and at fixed structural supports such as brackets, where no vertical adjustment is required.
- B. Trapeze piping supports:
  - 1. Field-fabricated from ASTM A 36 steel shapes.
  - 2. Weld steel according to AWS D-1.1.
  - 3. Size threaded rods in accordance with MSS SP-58.
  - 4. Design trapeze support assembly based on supported load plus a 50 percent safety factor.
- C. For hangers requiring vibration control, see Section 15070.
- D. Hanger rod sizes:

(See Schedule, next page)

PIPE SIZE NPS (DN)	ROD SIZE Inches (mm)
Up to 2 (Up to 50)	0.375 (10)
2.5 to 3.5 (65 to 90)	0.5 (15)
4 and 5 (100 to 125)	0.625 (16)
6 and 8 (150 to 200)	0.75 (20)
8 to 12 (200 to 300)	0.875 (22)

- E. Horizontal piping generally shall be supported from above.
  - 1. Attaching to walls: Use two 0.375-inch (9.5-mm) screw-type fasteners for attaching brackets and three 0.5-inch (13-mm) bolt-type fasteners for attaching structural supports.
  - 2. Attaching to bar joists and beams:
    - a. Pipes NPS 2.5 (DN 65) and smaller running parallel with joist or beam: Hanger rods welded to top chord of joist at panel points for joists.
    - b. Pipes NPS 2.5 (DN 65) and smaller running perpendicular to joist or beam: Support from every other joist or beam by method of hanging as described above.
    - c. Pipes NPS 3 (DN 80) and larger running parallel with joist or beam: Support from a length of structural channel or angle welded to the top cords of at least two beams or joists at panel points.
    - d. Pipes NPS 3 (DN 80) and larger running perpendicular to joist or beam: Support from every joist or beams by hanger rods welded to top chord of joist at panel points for joists.
    - e. Where large numbers of pipes are grouped together, their individual hangers shall be staggered so as to distribute the load among the available joists or beams.
  - 3. Attaching to concrete slab: Secure hanger rods to malleable iron inserts properly spaced and set on the forms before concrete is poured.
- F. Hangers and supports shall be spaced as follows:
  - 1. Copper pipe:
    - a. NPS 1.25 (DN 32) and smaller: At least every 6 feet (1.8 m).
    - b. NPS 1.5 and 2 (DN 40 and 50): At least every 8 feet (2.4 m).
    - c. NPS 2.5 (DN 65) and larger: At least every 10 feet (3 m).
  - 2. Steel pipe:
    - a. NPS 1 (DN 25) and smaller: At least every 6 feet (1.8 m).
    - b. NPS 1.25 and 1.5 (DN 32 and 40): At least every 9 feet (2.7 m).
    - c. NPS 2 to 6 (DN 50 to 150): At least every 10 feet (3 m).
    - d. NPS 8 to 12 (DN 200 to 300): At least every 14 feet (4.3 m).

- 3. Cast-iron pipe:
  - a. Where joints occur 5 feet (1.5 m) or less apart: At least every 5 feet (1.5 m).
  - b. Where joints occur over 5 feet (1.5 m) apart: At least every 10 feet (3 m).
- 4. Cast-iron no-hub pipe: Support within 18 inches (460 mm) of each horizontal joint. Maximum space between hangers: 5 feet (1.5 m).
- 5. Plastic pipe with solvent cement or thermal-bonded joint:
  - a. NPS 2 (DN 50) and smaller: At least every 3 feet (0.9 m) when line carries liquid; for vent, 6 feet (1.8 m).
  - b. NPS 2.5 (DN 65) and larger: At least every 4 feet (1.2 m) when line carries liquid; for vent, 8 feet (2.4 m).
  - c. Provide protection shield between hanger and plastic pipe at each support point.
- 6. Trapeze hangers:
  - a. Spacing shall not exceed the requirements for the smallest pipe in the rack.
  - b. For wood roof trusses, at least every 6 feet (1.8 m).
- G. Cast-iron no-hub pipe:
  - 1. Tighten bands alternately and firmly with a torque wrench to 60 lbs (265 N) of torque.
  - 2. Provide piping NPS 6 (DN 150) and larger and all storm piping with buttresses or tie rods at each change in direction.
  - 3. Brace horizontal piping against horizontal movement; secure closet bends, traps, and similar items against movement in any direction.
  - 4. Secure vertical piping at the stack base and top, and at each floor.
- H. Provide additional hangers or supports for concentrated loads such as flanges, valves, expansion compensators, fittings, and other specialties.
- I. Provide hangers as required for insulated piping systems. Coordinate selection of hangers and supports with requirements and selected options for insulation continuous through hanger or butted to each side. Provide pipe covering protection shield and structural insulation insert where insulation is continuous through hangers or supports.
- J. Provide pipe risers through floor slabs with riser clamps.
- K. Support PVC vertical risers at each floor and midway between floors.
- L. Support banks of pipes along the wall on a structural support system.

### 3.21 INSTALLING EQUIPMENT FOUNDATIONS AND SUPPORTS

A. Provide four-inch (100-mm) -high concrete foundations (housekeeping pads) or as indicated on drawings, reinforced with welded-wire fabric, for floor-mounted equipment and where indicated. Anchor concrete foundations by dowels inserted into the floor slab.

- B. Unless otherwise specified, provide concrete foundations, bolts, sleeves, and appurtenances as work of the section where the supported equipment is specified and in accordance with the requirements of Division 03.
- C. Equipment shall be properly aligned and leveled, and grouted where necessary. Support piping independently of equipment and so as not to cause a strain or thrust.
- D. Coordinate exact size, configuration and location of equipment, foundations, and supports using approved shop drawings of equipment.
- 3.22 INSTALLING PIPE GUIDES
  - A. Install guides where indicated on the drawings and where required to properly guide piping at expansion loops and joints.
  - B. Install guides at distances recommended by the manufacturer, in accordance with MSS SP-58, and where indicated on the drawings.
  - C. Guides do not support piping and do not serve as hangers or supports in determining spacing of hangers and supports.
- 3.23 INSTALLING ANCHORS
  - A. Provide anchors where indicated or required by good piping practice to control pipe movement.
  - B. Furnish and install heavy structural angle irons, channels, and wide flange beams as required for suitable anchor supports and bracing for the piping. Arrange anchor supports to suit field conditions. To be adequate for the required duty, and to transmit the thrust loads to the building structural system or floor slabs.
    - 1. Black steel pipes shall be welded to the supports for anchoring.
    - 2. Galvanized and copper pipes shall be attached to the supports by pipe clamps. Clamps for copper pipes shall be copper-plated or pipe shall be wrapped with lead sleeves.

### SECTION 22 05 48 - VIBRATION CONTROL SUPPORTS FOR PLUMBING

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Vibration control supports for mechanical equipment.
- 1.14 RELATED SECTIONS
  - A. Hangers and supports: Section 22 05 29.

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: For each type of vibration control support included in the work.
  - 1. For Specification D hanger, include scaled drawing showing degrees of hanger rod swing.
- C. Shop drawings: Custom-fabricated supports.

#### 1.40 QUALITY ASSURANCE

A. The vibration isolation materials manufacturer shall be responsible for the proper selection of springs to accomplish the specified minimum static deflections for all spring and pad type isolators based on the weight distribution of equipment to be isolated.

### PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Mason Industries product, or comparable product by one of the following:
  - 1. Mason Industries
  - 2. Amber/Booth Company, Inc.
  - 3. Kinetics Noise Control
  - 4. Vibration Eliminator Company, Inc.
  - 5. Vibration Mountings and Controls, Inc.

### 2.20 VIBRATION CONTROL SUPPORTS

- A. Provide engineered supports for equipment and locations shown on drawings and specified in Part 3 below. The units shall prevent the transmission of vibration and mechanically transmitted sound to the building structure.
  - 1. Select units in accordance with the weight distribution of the equipment, so as to produce reasonably uniform deflection. Deflections shall be as specified.
  - 2. Units installed on exterior shall be galvanized.

- B. Specification D: Equal to Mason Industries Type 30N hangers, combination spring and minimum 0.3-inch (8-mm) deflection neoprene in series.
  - 1. Neoprene element: Molded with a rod isolation bushing that passes through the hanger box.
  - 2. Spring diameters and hanger box lower hole sizes: Large enough to permit the hanger rod to swing through a 30-degree arc before contacting the edges of the hole.
  - 3. Springs shall have a minimum additional travel to solid equal to 50 percent of rated deflection.
- C. Specification E: Equal to Mason Industries Type PC30N, same as Specification D, except with adjustment to transfer load to spring while holding supported object at fixed elevation. Include spring deflection indicator.
- PART 3 EXECUTION
- 3.20 INSTALLATION, GENERAL
  - A. Adjust vibration control supports as recommended by manufacturer to eliminate transmission of vibration to building structure or other systems.
  - B. Replace springs that become permanently deformed with new springs.
- 3.26 PUMP VIBRATION CONTROL
  - A. Pumps suspended from structure: Specification E hanger, selected for weight with at least 1 inch (25 mm) static deflection.

### SECTION 22 07 00 - PLUMBING INSULATION

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Definitions and general requirements applicable to the insulation systems specified in "Related Sections."
- 1.14 RELATED SECTIONS
  - A. Plumbing piping insulation: Section 22 07 19.

#### 1.20 DEFINITIONS

- A. Ceiling space: The space between the ceiling and the floor of an air-conditioned space above.
- B. Roof space: The space between the ceiling and the roof, where building insulation is located at the roof level, or the space between the ceiling and the floor of a non-air conditioned space above.
- C. Attic space: The space between the ceiling and the roof, where building insulation is located at the ceiling level.
- D. Air-conditioned areas or spaces: Areas or spaces where the occupied room temperature is maintained between 65 and 80 degrees F (18.3 and 26.7 degrees C).
- E. Concealed insulation shall include work:
  - 1. Above ceilings.
  - 2. Where furred in and in pipe chases.
- F. Exposed insulation shall include work:
  - 1. Below ceilings in all rooms and areas.
  - 2. In mechanical equipment rooms or mechanical closets.
  - 3. In all rooms without ceilings.
  - 4. In storage rooms.

#### 1.40 QUALITY ASSURANCE

- A. Perform work in strict accordance with the building, fire and safety codes of the state and county in which the work is performed.
- B. Insulation, including fittings and butt strips, jackets, facings, and accessories such as adhesives, mastics, cements, tapes and cloth, shall have a fire and smoke hazard rating and label as tested by ASTM E84, NFPA 255, and UL 723, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50.
- C. All insulation and accessories shall be free of asbestos.

### 1.50 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation and accessory products in manufacturers' wrapping or cartons, identified on the exterior and bearing labels showing conformance to flame and smoke rating requirements.

## PART 2 - PRODUCTS

#### 2.10 MATERIALS

A. Refer to sections listed in "Related Sections".

#### PART 3 - EXECUTION

Not Used.

### **SECTION 22 07 19 - PLUMBING PIPING INSULATION**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Mechanical piping insulation for the piping systems listed in the schedule at the end of this section.
- 1.14 RELATED SECTIONS
  - A. Sections specifying requirements for LEED rating are specified in Division 01.
  - B. Definitions and general insulation requirements: Section 22 07 00.
  - C. Painting: Division 09.
  - D. Pipe hangers and protection shields: Section 22 05 29.

#### 1.20 REFERENCES

- A. ASTM C 450: Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.
- B. ASTM C 534: Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- C. ASTM C 547: Mineral Fiber Pipe Insulation.
- D. ASTM C 553: Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 22 01 01.
  - B. LEED submittal:
    - 1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
  - C. Schedule of products: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
  - D. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.
  - E. Samples required only upon request.

### 1.34 QUALITY CONTROL SUBMITTALS

- A. Manufacturer's instructions: Recommended accessory materials and products; installation instructions.
- 1.40 QUALITY ASSURANCE
  - A. Meet requirements specified in Section 22 07 00.
  - B. Comply with requirements for LEED certification specified in Division 01.
  - C. Installers shall be mechanics skilled in this trade.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Meet requirements specified in Section 22 07 00.

### PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 22 01 01.
- B. Fiberglass insulation:
  - 1. Johns Manville.
  - 2. Knauf Fiber Glass GmbH.
  - 3. Owens-Corning.
- C. Flexible elastomeric insulation:
  - 1. Armacell LLC
  - 2. Rubatex
- D. Coatings, adhesives, and fabrics:
  - 1. Childers.
  - 2. Foster.
  - 3. Manville Building Materials Group.
  - 4. Rock Wool Manufacturing Company

### 2.10 FIBERGLASS PIPE INSULATION

- A. Fiberglass insulation: Glass fibers bonded with a thermosetting resin.
  - 1. Preformed pipe insulation, ASTM C 547 Type I, with all-service jacket.
  - 2. Flexible sheet insulation, ASTM C 553 Type IV, without facing.

- B. All-service jacket (ASJ) or "Evolution" Paper-free ASJ: Factory-applied, fire-retardant, vaporbarrier foil/scrim/kraft jacket. All-service jacket with self-sealing lap (ASJ-SSL) is acceptable as Contractor's option.
  - 1. Tape: Matching jacket, pressure-sensitive.
- C. Fittings and valves: Prefabricated and field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

### 2.12 FLEXIBLE ELASTOMERIC PIPE INSULATION

- A. Flexible elastomeric tube and sheet: Equal to Armacell "AP Armaflex," or "Armaflex 2000", closed-cell, sponge- or expanded-rubber materials, ASTM C 534, Type I (tubular) and Type II (sheet).
- B. Fitting and valve covers: Field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

### 2.14 ADHESIVES

- A. Joints, fittings, and general application:
  - 1. Fiberglass insulation: Foster "Quick-Tack" 85-60.
  - 2. Flexible elastomeric insulation: Foster "Drion" 85-75.
- B. Lagging adhesive: Polyvinyl acetate adhesive, equal to Foster "Lagfas" 81-42W.

### 2.15 MASTICS AND COATINGS:

- A. Flexible elastomeric insulation: Armacell "WB Armaflex" latex enamel.
- B. Bituminous mastic: Fed. Spec. SS-C-153, Type I.
- C. Insulating and finishing cement: Mineral fiber cement with a hydraulic-setting binder, conforming to ASTM C 449.
- D. Vapor barrier coating:
  - 1. On fiberglass insulation: Foster "Vapor-Fas" 30-65.
  - 2. On flexible elastomeric insulation: Two coats of latex enamel coating.
- E. Finish coating for fiberglass insulation or lagging: Washable, abrasion-resistant, coating equal to Foster "Sealfas" 30-36.

## 2.16 LAGGING AND REINFORCING TEXTILES

- A. Canvas: Eight ounces/sq. yd. (270 g/sq. m), fire-retardant treated.
- B. Glass cloth and tape: MIL-C-20079. Tape: Type II, Class 3, 4.5 ounce/sq. yd. (150 g/sq. m). Cloth: Type I, Class 1, untreated.

### 2.17 FASTENERS

- A. Aluminum bands: 0.75 inches (19 mm) wide and 0.020 inches (0.4 mm) thick.
- B. Staples: Outward clinching type, Type 304 or 316 stainless steel.
- C. Pins: Serrated shaft, Type 304 or 316 stainless steel.
- 2.18 PROTECTIVE PIPE JACKETS
  - A. Aluminum: Smooth aluminum 0.016-inch-thick, lined with a bonded moisture barrier, equal to Childers "Aluminum Roll Jacketing."
    - 1. Aluminum straps: Same alloy as jacket.
    - 2. Elbows: Childers "Univers-Ell Jacs".
    - 3. Tees: Childers "Tee-Jacs."
    - 4. Fitting covers: Manufacturer's factory-fabricated aluminum covers suitable to size of fitting and thickness of insulation.
  - B. Polyvinyl chloride (PVC): High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming.
    - 1. Adhesive: As recommended by jacket material manufacturer.
    - 2. Color: White.
    - 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
  - C. Canvas: Finished with lagging coating, uniform, smooth, and ready for painting.

### PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Install in accordance with the Minimum Thickness Schedule at the end of this section, as modified by specifications for each location and type.
  - B. Insulation conductivity shall meet the 2015 International Energy Conservation Code for listed fluid operating temperature.
  - C. Fiberglass insulation: Apply insulation to a neat and smooth finish. Comply with manufacturers' recommendations and installation instructions. Butt joints tightly and apply a brush coat of vapor barrier coating to each lap and joint strip. Seal or fasten laps in jacketing as specified for location, pulling jacketing tight and smooth. Coat all fittings, valves, and flanges with vapor barrier coating and reinforcing mesh before applying fitting covers.

- D. Flexible elastomeric insulation: Apply by slipping seamless sections of tubing over the end of the piping, wherever possible. Use slit tubing only as necessary. Seal joints and slit seams with joint adhesive.
  - 1. Fittings and valves: Field fabricated from insulation same thickness as on the piping. Use manufacturer's miter tubes and boxes and templates.
- E. Tape and seal with vapor barrier coating to all terminations of insulation.
- F. Staple, tape, or seal plastic pipe fitting covers by methods recommended by manufacturer.
- G. Coordination with pipe hangers and supports for the systems listed below:
  - 1. Insulation shall be continuous through hanger for all piping systems. Install pipe covering protection shield with thickness of structural insulation insert equal, under load, to that of adjoining insulation. Shield and saddle support are specified in Section 22 05 29, Hangers and Supports for Plumbing Piping and Equipment.

### 3.21 INSTALLING INSULATION AT PENETRATIONS

A. Where the insulated piping systems pass through sleeves or openings in partitions and floors, the insulation shall be continuous through the sleeves and openings. See Firestopping specifications, for coordinating insulation and fire protection sealing.

### 3.22 INSTALLING CANVAS JACKET

- A. Locations:
  - 1. All pipe insulation in mechanical rooms and mechanical closets on exposed piping as defined in Section 22 07 00, Plumbing Insulation.
  - 2. Canvas jacket is not required where aluminum jacket is required.

### 3.23 INSTALLING ALUMINUM JACKET

- A. Locations: All insulated pipe exposed in finished areas within 8 feet (2440 mm) of the finished floor, and as specified for weather protection.
- B. Secure jacket with aluminum bands on 12-inch (305-mm) centers and at circumferential joints.
- C. Place longitudinal joints to face a wall and overhead joints to face the ceiling.

### 3.24 INSTALLING PVC JACKET

- A. Locations: As specified for weather protection.
- B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of pipes. Seal with manufacturer's recommended adhesive.

- 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- 2. Seams and joints shall completely prevent the entrance of water.

### 3.26 INSTALLING PLUMBING PIPING INSULATION

- A. Insulation: Fiberglass, thickness in accordance with Minimum Thickness Schedule.
- B. Fittings, valves, and flanges: Cover with prefabricated fitting covers. Coat all fittings, valves, and flanges with vapor barrier coating and reinforcing mesh before applying fitting covers.
- C. Seal or finish to maintain vapor barrier on the following systems:
  - 1. Aboveground domestic cold water
  - 2. Air-conditioning unit condensate drains,
  - 3. Floor drain bodies and piping receiving air-conditioning unit condensate
  - 4. Vertical and horizontal storm water piping and roof drain sump
- D. Seal or staple ASJ as contractor's option: Aboveground tempered, recirculating and domestic hot water.
- E. Do not insulate chrome-plated piping connections to plumbing fixtures, except wheelchairaccessible lavatories shall be insulated with special insulation and finish assemblies specified in Section 15411, Plumbing Fixtures.
- F. Insulate horizontal storm water piping from roof drain sump to minimum 10 feet downstream of connection to roof drain.
- G. Insulate all horizontal and vertical storm water piping that is exposed.
- H. Exception: On vertical storm-water piping concealed within walls or inaccessible chases, insulate only the first 5 feet above the point where the pipe goes underground. Insulate all storm-water piping connecting to roof drains receiving air-conditioning condensate from roof mounted equipment.
- I. Roof drain sumps/bodies and above ground floor drain sumps/bodies that receive airconditioning condensate: Fiberglass insulation, 1 inch thick. Provide vapor barrier. Finish with two coats of vapor-barrier coating with glass cloth embedded in final coat.
- J. Insulate sanitary piping in its entirety where piping is located above a ceiling or in a chase and runs above normally occupied spaces or a chase and is located within the occupied space.

### 3.90 SCHEDULES

- A. Minimum Thickness Schedule: Thicknesses scheduled are for aboveground, interior piping.
- B. Where noted, minimum thicknesses are less than requirements of the 2015 International Energy Conservation Code, the code minimum shall apply.

(See Schedule, next page)

MINIMUM THICKNESS SCHEDULE PIPE SIZES (NPS)									
Domestic cold water	56-180		1.0**	1.0**	1.0	1.0	1.0		
Domestic hot and recirculating	100-140	1.0	1.5	1.5	1.5				
Storm water			1.0**	1.0**	1.0**	1.0**	1.0**		
Roof drains			1.0	1.0	1.0	1.0	1.0		
Air-conditioning condensate			1.0**	1.0**	1.0**	1.0**	1.0**		
Floor drains (1)				1.0	1.0	1.0	1.0		
Sanitary piping (1)				1.0	1.0	1.0	1.0		

\*\* Contractors Option within partitions only: 0.5-inch flexible elastomeric insulation.

(1) Above ground, receiving air-conditioning condensate.

### **SECTION 22 11 16 - DOMESTIC WATER PIPING**

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Domestic cold water.
  - B. Domestic hot water.
  - C. Recirculated hot water.
  - D. Tempered water.
- 1.14 RELATED SECTIONS
  - A. Piping materials and methods: Section 22 05 00.
  - B. Excavation and fill: Section 22 05 01.
- 1.20 DEFINITIONS
  - A. Domestic water system: Potable water system for general human use, including hot and cold water supply and return.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 22 01 01.
  - B. Product data: Each type of pipe and fitting included in the project.
  - C. Submit proposed method for providing electrical continuity at pipe joints in water service line.
  - D. Submit proposed means for anchoring pipes at water service entrance.
  - E. Certifications: Disinfection test report

### 1.40 QUALITY ASSURANCE

- A. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
  - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
  - 2. NSF/ANSI 61.
- B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.

- C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.
- D. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label directly on the pipe, indicating compliance.

## PART 2 - PRODUCTS

### 2.01 ACCEPTABLE SUPPLIERS

- A. Disinfection of domestic water system:
  - 1. ARC Water Treatment Company, Inc.
  - 2. Ecolab
  - 3. Water Chemical Services, Inc.
  - 4. Olin Water Services

### 2.02 ACCEPTABLE MANUFACTURERS

- A. Piping and fittings:
  - 1. Mueller Industries
  - 2. Cerro Flow Products
  - 3. Wieland Copper Products
  - 4. Great Lakes Copper Ltd.

### 2.11 ABOVEGROUND PIPE AND FITTINGS

- A. Pipe: Copper tubing, ASTM B 88, Type L, hard drawn, plain end, or roll grooved; cut grooved not permitted.
- B. Fittings:
  - 1. For plain-end copper pipe: Solder joint, cast brass, ASME B16.18, or wrought copper, ASME B16.22.
  - 2. For grooved pipe, copper:
    - a. Couplings, gasket, and fittings capable of withstanding a constant temperature of 230 degrees F (110 degrees C), and 175 psi (1207 kPa) working pressure.
    - b. Reducing couplings not permitted; use reducing fittings at changes in pipe size.
    - c. Gaskets: EPDM.
    - d. Copper: Equal to Victaulic Style 606, designed to fit copper tube, coupling housing fastened with two bolts and nuts.
- C. Flanges for copper pipe: Bronze, solder type, ASME B16.24, Class 150.
- D. Unions for copper pipe: Cast bronze or wrought copper with solder ends, ASME B16.18 or B16.22.
- E. Dielectric pipe fittings shall comply with Section 22 11 19.
- F. Elbows in piping NPS 4 (DN 100) and larger shall be long radius type.

## 2.13 UNDERGROUND PIPE AND FITTINGS

- A. Pipe:
  - 1. Iron pipe: Class 54, cement mortar lined ductile iron, AWWA C-151.
    - a. Cement lining, AWWA C-104.
    - b. Mechanical or push-on joints, AWWA C-111.
  - 2. Copper tubing, ASTM B 88, Type K, hard drawn, plain end.
- B. Fittings:
  - 1. Iron: AWWA C-110, ductile iron, Class 350.
  - 2. Copper: Solder joint, cast brass, ASME B16.18, or wrought copper, ASME B16.22.
- C. Abutments: Concrete, not less than three pipe diameters wide and two pipe diameters high. Abutments for water service on fire protection shall be as required by NFPA 24.

## PART 3 - EXECUTION

## 3.20 INSTALLATION

- A. Install domestic water piping as shown on the drawings and in accordance with the provisions of Section 22 05 00, Common Work Results for Plumbing.
- B. Install aboveground piping in accordance with the Schedule of Pipe Systems, Sizes, and Materials at the end of this section.
- C. Underground pipe:
  - 1. NPS 3 (DN 80) and larger: Ductile iron.
  - 2. NPS 2.5 (DN 65) and smaller: Copper Type K.
- D. Provide hose connections with vacuum breakers at low points of domestic water system for drainage.
- E. Provide dielectric fittings between ferrous and copper piping.

## 3.22 EXTERIOR UNDERGROUND PIPING

- A. Pipe: Install as indicated on the drawings.
- B. Electrical continuity at pipe joints in water service line shall be provided by conductivity strips, wedges, or other approved methods.

- C. Use suitable tools and appliances for the safe and convenient handling and laying of the pipe. Prevent injury to the pipe coating. Examine each section of pipe for defects, and do not lay sections found to be defective. If any defective piece should be discovered after having been laid, remove it and replace with a sound one at no change to the contract sum.
- D. Install abutments at each change in direction of iron pipe, resting on and transmitting thrust to undisturbed earth.
- E. Anchor water service for cast iron pipes at point of entrance into building by means of clamps or special fittings, as approved and indicated on drawings.
- F. At the point of water service entrance, provide a shutoff valve as indicated on drawings.

## 3.75 CLEANING AND TESTING PIPING SYSTEMS

A. When a domestic water loop is completed, and before strainer baskets are installed, pressure test at the pressure shown in Piping Test Table in Section 22 05 00, and thoroughly flush. Water piping connections for flushing shall be same size as piping being flushed or one size smaller. When a major section of the building is completed, repeat the same procedure, except that water pipe connections for flushing shall be limited to NPS 1.5 (DN 40). Then install strainer baskets and conduct a preliminary operation test.

# 3.76 DISINFECTION OF DOMESTIC WATER SYSTEM

- A. Disinfect the entire domestic water system installed under this contract, cold, hot and return piping, before using. Unless prescribed otherwise by the county or state health department, the method of disinfecting shall be as follows:
  - 1. Through a NPS 0.75 (DN 20) hose connection in the main entering the building, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 ppm. Provide plumbing connections and power for service organization for pumping chlorine into the system.
  - 2. Proceed upstream from the point of chlorine application, opening each faucet and tap until chlorine is detected. Close each faucet and tap when chlorine is evident.
  - 3. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 ppm chlorine, retain this water in the system for at least three hours, but no more than 3.5 hours.
  - 4. At the end of the retention period, no less than 100 ppm of chlorine shall be present at the extreme end of the system.
  - 5. Open all faucets and taps and flush all lines until the chlorine residual in the water is less than one ppm.
  - 6. Obtain a representative water sample from the system for analysis by a recognized bacteriological laboratory.
  - 7. If the sample tested for coliform organisms is negative, the service organization shall submit a letter and laboratory report to the Contractor, certifying successful completion of the sterilization. Submit report.
  - 8. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.
  - 9. Close main sprinkler valves or branch sprinkler valves prior to disinfection of system. Open valves when disinfection is complete.

# 3.90 SCHEDULE OF PIPE SYSTEMS, SIZES AND MATERIALS

Pipe Types Listed Below				
System	1	2		
Cold water	Х	Х		
Hot water	Х	Х		
Hot water Return	Х	Х		
Tempered water	Х	Х		

- 1. NPS 4 (DN 100) and smaller, copper Type L.
- 2. NPS 3 (DN 80) to NPS 6 (DN 150), copper, rolled grooved.

## **SECTION 22 11 19 - DOMESTIC WATER PIPING SPECIALTIES**

## PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Specialties for plumbing piping systems.
- 1.14 RELATED SECTIONS
  - A. Piping: Section 22 11 16.
  - B. Access doors: Section 22 05 03.
  - C. Expansion tanks: Section 22 05 09.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: For each specialty included in the work. Include rated capacities of selected equipment and manufacturer's installation instructions where applicable. Indicate materials, finishes, dimensions, required clearances, methods of assembly of components; and piping and wiring connections.
- C. Backflow preventer for fire suppression connection: Provide a copy of the approved product performance data to the subcontractor doing sprinkler system calculations for the project.

## 1.40 QUALITY ASSURANCE

- A. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
  - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
  - 2. NSF/ANSI 61.
- B. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- C. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

A. Gaskets:

- 1. Garlock Mechanical Packing Division
- 2. Manville
- B. Dielectric fittings:
  - 1. Anvil International
  - 2. Elster Perfection
  - 3. Precision Plumbing Products, Inc.
  - 4. Sioux Chief Manufacturing Company, Inc.
  - 5. Victaulic Company of America
- C. Water strainers:
  - 1. Ames
  - 2. Febco
  - 3. Mueller Steam Specialty
  - 4. Spirax Sarco Inc.
  - 5. Tate Andale, Inc. "Guardian"
  - 6. Watts Industries, Inc.
  - 7. Zurn-Wilkins
- D. Backflow preventers:
  - 1. Zurn Wilkins
  - 2. Febco Division of CMB Industries
  - 3. Ames Division of Watts Water Technologies
  - 4. Apollo Valves
- E. High-capacity automatic air vents:
  - 1. Amtrol Inc.
  - 2. Hoffman Specialty Div. of ITT Industries
  - 3. Spirax Sarco Inc.
  - 4. Spirotherm, Inc.
  - 5. Taco, Inc.
- F. Water hammer arrestors:
  - 1. Zurn Plumbing Products
  - 2. Jay R. Smith Manufacturing Company
  - 3. Josam Company
  - 4. MIFAB Inc.
  - 5. Wade
  - 6. Watts Drainage
- G. Thermostatic mixing valves:
  - 1. Bradley Corporation
  - 2. Lawler Manufacturing Company Inc.
  - 3. Leonard Valve Company

- 4. Powers Regulator Company
- 5. Symmons Industries Inc.
- H. Trap primers:
  - 1. Jay R. Smith Manufacturing Company
  - 2. MIFAB Inc.
  - 3. Precision Plumbing Products
  - 4. Sloan Valve
  - 5. Watts Industries
  - 6. Zurn Plumbing Products
- I. Water pressure reducing valves:
  - 1. Spence Engineering Company Inc.
  - 2. Watts Industries Inc.

## 2.21 GASKETS AND UNIONS

- A. Gaskets for flanged joints: Cross-laminated long fiber composition suitable for service, temperature, pressure and liquid with which they come in contact.
- B. Unions NPS 2.5 (DN 65) and smaller: Malleable iron, Class 150, ASME B16.39, equal to Anvil International with ground bronze seats, or soldered type brass unions of equal quality.

## 2.22 DIELECTRIC FITTINGS

- A. General: Completely isolate dissimilar metals so that electric current is below 1 percent of the galvanic current which would exist with metal-to-metal contact. Gaskets approved for the medium carried by the piping system.
- B. Dielectric nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain or threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 degrees F (107 degrees C).
- C. Grooved piping: "Dielectric Waterway Fittings" equal to Victaulic Co. "Clearflow" steel threaded ends or thread to Victaulic groove with opaque, high-temperature thermoplastic copolymer liner designed for use at temperatures up to 225 degrees F (107 degrees C) and pressure up to 300 psi (2068 kPa). Complete with ring groove to lock steel casing to plastic liner.

## 2.23 WATER SPECIALTIES

- A. Basket-type water strainers: Epoxy-coated cast iron, flanged, equal to Mueller Steam Specialty No. 165, and meeting working pressure ratings published by Mueller. Basket: stainless steel screen with 1/8-inch (3-mm) perforations.
- B. Y-type strainers:
  - 1. Equal to Spirax Sarco Model IT threaded or Model CI flanged.

- 2. For use in copper piping: Watts lead free brass Model LF777SI threaded.
- 3. Screens in Y-type strainers: Stainless-steel having maximum 0.045-inch (1.2-mm) perforations.
- C. Backflow preventer for domestic water service: ASSE 1013, reduced-pressure-principle type, complete with dual check valves, relief valves assembly, tri-cocks, and stop valves.
- D. Backflow preventer for fire suppression service: ASSE 1047, reduced-pressure-principle type, detector assembly, complete with strainer, dual check valves, test cocks, and stop valves. Assembly shall be UL and FM approved for fire service.
- E. High-capacity automatic air vent: For releasing air from hot or cold water lines. Float-operated type with minimum 7 cfm (3.3 L/s) capacity.
  - 1. Materials: Cast-iron body and cover; stainless-steel valve pin and seat, and float; gasket conforming to ASTM F 104; high-strength steel cap screws.
  - 2. Operating limits: Maximum pressure 250 psig (1725 kPa); maximum temperature 300 degrees F (149 degrees C); hydrostatic pressure to 350 psig (2415 kPa).
- F. Water hammer arrestors: ASSE 1010 or PDI WH-201 certified, equal to Zurn "Shoktrol" Z-1700:
  - 1. Construction: Metal bellows or copper tube with piston.
  - 2. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.
- G. Thermostatic mixing valves: Utilize at domestic water heater:
  - 1. ASSE 1017, equal to Powers Regulator Company "Hydroguard" LFSH1430.
  - 2. Integral checks and screen strainers at inlets.
  - 3. Threaded or soldered connections.
  - 4. Discharge temperature adjustment range: 90 degrees F 160 degrees F, set at 120 degrees F.
  - 5. Rigid bulb indicating thermometer at supply outlet; 3-inch dial graduated 30 degrees to 130 degrees F, stainless steel, hermetically sealed with external calibration screw.
  - 6. Minimum flow: 0.5 gpm, with continuous recirculating pump.
- H. Trap primers:
  - 1. Water closet vacuum breaker trap primer: ASSE 1044, vacuum breaker assembly with chrome-plated fittings and chrome-plated flexible copper tubing and wall flange. Provide product equal to Sloan Valve Company Model VBF-72-A.
  - 2. Automatic inline Trap primer valve: ASSE 1044, equal to Precision Plumbing Products "Mini-Prime Electronic Trap Priming System," factory assembled unit consisting of the following:
    - a. Pre-set 24-hour timer that actuates a solenoid valve 6 seconds every 24 hours providing 2.0 ounces discharge at 20 psi inlet pressure.
    - b. NPS 0.50 (DN 15) copper inlet connection.
    - c. NPS 0.50 (DN 15) copper outlet connection.

- d. Distribution Unit: Connects directly to the primer valve with up to four 0.375-inch compression outlet fittings for NPS 0.50 (DN 15) copper tubing.
- e. Provide a steel box and accessible cover.
- f. Electrical: 120 volt, single phase, 60 Hertz, single-point power supply, circuit breaker, manual override switch and test button.
- 3. Automatic trap priming panel: ASSE 1044, equal to Precision Plumbing Products "Prime-Time Electronic Trap Priming System," factory assembled unit consisting of the following:
  - a. Pre-set 24-hour timer that actuates a solenoid valve 6 seconds every 24 hours providing 2.0 ounces discharge at 20 psi inlet pressure.
  - b. NPS 0.75 (DN 20) copper inlet connection with bronze ball type shutoff valve.
  - c. NPS 0.75 (DN 20) supply manifold with ASSE 1001 atmospheric vacuum breaker, 0.625-inch compression outlet fittings for NPS 0.50 (DN 15) copper tubing. Provide one outlet for each floor to be primed. Manifold assembly shall be calibrated for equal water distribution.
  - d. Provide a steel-surface-mounted cabinet with access cover where concealed above ceilings or mounted in mechanical rooms.
- I. Pressure relief valves: ASME rated, NB approved, automatic reseating type conforming to ANSI Z21.22.
  - 1. Provide straight pressure type where installed in pipe lines and for protection of coils and cold water vessels.
  - 2. Provide combination pressure and temperature type where installed for hot water tanks and vessels.
- J. Water pressure-reducing valves: Equal to Zurn-Wilkins 500XL, direct acting with integral bypass:
  - 1. Construction: Bronze body and stainless-steel seat, FDA approved elastomers.
  - 2. Pressure rating: Maximum working water pressure of 300 psig (2070 kPa).
  - 3. Temperature rating: Maximum working water temperature of 140 degrees F.
  - 4. Pressure range: 25 psi to 75 psi (172 to 517 kPa).
  - 5. Size: NPS 3.0 (DN 80) or smaller.

## PART 3 - EXECUTION

## 3.20 INSTALLATION, GENERAL

A. Plastic piping specialties are not permitted in HVAC system ceiling plenums or shafts used to convey building HVAC air distribution.

## 3.23 INSTALLING GASKETS AND DIELECTRIC FITTINGS

- A. Gaskets shall be installed in accordance with manufacturer's recommendations.
- B. Pipe connections to fixtures, control valves, equipment and appliances shall be provided with unions or flanges so that the units may be disconnected and replaced without damage to the pipe.

C. Provide dielectric fittings between copper and steel piping NPS 0.5 through 2.5 (DN 15 through 65).

## 3.24 INSTALLING WATER SPECIALTIES

- A. Provide specialties for each piping system, as indicated.
- B. Strainers at domestic service entrance shall be basket type. Install y-pattern strainers on the supply side of each control valve, water pressure reducing valve, inline pump, and where indicated on drawings.
- C. The water pressure-reducing valves and pressure relief valves shall be line size and adjusted to the pressures indicated on the drawings.
- D. Provide backflow preventers with Y strainers; if required for service entrance, provide basket type strainer.
- E. Install relief valves for water heaters and other devices where required by governing codes. Relief valve discharge shall be piped as indicated or to the nearest floor drain or to within six inches of the floor beside unit.
- F. Install water pressure-reducing valve in water service at point of entry into building arranged as indicated. Install bypass with globe valve as shown on drawings. Provide pressure gage on each side of the pressure-reducing valve.
- G. Automatic fill for the hydronic systems shall be as diagramed on the drawings. The pressurereducing valves and pressure-relief valves shall be line size and adjusted to the pressures indicated on the drawings.
- H. Install backflow preventers in the building water supply, each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Mount 48 inches (1219 mm) above the floor unless otherwise noted on the drawings. Comply with the authorities having jurisdiction.
  - 1. Install drains for backflow preventers with atmospheric-vent drain connections with airgap fitting, and pipe as indicted on the drawings. Do not install bypass piping around backflow preventers.
- I. Trap primers:
  - 1. Install flush valve vacuum breaker trap primers for floor drains in toilet rooms.
    - a. Priming line shall be taken from the valve vacuum breaker of the nearest water closet to the floor drain to be primed.
    - b. Provide one primer for each floor drain.
  - 2. Install automatic trap primers where indicated on the drawings.
  - 3. Install a shutoff valve in the branch line serving each primer valve or system.

- 4. Install trap primer assemblies level and plumb to ensure equal flow distribution to the primer lines or distribution unit.
- 5. Run primer outlet piping concealed with NPS 0.5 (DN 15) soft drawn copper pipes pitch down toward drains at minimum 1.0 percent slope and connect to floor drain trap primer fittings.
  - a. Install type L copper tubing except Type K copper where installed below floor slabs on earth.
- J. Installing water hammer arrestors: Size and locate water hammer arrestors as recommended by the Plumbing and Drainage Institute Standard PDH –WH 201 or ASSE 1010.
  - 1. Install water hammer arrestors in each branch domestic water pipe (hot and cold) which feeds either a battery of fixtures or a single fixture. Install water hammer arrestors upstream of quick-closure valves.
- K. Installing thermostatic mixing valves: Connect as shown as shown on the drawings and in compliance with the manufacturer's recommendations for two temperature hot water recirculating system.

## SECTION 22 11 23 - DOMESTIC WATER PUMPS

#### PART 1 - GENERAL

#### 1.11 WORK INCLUDED

- A. In-line hot water recirculating pump.
- 1.14 RELATED SECTIONS
  - A. Motors: Section 22 05 13.
  - B. Controls: Sections 23 09 01 through 23 09 23.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Include certified performance curves and rated capacities of selected models; shipping, installed, and operating weights; furnished specialties; and accessories for each type and size of pump specified. Indicate pumps' operating point on curves.
- C. Shop drawings: Show layout and connections for pumps. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.
  - 1. Wiring diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
- D. Maintenance data: For each pump specified, to include in maintenance manuals specified in Division 01 and Section 22 01 01.
- E. Certifications: Written certification that each unit has been factory tested and performs as specified and scheduled.

## 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 22 05 00, Common Work Results for Plumbing.
- B. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
  - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
  - 2. NSF/ANSI 61.
- C. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.

D. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Specified units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 22 01 01 and submit shop drawings as specified in article 1.30 above.
- B. In-line domestic hot water recirculating pump:
  - 1. Armstrong Pumps Inc.
  - 2. Bell and Gossett Domestic Pump, ITT Industries
  - 3. Deming, Crane Pumps and Systems
  - 4. Patterson Pump Co.
  - 5. Taco Inc.
  - 6. Paco Pumps; Grundfos Group.

## 2.23 IN-LINE DOMESTIC HOT WATER RECIRCULATING PUMP

- A. Equal to Taco Inc. Series 100S pumps of size scheduled on the drawings. Pump shall have stainless-steel body, with non-ferrous impeller, stainless-steel shaft, bronze sleeve bearing, two-piece carbon/ceramic seal assembly, one piece spring coupling. Pump flanges shall conform to ANSI B16.1.
- B. Equal to Taco Inc. Series 00 cartridge type circulator of size scheduled on the drawings. "Low lead" bronze or stainless steel body, stainless steel cartridge with non-metallic impeller, ceramic shaft, carbon bearings and EPDM seals.

PART 3 - EXECUTION

## 3.25 INSTALLING IN-LINE DOMESTIC HOT WATER RECIRCULATING PUMP

- A. In-line pumps shall be provided where indicated and shall be installed with motor in horizontal position. Provide necessary bracket to building construction to support the pump and reduce vibration in pipe work.
- 3.70 ADJUST AND CLEAN
  - A. Set pump controls for specified operation.
  - B. Before starting, perform preventive maintenance:
    - 1. Lubricate bearings.
    - 2. Disconnect couplings and inspect motors for proper direction of rotation.

- 3. Verify that each pump rotates freely by hand. If it is bound or drags, determine the cause and correct it.
- 4. Verify that pump controls are correct for the application.

## 3.80 STARTUP

- A. Start motors.
- B. Open discharge valves only.
- C. Check general mechanical operations of systems and motors.

## SECTION 22 13 16 - SANITARY WASTE AND VENT PIPING

## PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Sanitary piping, interior and exterior.
  - B. Air-conditioning condensate drain
- 1.14 RELATED SECTIONS
  - A. Piping installation and testing: Section 22 05 00

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Each specified material and product.
- 1.40 QUALITY ASSURANCE
  - A. PVC pipe and fittings shall be marked with the collective trademarks and universal standard code noting manufacturer, ASTM designation, pipe size, pressure rating and schedule number.

#### PART 2 - PRODUCTS

- 2.20 PIPING AND FITTINGS, TYPES
  - A. Install each type of pipe and fittings in locations required or permitted in Part 3, including the Pipe Installation Schedule at the end of the section.
  - B. Type D: Copper tubing Type DWV, ASTM B 306, with wrought copper drainage fittings, ANSI B16.29; or cast-brass fittings, ANSI B16.23.
  - C. Type F: Copper tubing Type L, hard drawn, plain end, solder joint fittings, cast brass, ASME B16.18 or wrought copper ASME B16.22.
  - D. Type G: Plastic DWV pipe and fittings:
    - 1. Pipe: PVC, Schedule 40, ASTM D 1785.
    - 2. Fittings: PVC, DWV, ASTM D 2665.
    - 3. Solvent cement: PVC, ASTM D 2564.

## PART 3 - EXECUTION

#### 3.05 PREPARATION

A. Connect piping to site utility as shown on the drawings. Check elevations of these connection points before installing new work.

## 3.20 INSTALLATION, GENERAL

- A. Use suitable tools and appliances for the safe and convenient handling and laying of pipe. Examine each section of pipe for defects. Do not lay any piece that is known to be defective. If any defective piece should be discovered after having been laid, remove and replace it at no change to the contract price.
- B. Install piping in accordance with the Pipe Installation Schedule at the end of this section, as indicated on the drawings, and in accordance with Section 22 05 00, Common Work Results for Plumbing. Materials and work shall conform to local plumbing codes and health department regulations.
- C. Install underground PVC piping according to the latest installation instructions published by the manufacturer, and ASTM D2321 Underground Installation of Flexible Thermoplastic Sewer Pipe. Where piping is installed below slab on grade and exterior of the building, special care shall be utilized in trenching, preparing laying bed, supporting and backfilling piping.
- D. Thoroughly clean all pipe and fittings before installing them, and keep them clean until the acceptance of the completed work. Cap or plug ends of lines to prevent debris from entering during construction.
- E. Make changes in direction of sanitary piping with approved sanitary fittings, Y branches, 1:8 or 1:16 bends.
- F. In soil, waste, and vent stacks where branches occur that are smaller than stacks, provide properly sized reducing fittings.
- G. Seal air-conditioning condensate drain where it passes through outside wall and provide splashblock if required.
- H. Utilize copper Type L piping where condensate drain piping is 1-inch or smaller.
- 3.21 RESTRICTIONS ON LOCATIONS
  - A. Piping and fitting types and joining methods for piping located above kitchen areas, including food storage, serving line and food preparation shall be in strict compliance with Code of Maryland Regulations.
  - B. Plastic piping above ground (Types G):
    - 1. Are not allowed in HVAC ceiling plenums or shafts used to convey building air distribution where not rated for that application.
    - 2. Require special protection designed for plastic piping penetrations where they occur in fire-rated assemblies or floors.

## 3.90 SCHEDULES

(See schedule, next page)

SANITARY PIPE INSTALLATION SCHEDULE Contractor has option where more than one x appears on a line				
MATERIAL TYPE				
USE	D	F	G	
Sanitary, exterior			Х	
Sanitary, below slab on earth			Х	
Sanitary vent			Х	
Sanitary, concealed within walls or partitions			Х	
Sanitary, ceiling space			Х	
Sanitary, interior exposed			Х	
Backflow preventer discharge drain piping			Х	
Air conditioning condensate, interior	х	Х		
Air conditioning condensate, exterior (1)			Х	
Miscellaneous drains from equipment	x		X	
Radon vent			X	
Sump Pump Discharge		Х		

# ALL OF THE ABOVE SUBJECT TO LOCAL PLUMBING CODE AND HEALTH DEPARTMENT REQUIREMENTS

Note:

1. Piping shall be field or shop painted with UV resistant, water-based latex paint specifically formulated for exterior use.

## MATERIAL TYPES (Refer to Part 2 - Products)

D - Copper DWV F - Copper, Type L G - Plastic DWV

## SECTION 22 13 19 - SANITARY WASTE PIPING SPECIALTIES

## PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Drains and cleanouts.
- B. Flashing material.
- C. Solids and fats, oils and grease interceptor.

## 1.14 RELATED SECTIONS

- A. Piping: Section 22 13 16.
- B. Penetrations and flashings: Section 22 05 06.
- C. Insulation: Section 22 07 00 and 22 07 19.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Each specialty device or equipment, with installation instructions.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. General: Model numbers are provided in the articles below to set a standard for materials, quality of construction, options and details, and performance. Provide named products, or equal products by the acceptable manufacturers listed.
- B. Drains and cleanouts:
  - 1. Josam Company
  - 2. Jay R. Smith Manufacturing Company
  - 3. MIFAB, Inc.
  - 4. Wade
  - 5. Watts Drainage
  - 6. Zurn Plumbing Products
- C. Fats, oils, and grease interceptor:
  - 1. Mayer Brothers, Inc.
  - 2. A.C. Miller Concrete Products, Inc.
  - 3. York Concrete Septic Tanks, Inc.

## 2.23 FLOOR DRAINS AND FLOOR SINKS

- A. Equal to the Zurn catalog numbers noted on drawings. Those installed in slabs on grade and above crawl space do not require flashing clamp devices. All others shall have flashing clamp devices.
- B. Floor drain P traps shall be deep seal type and shall have primer plugs.
- C. Floor sinks shall have acid-resistant porcelain enamel interior finish with internal aluminum dome strainers.

#### 2.24 FLEXIBLE FLASHING

- A. Flexible polyvinyl chloride sheet, waterproof and impermeable to water vapor, unreinforced, minimum 56 mils thick, recommended for use in concealed locations only.
- B. Shows no physical deterioration when tested in accordance with ASTM D 822 for at least 400 hours.
- C. Shows no cracking or flaking when, at -20 degrees F (-6.5 degrees C), it is bent 180 degrees over a 1/32-inch (0.8-mm) mandrel and back 360 degrees over the same mandrel in the opposite direction.
- D. Has no less than 1000 lbs per sq. in. (6900 kPa) tensile strength and no more than 7 percent tension set at 50 percent elongation, when tested in accordance with ASTM D 412.
- E. Products which meet this specification include but are not limited to:
  - 1. Advanced Building Products "Moistseal"
  - 2. Afco Products Company "Vi-Seal"
  - 3. York Manufacturing, Inc. "Wascoseal"

## 2.25 CONCRETE FATS, OILS AND GREASE INTERCEPTOR (GRAVITY TYPE)

- A. Precast reinforced concrete tank, size and capacity shown on drawings, with high and low equalizer openings.
  - 1. Inlet and outlet pipe and fittings: Standard weight cast-iron soil pipe, sizes as shown on drawings.
  - 2. Include 24-inch reinforced concrete extension to grade.
- B. Frame and cover: Roadway-type manhole frame and solid cover, equal to Neenah R-1500. Cast the words "GREASE INTERCEPTOR" into the cover surface.

## 2.26 CLEANOUTS

A. Cleanouts: Equal to following Zurn Catalog numbers. Those installed in slab on grade and in slab above crawl spaces do not require membrane flashing device. All others shall have flashing devices.

- B. In vertical sanitary lines:
  - 1. Exposed piping: PVC threaded cleanout plug.
  - 2. Concealed piping: PVC threaded cleanout plug.
  - 3. Concealed piping where more than 8 inches (205 mm) back from finished wall line: Install a sanitary 90 degrees long turn Y fitting with PVC cleanout plug extended out to finish 1 inch (25 mm) behind finished wall. Provide with Z-1460-9x9 cover plate (access panel) with vandalproof screws.
- C. In underfloor sanitary lines: (See Floor Finish Schedule) All units complete with bronze plug.
  - 1. In storage areas with plain or painted concrete floors: ZB-1400.
  - 2. In exposed areas with plain or painted concrete floors: ZN-1400.
  - 3. In resilient tile floors: ZN-1400-TX.
  - 4. In ceramic tile floors: ZN-1400-T.
  - 5. In carpeted floors: ZN-1400-CM.
  - 6. In terrazzo floors: ZN-1400-DC.
- D. Outside cleanouts shall be ZN-1400-HD with vandalproof screws.

## 2.30 SOLIDS INTERCEPTOR

A. Equal to Zurn ZA-1180-CS-SS, interior and exterior acid-resistant coated, steel fabricated solids interceptor. Top access with gasketed and secured cover, removable 3/32-inch-perforated stainless-steel diffusing/intercepting screens and acid-resistant-coated steel sediment bucket.

# PART 3 - EXECUTION

# 3.23 INSTALLING FLOOR DRAINS AND FLOOR SINKS

- A. Where floor drains are over occupied areas, flash them with flashing specified in this section, single piece for each drain, 30 by 30 inches (762 by 762 mm) with opening cut in center to suit clamping device of drain. Adhere flashing to substrate with adhesive and secure to clamping device of drain. Ascertain that weep holes from drainage pan are open.
- B. Generally, the rims of floor drains and sinks shall be set 1 inch (25 mm) below specified floor finish level and the floor sloped to the drain so as to finish flush with the rim.
- C. Floor drains and floor sinks shall be provided with deep seal cast-iron P traps with primer connections.
- D. Floor drains and floor sinks shall be provided with trap primers.
  - 1. Floor drains in toilet areas discharging into sanitary sewer shall be provided with primers taken from flush valve tailpiece of nearest water closet. The priming line shall be run concealed in NPS 0.5 (DN 15) soft drawn copper pipe to the P trap connection. Provide one primer for each floor drain.
  - 2. Where a water closet is not available, or more than one trap (up to a maximum of four traps) is to be primed, provide pressure type primers from water mains. Take the water connection from the nearest cold water line. Provide connection with loose key stop.

Provide a NPS 0.5 (DN 15) balancing valve in line to each trap. Set primer valves above floor level of the drains they serve, and locate where possible in janitor's closets, storage rooms, or other spaces accessible to maintenance personnel only.

- 3. Kitchen areas, and areas requiring more than four and up to a maximum of eighteen trap primers, shall be provided with an automatic trap priming system.
- E. Do not kink primer tubing runouts to P traps during installation.
- F. Floor drains shall be covered until placed in service to prevent the entrance of any foreign matter.
- 3.24 INSTALLING CLEANOUTS
  - A. Install cleanouts at base of each vertical sanitary, waste, and vent stack, in the vertical piping.
  - B. Cleanouts shall be the same size as the pipe into which they are installed, except no cleanout shall be larger than NPS 4 (DN 100).
  - C. Install cleanouts in horizontal piping where indicated on drawings. Where cleanouts occur directly below a floor, the cleanout shall terminate with top flush with floor. Provide for the floor finish to be installed on the cleanout cover, and separated from surrounding material. Install carpet markers after carpet installation is completed. Install ceramic tile and terrazzo per manufacturer's instructions.
- 3.25 INSTALLING FATS, OIL AND GREASE INTERCEPTORS
  - A. Install between waste lines and sanitary sewer connection as shown on the drawings.
  - B. Install concrete interceptor in accordance with manufacturer's instructions and as indicated on the drawings.
  - C. Install concrete tank and extension so that frame and cover will be flush at grade, in accordance with drawings.
- 3.26 INSTALLING SOLIDS INTERCEPTOR
  - A. Install so that strainer can be removed for cleaning.

## SECTION 22 14 13 - STORM DRAINAGE PIPING

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Storm piping, interior and exterior.
- 1.14 RELATED SECTIONS
  - A. Piping installation and testing: Section 22 05 00.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Each specified material and product.

### 1.40 QUALITY ASSURANCE

A. PVC pipe and fittings shall be marked with the collective trademarks and universal standard code, noting manufacturer, ASTM designation, pipe size, pressure rating and schedule number.

## PART 2 - PRODUCTS

#### 2.20 PIPING AND FITTINGS, TYPES

- A. Install each type of pipe and fittings in locations required or permitted in Part 3, including the Pipe Installation Schedule at the end of the section.
- B. Type G: Plastic DWV pipe and fittings:
  - 1. Pipe: PVC, Schedule 40, ASTM D 1785.
  - 2. Fittings: PVC, DWV, ASTM D 2665.
  - 3. Solvent cement: PVC, ASTM D 2564.

## PART 3 - EXECUTION

#### 3.05 PREPARATION

- A. Connect piping to site utility as shown on the drawings. Check elevations of these connection points before installing new work.
- 3.20 INSTALLATION, GENERAL
  - A. Use suitable tools and appliances for the safe and convenient handling and laying of pipe. Examine each section of pipe for defects. Do not lay any piece that is known to be defective. If any defective piece should be discovered after having been laid, remove and replace it at no change to the contract price.

- B. Install piping in accordance with the Pipe Installation Schedule at the end of this section, as indicated on the drawings, and in accordance with Section 22 05 00, Common Work Results for Plumbing. Materials and work shall conform to local plumbing codes and health department regulations.
- C. Install PVC piping according to the latest installation instructions published by the manufacturer, and ASTM D2321 Underground Installation of Flexible Thermoplastic Sewer Pipe. Where piping is installed below slab on grade and at exterior of the building, special care shall be utilized in trenching, preparing laying bed, supporting and backfilling piping.
- D. Thoroughly clean all pipe and fittings before installing them, and keep them clean until the acceptance of the completed work. Cap or plug ends of lines to prevent debris from entering during construction.
- E. Make changes in direction of sanitary piping with approved sanitary fittings, Y branches, 1:8 or 1:16 bends.
- F. In soil, waste, and vent stacks where branches occur that are smaller than stacks, provide properly sized reducing fittings.
- 3.21 RESTRICTIONS ON LOCATIONS
  - A. Piping and kitchen types and joining methods for piping located above kitchen areas including food storage, serving line, and food preparation shall be in strict compliance with Code of Maryland regulations.
  - B. Plastic piping above ground (Types G):
    - 1. Are not allowed in HVAC ceiling plenums or shafts used to convey building air distribution where not rated for that application.
    - 2. Require special protection designed for plastic piping penetrations where they occur in fire-rated assemblies or floors.

# 3.25 INSTALLING STORM PIPING

- A. Install roof overflow spout on each roof overflow drain outlet.
  - 1. Locations: Shown on drawings, no less than 24 inches (610 mm) above finished grade.
  - 2. Coordinate installation with wall construction and wall finish application materials, as applicable.

## 3.90 SCHEDULES

STORM PIPE INSTALLATION SCHEDULE Contractor has option where more than one x appears on a line		
MATERIAL TYPE		
USE	G	
Storm, exterior	Х	
Storm, below slab on earth	Х	
Storm, concealed within walls or partitions	Х	
Storm, ceiling space	Х	
Storm, interior exposed	Х	

# ALL OF THE ABOVE SUBJECT TO LOCAL PLUMBING CODE AND HEALTH DEPARTMENT REQUIREMENTS

# MATERIAL TYPES (Refer to Part 2 - Products)

G - Plastic DWV

## SECTION 22 14 23 - STORM DRAINAGE PIPING SPECIALTIES

## PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Drains and cleanouts.
  - B. Flashing material.
- 1.14 RELATED SECTIONS
  - A. Piping: Section 22 14 13.
  - B. Flashings: Section 22 05 06.
  - C. Insulation: Section 22 07 19.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Each specialty device or equipment, with installation instructions.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. General: Model numbers are provided in the articles below to set a standard for materials, quality of construction, options and details, and performance. Provide named products, or equal products by the acceptable manufacturers listed.
- B. Drains and cleanouts:
  - 1. Josam Company
  - 2. Jay R. Smith Manufacturing Company
  - 3. MIFAB, Inc.
  - 4. Wade
  - 5. Watts Drainage
  - 6. Zurn Plumbing Products

## 2.21 PRIMARY ROOF DRAIN AND SECONDARY OVERFLOW DRAIN

- A. Primary roof drain RD-A, RD-B, and RD-D: Equal to Zurn ZA-100, ZA-125, and Z-100.
  - 1. Include options as noted in "Roof Drain Schedule" on drawings.
  - 2. Overall size as noted in "Rood Drain Schedule" on drawings.
  - 3. Outlet size as noted on drawings.
  - 4. Connection: As noted in "Roof Drain Schedule" on drawings.

- B. Secondary overflow drain OFD-E and OFD-F: Equal to Zurn ZA-100, ZA-125, and Z-100.
  - 1. Include options as noted in "Roof Drain Schedule" on drawings.
  - 2. Overall size as noted in "Roof Drain Schedule" on drawings.
  - 3. Outlet size as noted on drawings.
  - 4. Connection: As noted in "Roof Drain Schedule" on drawings.
- C. Primary green roof drain RD-C: Equal to Zurn ZA-110.
  - 1. Include options as noted in "Roof Drain Schedule" on drawings.
  - 2. Overall size as noted in "Roof Drain Schedule" on drawings.
  - 3. Outlet size as noted on drawings.
  - 4. Connection: As noted in "Roof Drain Schedule" on drawings.
- D. Secondary/overflow green roof drain OFD-G: Equal to Zurn ZA-110.
  - 1. Include options as noted in "Roof Drain Schedule" on drawings.
  - 2. Overall size as noted in "Roof Drain Schedule" on drawings.
  - 3. Outlet size as noted on drawings.
  - 4. Connection: As noted in "Roof Drain Schedule" on drawings.
- E. Lead for flashing roof drain: 4-lb (1.55-mm-thick) sheet.

## 2.22 ROOF OVERFLOW SPOUT

- A. Equal to Zurn Z-199 downspout nozzle, flanged spout designed to direct roof overflow away from building.
- B. Materials: Polished nickel bronze body with removable stainless-steel screen.
- C. Size: Noted on drawings.
- D. Connections: No hub.

## 2.26 CLEANOUTS

- A. Cleanouts: Equal to following Zurn Catalog numbers. Those installed in slab on grade and in slab above crawl spaces do not require membrane flashing device. All others shall have flashing devices.
- B. In vertical storm lines:
  - 1. Exposed piping: PVC threaded cleanout plug.
  - 2. Concealed piping: PVC threaded cleanout plug.
  - 3. Concealed piping where more than 8 inches (205 mm) back from finished wall line: Install a sanitary 90 degrees long turn Y fitting with bronze cleanout plug extended out to finish 1 inch (25 mm) behind finished wall. Provide with Z-1460-9x9 cover plate (access panel) with vandalproof screws.
- C. In underfloor storm lines: (See Floor Finish Schedule) All units complete with bronze plug.
  - 1. In storage areas with plain or painted concrete floors: ZB-1400-2.

- 2. In exposed areas with plain or painted concrete floors: ZN-1400-2.
- 3. In resilient tile floors: ZN-1400-TX.
- 4. In ceramic tile floors: ZN-1400-T.
- 5. In carpeted floors: ZN-1400-CM.
- 6. In terrazzo floors: ZN-1400-DC.
- D. Outside cleanouts shall be ZN-1400-HD with vandalproof screws.

## PART 3 - EXECUTION

## 3.21 INSTALLING ROOF DRAINS

- A. The first fitting below the roof drain shall be a combination Y and eight bend with cleanout plug, except over food preparation and serving areas.
- B. Set roof drains so flashing clamp ring is depressed below normal roof membrane level. Flashing of the roof drains shall be as specified in Division 07.
- C. Set roof drains to fit pitch of roof.
- D. Sheet lead gaskets shall extend 12 inches (305 mm) beyond outer edge of roof drains and shall be secured with the flashing clamp.
- E. Flashing clamp ring shall be embedded into the roofing and made watertight.
- F. Ascertain that weep holes into drainage pans are open.
- 3.22 INSTALLING ROOF OVERFLOW SPOUT
  - A. Install roof overflow spout on each roof overflow drain outlet. Outlets shall be at locations shown on drawings, no less than 24 inches (610 mm) above finished grade.
  - B. Coordinate installation with construction of wall and with application of wall finish materials, as applicable.
- 3.24 INSTALLING CLEANOUTS
  - A. Install cleanouts at base of each vertical storm water, soil, waste, and vent stack, in the vertical piping.
  - B. Cleanouts shall be the same size as the pipe into which they are installed, except no cleanout shall be larger than NPS 4 (DN 100).
  - C. Install cleanouts in horizontal piping where indicated on drawings. Where cleanouts occur directly below a floor, the cleanout shall terminate with top flush with floor. Provide for the floor finish to be installed on the cleanout cover, and separated from surrounding material. Install carpet markers after carpet installation is completed. Install ceramic tile and terrazzo per manufacturer's instructions.

#### SECTION 22 14 29 - SUMP PUMPS

#### PART 1 - GENERAL

- 1.11 WORK INCLUDED
  - A. Elevator shaft sump pump system.
- 1.14 RELATED SECTIONS
  - A. Motors: Section 22 05 13.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Include certified performance curves and rated capacities of selected models; shipping, installed, and operating weights; furnished specialties; and accessories for each type and size of pump specified. Indicate pumps operating point on curves.
- C. Shop drawings: Show layout and connections for pumps. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.
  - 1. Wiring diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
- D. Maintenance data: For each pump specified, to include in maintenance manuals specified in Division 01 and Section 22 01 01.

## 1.40 QUALITY ASSURANCE

A. UL label and local testing (if required): As specified in Section 22 05 00, Common Work Results for Plumbing.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Specified units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 22 01 01, and submit shop drawings as specified in article 1.30 above.
- B. Elevator shaft submersible sump pump systems:
  - 1. Stancor, Inc.
  - 2. Barnes, Crane Pumps and Systems
  - 3. Zoeller Co.

## 2.22 ELEVATOR SHAFT SUBMERSIBLE SUMP PUMP SYSTEM

- A. Basis-of-design product: Subject to compliance with requirements, provide Stancor "Oil Minder" or comparable product manufactured by other listed manufacturer.
- B. Packaged system: Submersible elevator pit system, UL 508 controller and UL 778 pump, listed and tested for elevator shaft service for automatic pumping of elevator shafts in accordance with ASME A17.1 and approved by the authority having jurisdiction.
  - 1. Components:
    - a. Liquid level switches mounted as indicated on drawings: Detect liquid levels (Pump On level and High Water Alarm level).
    - b. Sensor: Detects the presence or absence of oil.
    - c. Control system in wall-mounted NEMA 250 Type 4X enclosure.
    - d. Audible local alarm with manual reset and connections for remote alarm annunciation.
- C. Sump pump: Stancor SE100, heavy-duty, single mechanical seal, capacities and current characteristics indicated on drawings, factory-assembled and -tested, submersible, freestanding unit, rated for continuous operation.
  - 1. Minimum NPS 2 (DN 50) discharge connection with shutoff valve and check valve.
  - 2. Impeller: Cast iron or thermoplastic.
  - 3. Housing: Cast iron or stainless steel.
  - 4. Exposed parts: Stainless steel, bronze, rubber, PTFE, or high-impact molded plastic.
  - 5. Motor: Capacitor start, built-in thermal overload and lightning protection.
- D. Operation: Liquid level switches and oil sensor act in concert to automatically remove water from the sump pit while ensuring that no oil or similar substance is pumped.
  - 1. When switch indicates the Pump On level, and the oil sensor does not indicate the presence of oil, the switch shall initiate pumping until either the Pump Off level is reached or the sensor senses oil.
  - 2. When switch indicates the Pump On level, but the sensor indicates oil, pump shall shutoff and the audible alarm shall sound and alarm condition shall be annunciated.
  - 3. When switch indicates the High Water alarm level, the audible alarm condition shall be annunciated.
  - 4. Alarm condition shall require manual silencing and reset.

## 2.27 SUMP PUMP PIT

- A. Concrete pit as detailed on structural drawings.
- B. Pit: 24 by 24 inch (610 by 610 mm) by 24 inches (610 mm) deep.
- C. Sump pit grate: Equal to Neenah R-4826-A, heavy-duty bar grate, designed for use with concrete pit.

## PART 3 – EXECUTION

## 3.21 INSTALLING SUMP PUMP PIT

- A. Coordinate construction of concrete pit with installation of cover. Set frame so that cover will be flush with floor.
- 3.22 INSTALLING SUMP PUMP
  - A. Provide stop valve and spring loaded check valve in discharge from each pump.
  - B. Install pump and connect to drainage piping.
  - C. Set the alarm to sound if water in pit rises above the high water (pump start) level.
  - D. Connect wiring between controls, pump, and remote control panel.

## 3.70 ADJUST AND CLEAN

- A. Set pump controls for specified operation.
- B. Before starting, perform preventive maintenance:
  - 1. Lubricate bearings.
  - 2. Disconnect couplings and inspect motors for proper direction of rotation.
  - 3. Verify that each pump rotates freely by hand. If it is bound or drags, determine the cause and correct it.
  - 4. Verify that pump controls are correct for the application.

## 3.80 STARTUP

- A. Start motors.
- B. Open discharge valves only.
- C. Check general mechanical operations of systems and motors.

## SECTION 22 33 00 - ELECTRIC DOMESTIC WATER HEATERS

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Commercial, storage type electric water heaters.
- 1.14 RELATED SECTIONS
  - A. Equipment foundation: Section 22 05 29.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: Each type and size water heater. Include nominal capacity and pressure rating; shipping, installed, and operating weights; and specialties and accessories furnished for this project. Indicate dimensions, wall thicknesses, required clearances, method of assembly, and piping connections.
- C. Shop drawings: Diagram power, signal, and control wiring.
- D. Include product data which verifies compliance with the energy performance requirements of ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
- E. Include operation and maintenance instructions and parts list for each type of water heater.

## 1.40 QUALITY ASSURANCE

- A. Each water heater shall meet the energy performance requirements of ASHRAE 90.1.
- B. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. ASME compliance: Fabricate and label water heater to comply with ASME Boiler and Pressure Vessel Code.
- D. UL label and local testing (if required): As specified in Section 22 05 00, Common Work Results for Plumbing.
- E. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
  - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
  - 2. NSF/ANSI 61.

- E. Acceptance product marking: NSF®-61 and NSF®-372 (or NSF®-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.
- F. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Scheduled units are the basis for design of the Project. If units by other manufacturers should be proposed, verify that they meet requirements specified in Division 01and the article "Product Options" in Section 22 01 01, and submit shop drawings as specified in article 1.30 above.
- B. Electric water heaters:
  - 1. A.O. Smith Corporation
  - 2. Hubbell
  - 3. PVI
  - 4. State Industries, Inc.

# 2.24 ELECTRIC TANK WATER HEATER

- A. Equal to A.O. Smith DVE, as scheduled; model, capacity, and electrical characteristics scheduled on the drawings, rated at maximum working pressure of 150 psi (1035 kPa), listed and labeled in accordance with UL 174. Heater shall be constructed in accordance with ASME Code, and shall bear appropriate symbol and be listed with the National Board.
- B. Tank: Internal surfaces exposed to water shall be lined with glass or cement. Insulation: Fiberglass. Jacket: Steel, containing full-size control compartments for service and maintenance through front. Finish: Manufacturer's standard baked enamel.
- C. Equipment:
  - 1. Inlet carries entering cold water to bottom of tank.
  - 2. Tank-mounted, replaceable, magnesium anode. Anode rods not required for cement-lined water heaters.
  - 3. Combination thermostat and high-temperature-limit control.
  - 4. Incoloy sheathed heating elements.
  - 5. 0.75-inch top opening for field installation of relief valve.
  - 6. Solid state modulating step control.
  - 7. Relief valve: ASME-rated temperature and pressure relief valve for field installation. Include relieving capacity at least as great as heat input, and pressure setting less than heater working pressure rating.
  - 8. Provide magnetic contactors, low-water cutoff, and fused control transformer.

## 2.70 WATER HEATER SPECIALTIES

- A. Vacuum relief valve: Designed for vacuum relief in hot water tanks and heaters, ANSI Z21.22, brass body, high-heat-resisting disk, equal to Watts No. N36.
  - 1. Working pressure: At least 200 psi.
  - 2. Temperature rating: At least 250 degrees F.
  - 3. Operation: Closes under pressure and opens on vacuum of not more than 0.5 inches of mercury.

## PART 3 - EXECUTION

#### 3.20 INSTALLATION

- A. Provide each heater with ASME rated temperature and pressure relief valves.
- 3.23 INSTALLING DOMESTIC WATER HEATER
  - A. Set heater on an equipment foundation (housekeeping pad). Plug all unused tappings.
  - B. Install level and plumb, according to drawings and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so that controls and devices are accessible.
  - C. Anchor water heaters to substrate per manufacturer's instructions.
  - D. Install and connect water heaters in accordance with applicable code for electric water heaters.
  - E. Install temperature and pressure relief valves. Extend relief valve outlet with water piping in continuous downward pitch and discharge to nearest floor drain.
  - F. Install vacuum relief valves.
- 3.60 MANUFACTURER'S FIELD SERVICE
  - A. Provide manufacturer's startup and adjustment for water heaters.
- 3.81 OPERATING INSTRUCTIONS
  - A. As specified in Section 22 05 00, provide operating instructions.

## **SECTION 22 42 00 - INSTITUTIONAL PLUMBING FIXTURES**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Institutional grade plumbing fixtures and trim, faucets, other fittings, and related components.
- 1.14 RELATED SECTIONS
  - A. Piping: Sections 22 11 16, 22 13 16, and 22 14 13.
  - B. Valves: Section 22 05 23.
  - C. Plumbing specialties: Section 22 11 19.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 22 01 01.
- B. Product data: For each type of plumbing fixture specified, including fixture and trim, fittings, accessories, appliances, appurtenances, equipment, supports, construction details, dimensions of components, and finishes.
- C. Shop drawings:
  - 1. Provide a schedule of fixtures and trim proposed for use, in the same order as the lists in the specification.
  - 2. Wiring diagrams for field-installed wiring of electrically operated units.
- D. LEED Submittals: For water closets, urinal, documentation indicating flush rate in gallons per flush (gpf); for faucets, showerhead and spray rinse valves, documentation indicating flow rate in Gallons per minute (gpm).

## 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 22 05 00, Common Work Results for Plumbing.
- B. Fixtures shall be of the best commercial grade of their respective kinds, free from flaws, cracks, craze or other imperfections, complete with fittings and connections. Residential grade fixtures shall not be acceptable. Fixtures manufactured by acceptable manufacturers are acceptable provided they are equal and similar to those specified.
- C. Fixtures and trim where required to be accessible to disabled people, identified in this section as "for disabled," shall comply with requirements of the Americans with Disabilities Act (ADA) Regulations, as applicable to each type of fixture or its use.
  - 1. Trim must meet requirements for water pressures up to 80 psi.

- 2. Water closets and urinal models must be selected and installed so that flush controls will be on the fixture's open side.
- D. Potable water system components intended to dispense water for human consumption, including pipe and joining materials, shall comply with the following:
  - 1. A weighted average lead content of not more than 0.25 percent as determined by NSF/ANSI 372.
  - 2. NSF/ANSI 61.
- E. Product specifications herein may not necessarily meet all regulations for the limits on lead content. The Contractors and product suppliers shall be responsible to provide products that comply with NSF/ANSI 61 and NSF/ANSI 372 for domestic water systems.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design products: Subject to compliance with requirements, provide specified or scheduled products or comparable product by one of the following.
  - 1. Fixtures:
    - a. American Standard
    - b. Bradley Corporation
    - c. Commercial Enameling Co.
    - d. Crane Co.
    - e. Eljer
    - f. Elkay Manufacturing Co.
    - g. Fiat Products.
    - h. Guy Gray; IPS Corporation
    - i. Just Co.
    - j. Kohler Co.
    - k. E.L. Mustee & Sons, Inc.
    - 1. Zurn Plumbing Products
  - 2. Emergency fixtures:
    - a. Bradley Corporation
    - b. Encon Safety Products
    - c. Guardian Equipment
    - d. Haws Corp.
    - e. Speakman Co.
  - 3. Faucets:
    - a. Chicago Faucet Co.
    - b. Speakman Co.
    - c. T & S Brass and Bronze Works, Inc.

- 4. Supplies, traps, and miscellaneous trim:
  - a. Brass-Craft Manufacturing Co.
  - b. Chicago Faucet Co.
  - c. Engineered Brass Co.
  - d. McGuire Manufacturing Co.
  - e. T & S Brass and Bronze Works, Inc.

#### 5. Toilet seats:

- a. Bemis
- b. Beneke Corp.
- c. Church Seats
- d. Olsonete Co.
- e. Sperzel Co.
- 6. Flush valves:
  - a. Delaney Flush Valves
  - b. Sloan Valve Co.
  - c. Zurn Plumbing Products
- 7. Water coolers:
  - a. Eljer Mfg. Co.
  - b. Elkay Manufacturing Company
  - c. Halsey Taylor
  - d. Haws Corp.
  - e. Oasis Water Coolers
  - f. Sunroc Corporation
- 8. Fixture supports and carriers:
  - a. Josam Mfg. Co.
  - b. J.R. Smith
  - c. Zurn Plumbing Products

## 2.20 FIXTURES

- A. Model numbers are intended to describe complete fixtures. Furnish all parts and fittings regularly required such as tailpieces for lavatory faucets, escutcheons, and appurtenances, including low-voltage devices and wiring for fixtures which require them to operate.
- B. Fixtures shall be white except where another color is specified for a particular fixture.
- C. Water closet and urinal models specified or noted to be accessible in accordance with ADA requirements: Select models such that flush controls will be on the fixture's open side when fixtures are installed.

## 2.31 WATER CLOSETS

- A. F-1 water closet, student: Kohler "Wellcomme" K-4350, dual flush.
  - 1. Material: Vitreous china.
  - 2. Bowl type: Elongated, siphon jet, NPS 1.5 (DN 40) top spud.
  - 3. Passageway: 2.25 inches (57 mm).
  - 4. Mounting: Floor-mounted, 14.75 inches (375 mm) rim to floor, 15.75 inches (400 mm) top of seat. Use solid brass closet bolts.
  - 5. Consumption: 1.1 gallon (4.2 L) and 1.6 gallons (6 L) for dual flush cycles.
  - 6. Trim:
    - a. Seat: No. 1
    - b. Flush valve: No. 14
    - c. Bolt caps: Two, No. 115
- B. F- 1A water closet, student disabled: Kohler "Wellcomme" K-4350, dual flush.
  - 1. Material: Vitreous china.
  - 2. Bowl type: Elongated, siphon jet, NPS 1.5 (DN 40) top spud.
  - 3. Passageway: 2.25 inches (57 mm).
  - 4. Mounting: Floor-mounted, 14.75 inches (375 mm) rim to floor, 15.75 inches (400 mm) top of seat. Use solid brass closet bolts.
  - 5. Consumption: 1.1 gallon (4.2 L) and 1.6 gallons (6 L) for dual flush cycles.
  - 6. Trim:
    - a. Seat: No. 1
    - b. Flush valve: No. 14
    - c. Bolt caps: Two, No. 115
- C. F-1B water closet, adult disabled: Kohler "Highcliff" K-4368, dual flush.
  - 1. Material: Vitreous china.
  - 2. Bowl type: Elongated, siphon jet, NPS 1.5 (DN 40) top spud.
  - 3. Passageway: 2.25 inches (57 mm).
  - 4. Mounting: Floor-mounted, 17.5 inches (445 mm) rim to floor, 18.5 inches (545 mm) top of seat. Use solid brass closet bolts.
  - 5. Consumption: 1.1 gallons (4.2 L) and 1.6 gallons (6 L) for dual flush cycles.
  - 6. Trim:
    - a. Seat: No. 1
    - b. Flush valve: No. 14
    - c. Bolt caps: Two, No. 115
- D. F-1C water closet, child disabled: Kohler "Primary" K-4384.
  - 1. Material: Vitreous china.
  - 2. Bowl type: Elongated, siphon jet, NPS 1.5 (DN 40) top spud.
  - 3. Passageway: 2 inches (51 mm).
- 4. Mounting: Floor-mounted, 10.75 inches (273 mm) rim to floor, 12 inches (305 mm) top of seat. Use solid brass closet bolts.
- 5. Consumption: No more than 1.28 gallons (4.8 L) per flushing cycle.
- 6. Trim:
  - a. Seat: Furnished with water closet.
  - b. Flush valve: No. 9
  - c. Bolt caps: Two No. 115

## 2.32 URINALS

- A. F-2 urinal: Kohler HEU System "Bardon" K-4991-ET.
  - 1. Material: Vitreous china.
  - 2. Urinal type: Washdown action, NPS 3/4 (DN 20) top spud.
  - 3. Mounting and outlet: Wall-mounted, outlet threaded, NPS 2 (DN 50).
  - 4. Rim height: 24 inches (610 mm), above floor.
  - 5. Consumption: No more than 1 pint or 0.125 gallon (0.5 L) per flushing cycle.
  - 6. Trim:
    - a. Flush valve: No. 16.
- B. F- 2A Urinal, wall hung for disabled: Kohler HEU System "Bardon" K-4991-ET
  - 1. Material: Vitreous china.
  - 2. Urinal type: Washdown action, NPS 3/4 (DN 20) top spud.
  - 3. Mounting and outlet: Wall-mounted, outlet threaded, NPS 2 (DN 50).
  - 4. Rim height: 17 inches (432 mm), above floor.
  - 5. Consumption: No more than 1 pint or 0.125 gallon (0.5 L) per flushing cycle.
  - 6. Trim:
    - a. Flush valve: No. 16.

# 2.33 LAVATORIES

- A. F- 3 lavatory, student disabled: Kohler "Hudson" K-2868
  - 1. Material: Cast iron with acid-resisting enamel.
  - 2. Lavatory type: Rectangular, front overflow, 8-inch (203-mm) faucet centers.
  - 3. Dimensions: 20 by 18 inches (508 by 457 mm).
  - 4. Mounting: Wall-mounted, 31 inches (787 mm) rim to floor. Include cast-iron carrier fitting to connect to support specified in the article "Support for Wall-Mounted Fixtures" below.
  - 5. Trim:
    - a. Faucet: No. 41
    - b. Supply: Two No. 25
    - c. Nipple: Two No. 62
    - d. Drain: No. 80
    - e. Trap: No. 106

- f. Lavatory insulation kit: No. 122
- g. Thermostatic mixing valve: No. 61
- B. F- 3A lavatory adult disabled: Kohler "Hudson" K-2868
  - 1. Material: Cast iron with acid-resisting enamel.
  - 2. Lavatory type: Rectangular, front overflow, 8-inch (203-mm) faucet centers.
  - 3. Dimensions: 20 by 18 inches (508 by 457 mm).
  - 4. Mounting: Wall-mounted, 34 inches (876 mm) rim to floor. Include cast-iron carrier fitting to connect to support specified in the article "Support for Wall-Mounted Fixtures" below.
  - 5. Trim:
    - a. Faucet: No. 41
    - b. Supply: Two No. 25
    - c. Nipple: No. 62
    - d. Drain: No. 80
    - e. Trap: No. 106
    - f. Lavatory insulation kit: No. 122
    - g. Thermostatic mixing valve: No. 61
- C. F- 3B lavatory, child disabled: Kohler "Hudson" K-2868
  - 1. Material: Cast iron with acid-resisting enamel.
  - 2. Lavatory type: Rectangular, front overflow, 8-inch (203-mm) faucet centers.
  - 3. Dimensions: 20 by 18 inches (508 by 457 mm).
  - 4. Mounting: Wall-mounted, 24 inches (610 mm) rim to floor. Include cast-iron carrier fitting to connect to support specified in the article "Support for Wall-Mounted Fixtures" below.
  - 5. Trim:
    - a. Faucet: No. 41
    - b. Supply: Two No. 25
    - c. Nipple: Two No. 62
    - d. Drain: No. 80
    - e. Trap: No. 106
    - f. Lavatory insulation kit: No. 122
    - g. Thermostatic mixing valve: No. 61.
- E. F-3C wash station: Bradley MF 2949 "Terreon Wall Hung" "Quadra-Fount"
  - 1. Material: "Terreon" solid surface material composed of polyester resin certified to meet ANSI Z124.3, Z124, and ANSI/1 CPA SS-1-2001.
  - 2. Color: Lannon.
  - 3. Pedestal frame and access panel: Type 304 stainless steel.
  - 4. Sprayheads: Four sprayheads, molded as integral part of bowl.
  - 5. Infrared control: Each sprayhead shall be controlled by separate solenoid valves. Solenoid valves shall be 24-V-60Hz with 0.375 inch NPT connection.
  - 6. Thermostatic water temperature controller (ASSE 1070).
  - 7. Low-voltage transformer: Class II UL listed, 110/24 VAC plug-in transformer.

- 8. Mounting: Wall-mounted, 34 inches (864 mm) rim to floor. Include cast-iron carrier fitting to connect to support specified in the article "Support for Wall-Mounted Fixtures" below.
- 9. Trim:
  - a. Trap: No. 104

## 2.34 SERVICE SINKS

- A. F-4 sink, mop: Fiat Model MSB-3624.
  - 1. Material: Molded stone, white with black accents.
  - 2. Sink type: One-piece mop service basin with integrally molded shelf 10.5 inches (267 mm) wide.
  - 3. Dimensions: 36 by 24 inches (914 by 610 mm), 10 inches (254 mm) deep. Both sides shall be 10 inches (254 mm) high with one-inch (25-mm) -wide shoulders.
  - 4. Mounting: Floor-mounted.
  - 5. Accessories: Drain body, No. 302 stainless steel, with combination dome strainer and lint basket, designed for an NPS 3 (DN 80) connection.
  - 6. Trim:
    - a. Faucet: No. 47.
    - b. Mop hanger: No. 121.

# 2.35 SINKS

- A. F-5 classroom sink for student disabled: Elkay Model LRADQ 2521-5.5.
  - 1. Material: Type 304 stainless steel, 18-gage, coated on the underside with sound deadening material.
  - 2. Sink type: Single-compartment, with seamless radius-coved corners, two-hole ledge for faucet, 8-inch (203-mm) centers, rear center 3.5-inches (89 mm) drain outlet.
  - 3. Overall dimensions: 25 by 21 inches (635 by 540 mm), by 5.5 inches (144 mm) deep.
  - 4. Bowl dimensions: 21 by 15.75 inches (533 by 400 mm).
  - 5. Mounting: In countertop specified in Division 06.
  - 6. Trim:
    - a. Faucet: No. 200
    - b. Supply: Two No. 25
    - c. Nipple: Two No. 62
    - d. Drain: No. 85
    - e. Trap: No. 104
    - f. Thermostatic mixing valve: No. 61
- B. F-5A classroom sink for child disabled: Elkay Model LRADQ2521-5.5.
  - 1. Material: Type 304 stainless steel, 18-gage, coated on the underside with sound deadening material.
  - 2. Sink type: Single-compartment, with seamless radius-coved corners, two-hole ledge for faucet, 8-inch (203-mm) centers, rear center, 3.5-inches (89 mm) drain outlet.

- 3. Overall dimensions: 25 by 21 inches (635 by 540 mm) by 5.5 inches (144 mm) deep.
- 4. Bowl dimensions: 21 by 15.75 inches (533 by 400 mm).
- 5. Mounting: In countertop specified in Division 06.
- 6. Trim:
  - a. Faucet: No. 200
  - b. Supply: Two No. 25
  - c. Nipple: Two No. 62
  - d. Drain: No. 85
  - e. Trap: No. 104
  - f. Thermostatic mixing valve: No. 61
- C. F-5B sink for (disabled): Elkay Model LRAD-2219.6.5
  - 1. Material: Type 304 stainless steel, 18-gage, coated on the underside with sound deadening material, satin finish with polished rim.
  - 2. Sink type: Single-compartment, with seamless radius-coved corners, 3-hole ledge for faucet, 8-inch (203-mm) centers, rear center, 3.5 inches (89 mm) drain outlet.
  - 3. Overall dimensions: 22 by 19 inches (559 by 483 mm) by 6.5 inches (165 mm) deep.
  - 4. Bowl dimensions: 18 by 14 inches (457 by 356 mm)
  - 5. Mounting: In countertop specified in Division 06.
  - 6. Trim:
    - a. Faucet: No. 200
    - b. Supply: Two No. 25
    - c. Nipple: Two No. 62
    - d. Drain: No. 85
    - e. Trap: No. 104
    - f. Thermostatic mixing valve: No. 61
- D. F-5C sink art room: Elkay DLRQ-3319-10
  - 1. Material: Stainless steel with sound deadening material on underside, Type 304, 18-gage, nickel bearing stainless steel finish with polished rim.
  - 2. Sink type: Double-compartment, self-rimming, two-hole ledge for faucet, 8-inch (203mm) centers, punched to receive the faucet specified in this trim. Center 3.5 inches (89 mm) drain outlet.
  - 3. Overall dimensions: 33 by 19 inches (838 by 483 mm), 10 inches (254 mm) deep.
  - 4. Bowl dimensions: 14 by 14 inches (356 by 356 mm).
  - 5. Mounting: In countertop specified in Division 06.
  - 6. Trim:
    - a. Faucet: No. 201
    - b. Supply: Two No. 25
    - c. Nipple: Two No. 62
    - d. Drain: No. 85
    - e. Solids interceptor: No. 110
    - f. Thermostatic mixing valve: No. 61
- E. F-5D sink for student disabled, art room: Elkay LRAD-3319-6.5

- 1. Material: Stainless steel with sound deadening material on underside, Type 304, 18-gage, nickel bearing stainless steel finish with polished rim.
- 2. Sink type: Double-compartment, self-rimming, two-hole ledge for faucet, 8-inch (203mm) centers. Rear off-center 3.5 inches (89 mm) drain outlet.
- 3. Overall dimensions: 33 by 19 inches (838 by 483 mm), 6.5 inches (165 mm) deep.
- 4. Bowl dimensions: 14 by 14 inches (356 by 356 mm).
- 5. Mounting: In countertop specified in Division 06.
- 6. Trim:
  - a. Faucet: No. 200
  - b. Supply: Two No. 25
  - c. Nipple: Two No. 62
  - d. Drain: No. 85
  - e. Solids interceptor: No. 110
  - f. Thermostatic mixing valve: No. 61
- F. F-5E sink for disabled: Elkay Model LRAD-3319-6.5.
  - 1. Material: Stainless steel with sound deadening material on underside, Type 304, 18 gage, satin finish with polished rim.
  - 2. Sink type: Two-compartment, self-rimming, four-hole ledge for faucet with spray, 4-inch (100-mm) centers. Rear centered 3.5 inches (89 mm) drain outlet.
  - 3. Overall dimensions: 33 by 19 inches (838 by 483 mm), 6.5 inches (165-mm) deep.
  - 4. Bowl dimensions: 14 by 14 inches (356 by 356 mm).
  - 5. Mounting: In countertop specified in Division 06.
  - 6. Trim:
    - a. Faucet: No. 70
    - b. Supply: Two No. 25
    - c. Nipple: Two No. 62
    - d. Drain: No. 86
    - e. Continuous drain: No. 89
    - f. Trap: No. 104
    - g. Thermostatic mixing valve: No. 61
- G. F-5F sink for disabled: Elkay Model LRAD-3319-6.5.
  - 1. Material: Stainless steel with sound deadening material on underside, Type 304, 18-gage, satin finish with polished rim.
  - 2. Sink type: Two-compartment, self-rimming, four-hole ledge for faucet with spray, 4-inch (100-mm) centers. Center, 3.5 inches (89 mm) outlet on bowl without food waste disposal; rear center, 3.5 inches (89 mm) outlet on bowl with food waste disposal.
  - 3. Overall Dimensions: 33 by 19 inches (838 by 483 mm), 6.5 inches (165-mm) deep.
  - 4. Bowl dimensions: 14 by 14 inches (356 by 356 mm).
  - 5. Mounting: In countertop specified in Division 06.
  - 6. Trim:
    - a. Faucet: No. 70
    - b. Supply: Two No. 25

- c. Nipple: Two No. 62
- d. Drain: No. 86
- e. Continuous drain: No. 89
- f. Trap: No. 104
- g. Thermostatic mixing valve: No. 61
- h. Food waste disposal: No. 119
- H. F-5G sink, instrumental classroom: Elkay Model DLR 3122-10.
  - 1. Material: Stainless steel with sound deadening material on underside, Type 304, 18 gage, satin finish with polished rim.
  - 2. Sink type: One-compartment, self-rimming, two-hole ledge for faucet, 8-inch (203-mm) centers. Center, 3.5 inches (89 mm) drain outlet.
  - 3. Dimensions: 31 by 22 inches (787 by 559 mm), 10 inches (254 mm) deep.
  - 4. Mounting: In countertop specified in Division 06.
  - 5. Trim:
    - a. Faucet: No. 201
    - b. Supply: Two No. 25
    - c. Nipple: Two No. 62
    - d. Drain: No. 86
    - e. Trap: No. 104
    - f. Thermostatic mixing valve: No. 61
- I. F-5H sink for adult disabled, countertop:
  - 1. Same as F-5B, except fitted with:
    - a. Faucet: No. 202
    - b. Foot pedal control: No. 203
    - c. Supply: Two No. 25
    - d. Nipple: Two No. 62
    - e. Drain: No. 86
    - f. Trap: No. 104
    - g. Eyewash: No. 204
    - h. Mixing valve: No. 60

### 2.36 WATER COOLERS

- A. F-6 bi-level (student disabled) water cooler: Oasis Model PG8EBFSL, barrier free, surface wall mounted unit with bottle filling station mounted above ADA side.
  - 1. Water cooler type: Refrigeration circuit with hermetically sealed compressor with aircooled condenser, utilizing refrigerant R-134a. Unit shall be UL listed and comply with ARI 1010 Testing, Operating and Rating requirements.
  - 2. Capacity: To cool 8 gallons (30 L) per hour with inlet water at 80 degrees F and room temperature at 90 degrees F. Unit shall have built-in strainer.
  - 3. Lead: Unit shall contain no lead. This requirement exceeds the standard designation of "lead free." Unit shall be NSF/ANSI Standard 61 and 372 certified.

- 4. Construction: Front and side mounted push pads, stainless-steel satin finish basin, heavyduty galvanized-steel supporting powder-coated galvanized exterior panels
- 5. Bubbler: Flexible hooded rubber bubbler with non-squirt feature.
- 6. Mounting: Bubblers shall be 36 and 30 inches (914 and 762 mm) above finished floor.
- 7. Bottle filling station with brushed stainless-steel cabinet and hands-free activation. Install above ADA side.
- 8. Electrical: 115 volt duplex receptacle connected to a minimum 20 amp ground fault circuit interrupting (GFCI) device to meet UL requirements.
- 9. Fittings and accessories:
  - a. Supply: With shutoff valve and strainer furnished by manufacturer.
  - b. Trap: Trim No. 106.
- B. F-6A bi-level (student disabled) water cooler: Oasis Model PG8ACSL, barrier free, surface wall mounted unit.
  - 1. Water cooler type: Refrigeration circuit with hermetically sealed compressor with aircooled condenser, utilizing refrigerant R-134a. Unit shall be UL listed and comply with ARI 1010 Testing, Operating and Rating requirements.
  - 2. Capacity: To cool 8 gallons (30 L) per hour with inlet water at 80 degrees F and room temperature at 90 degrees F. Unit shall have built-in strainer.
  - 3. Lead: Unit shall contain no lead. This requirement exceeds the standard designation of "lead free." Unit shall be NSF/ANSI Standard 61 and 372 certified.
  - 4. Construction: Front and side mounted push pad, stainless-steel satin finish basin, heavyduty galvanized-steel supporting powder-coated galvanized exterior panels.
  - 5. Bubbler: Flexible hooded rubber bubbler with non-squirt feature.
  - 6. Mounting: Bubblers shall be 36 and 30 inches (914 and 762 mm) above finished floor.
  - 7. Electrical: 115 volt duplex receptacle connected to a minimum 20-amp ground fault circuit interrupting (GFCI) device to meet UL requirements.
  - 8. Fittings and accessories:
    - a. Supply: With shutoff valve and strainer furnished by manufacturer.
    - b. Trap: Trim No. 106
- C. F-6B bi-level (adult disabled) water cooler.
  - 1. Same as F-6A above, except mount bubblers at 39 and 33 inches (991 and 838 mm) above finished floor

### 2.37 SHOWERS

- A. F- 7 shower, adult, for disabled: Bradley Type HN250 shower panel, stainless-steel, with plumbing access panel and piping shroud extending to ceiling. Wall-mounted on brackets provided with unit.
  - 1. Enclosure and receptor: Not part of specified unit.
  - 2. Mounting height of shower head: 72 inches
  - 3. Fittings and accessories:

- a. Shower head: Bradley Model SX fixed direction type, with Equa-Flo HD pressure balance mixing valve with integral stops, and diverter valve with lever handle and Model G, 1.5 gpm flow control.
- b. Hand shower: Hand-held spray with 59-inch stainless-steel flexible hose and poststyle mounting bracket to hold spray on panel. Elevated inline backflow preventer with quick disconnect for flexible hose.
- c. Accessories: Recessed cake soap tray, panel-mounted grab bar meeting accessibility requirements, folding shower seat with Naugahyde cover, shower curtain rod with vinyl curtain and hooks.

### 2.38 OUTLET BOXES FOR ICE MAKER

- A. F- 8 Ice maker supply box: Guy Gray Model SSIB 1 AB
  - 1. Material: 20-gauge, Type 304 stainless-steel box and cover.
  - 2. Mounting: Flush mount in partition 42 inches (1066 mm) above floor.
  - 3. Valve: NPS 0.5 (DN 15) supply valve. NPS 0.25 (DN 8) compression outlet.
  - 4. Box dimensions: 8.25 by 6 inches (210 by 152 mm) by 3.5 inches (90 mm).
  - 5. Trim cover dimensions: 10.875 by 8.375 inches (276 by 212 mm).
  - 6. Trim:
    - a. Backflow preventer: No. 67

#### 2.40 EMERGENCY FIXTURES

- A. F-9 emergency eye and face wash unit: Haws Model 7260BT.
  - 1. Applicable standard: ANSI Z358.1.
  - 2. Materials: Receptor ABS plastic, ANSI Z535.1 safety green, resistant to damage from alkalies, salt solutions, and most acids.
  - 3. Type: Instant-action, stay-open, operated by push flag.
  - 4. Mounting: On wall bracket provided with unit.
  - 5. Fittings and accessories:
    - a. Valve: Model SP225, instant-action, stay-open, chrome-plated brass ball valve. Steady water flow under varying pressures provided by dual automatic pressure compensation devices.
    - b. Operator: Push flag with sign showing operation.
    - c. Heads: Two, Model SP11, ABS plastic mounted on chrome-plated brass supply, with dust covers which automatically release with water pressure.
    - d. Trap: 1.5-inch, satin chrome plated.
  - 6. Trim: No. 60, equal to Bradley Model S19-2000, 8 gpm (30.3 L/min).

### 2.65 TRIM

- A. Exposed trim shall be chrome-plated.
- B. Exposed trim shall be vandalproof.

- C. Faucets: Equal to the named model shall mean similar in appearance, function, construction and design features. Internal parts are not required to be interchangeable.
- D. Flush valves shall be provided with vacuum breakers.
- E. Trim numbers listed in the fixture descriptions above represent the descriptions in the article "Trim Schedule" at the end of the section.

### 2.70 SUPPORTS FOR WALL-MOUNTED FIXTURES

- A. Lavatories mounted on shafts or partitions where there is no floor on the opposite side: Equal to Zurn Z-1259 plate carriers.
  - 1. Single lavatory: The plate carrier shall have a backup plate of 10-gauge steel, at least 6 inches (152 mm) high by 38 inches (965 mm) long.
  - 2. Battery-mounted lavatories: The 10-gauge backup plate shall be continuous for full length of battery of fixtures, with the carrier plates properly spaced and welded to the backup plate.
- B. For lavatories mounted on partitions where there is a floor on the opposite side: Equal to Zurn Z-1224 plate carrier with legs anchored to floor.
- C. Urinals: Equal to Zurn Z-1222 chair carriers, anchored to floor.
- D. Other wall-supported fixtures: Cast-iron wall hangers securely bolted to wall.
  - 1. Where void spaces occur on opposite side of partition: 0.375-inch through bolts with plate washers.
  - 2. Where finished surfaces occur on opposite side of partition: Toggle bolts or bolts with plate washers built within the walls.

### PART 3 - EXECUTION

### 3.20 INSTALLATION

- A. Furnish, provide rough-in for, and set fixtures to extent and number indicated on drawings. The fixtures shall be left in first class condition, properly adjusted, cleaned and ready for satisfactory operation.
  - 1. Where water closets and urinals are specified or noted to be accessible in accordance with ADA requirements, ensure that flush controls are installed on the fixture's open side.
- B. Protect plumbing fixtures and board them over so that they cannot be used until final acceptance of the work.

### 3.21 SETTING OF FIXTURES

A. In locations where fixtures are set against walls, seal crack between wall and fixture with white or clear silicon sealant.

- B. Set floor outlet fixtures on floor flanges with gaskets and cement-grout them to rest firmly and evenly on floors. Water closets shall be secured with two bolts attaching to the floor flanges and the base shall be sealed to the floor using a clear silicone caulk. The fixtures shall be secured over these bolts with Trim No. 115 bolt caps.
- C. Securely attach wall hung fixtures to wall using specified supports.
- D. Install solids interceptor so that basket strainer can be removed for cleaning from the top.
- E. After installation, paint undersides of cast-iron lavatories.
- F. Maximum length of supply risers shall be 12 inches (305 mm), install supplies at heights as required to make connection to faucet.

### 3.22 MOP SINKS

A. Install basins for mop sinks as recommended by manufacturer with space between basin and wall completely filled with a waterproof silicon sealant. Provide P trap.

### 3.23 INSTALLATION OF OUTLET BOXES FOR ICE MAKER

A. Install box(es) in accordance with the manufacturer's recommendations.

#### 3.90 TRIM SCHEDULE

## <u>Trim No.</u>

## Description

- 1 Seat: Church No. 295 SSCT white solid plastic, elongated, open front; stainless-steel hinge posts with combination self-sustaining and check hinge.
- <sup>9</sup> Flush valve: Sloan "Royal" No. 111-1.28, complete with dual bypass filter diaphragm, vacuum breaker, NPS 1.5 (DN 40) top spud connection and flanges, 1.28 gallons (4.8 L) per flushing cycle. Include cast escutcheon, vandal-resistant stop cap, and ADA-compliant handle operation.
- 14 Flush valve: Sloan Dual-Flush No.WES-111, complete with vacuum breaker, NPS 1.5 (DN 40) top spud connection and flanges, 1.6 gallons (6 L) per flushing cycle by pushing down, and 1.1 gallons (4.2 L) per cycle by pulling up. Include cast escutcheon, vandalresistant stop cap, and ADA-compliant handle operation.
- 16 Flush valve: Sloan "Royal" No. 186-0.125 manual flush valve for HEU system, complete with vacuum breaker, NPS 0.75 (DN 20) top spud connection and flanges, 0.125 gallon (0.5 L) per flushing cycle. Include cast escutcheon, vandal-resistant stop cap, and ADAcompliant handle operation.
- 25 Supply and stop: Chicago No. 1019-ABCP supply with 0.500-inch threaded inlet angle valve, 0.375-inch OD by 12-inch bullnose riser, chrome-plated finish, and slip wall flange.
- 41 Faucet: Chicago No. 404-VE2805-665ABCP combination hot and cold metering, widespread, slow-closing, with 5-inch (127-mm) spout and vandalproof 0.5 gpm flow restrictor. Adjust metering faucet for 10 seconds.

#### <u>Trim No.</u>

#### Description

- 47 Faucet: Chicago No. 445-897SRCXKCP, vacuum breaker spout with <sup>3</sup>/<sub>4</sub>-inch hose thread outlet, integral stops in shank, lever handles, adjustable support arms, wall brace with adjustable rod, and pail hook.
- 60 Emergency fixture thermostatic mixing valve: ANSI Z358.1, vandal-resistant temperature adjustment, bronze body, check stop on inlets, liquid-filled motor, operating pressure 125 psi (860 kPa), rough bronze finish. Temperature control shall be accurate to plus or minus 3 degrees F (1.5 degrees C) of the setpoint. Hot water shall be shut off if cold water supply should fail; cold water shall flow if hot water supply should fail.
- 61 Individual thermostatic mixing valve: Chicago Faucet No. 131-CABNF, ASSE 1070, brass body construction, less than 0.25 percent lead content, 0.375-inch compression inlets/outlets, integral check valves, temperature adjustment cap with lock, wall bracket, minimum flow rate 0.35 gpm, maximum flow rate 4.6 gpm, 0.375-inch compression tee inlet connection for cold water bypass.
- 62 Nipples: Brass-craft triple-plated polished chrome of length and size as required.
- 67 Backflow preventer: Watts No. LFN9C dual check vacuum breakers to prevent backsiphonage of water flow. Complies with the requirements of CSA B64.8. Brass body construction with polish chrome plating. 125 psi (8.6 bar) maximum working pressure and 33 degrees F to 140 degrees F (0.5 degrees C to 60 degrees C) temperature range. Inlet and outlet connection is NPS 0.25 (DN 6).
- 70 Faucet: Chicago No. 1102-ABCP top mount deck sink fitting with No. L8 8-inch (203mm) swing spout, No. E34JKABCP spray outlet, 1.5 gpm laminar flow, No. 1000 handles, self-closing thumb control spray with 4 feet of hose. Inlet shanks on 8-inch (203-mm) centers.
- 71 Faucet: Chicago No. 786-ABCP top mount deck sink fitting with No. GN2 6-inch (152 mm) swing gooseneck spout, No. BVBE2 vacuum breaker, No. 317 wristblade handles, inlet shanks on 8-inch (203-mm) centers, 0.75-inch (20 mm) male hose thread adapter.
- 80 Drain: McGuire No. 155-A, non-removable open grid strainer, 1.25 by 6 inch tailpiece.
- 85 Drain: Elkay No. LK-18-B stainless-steel stamped drain fitting, 4.5-inch (114-mm) top with 3-inch (76-mm) grid, and 2.0-inch (51 mm) OD by 4-inch (102 mm) tailpiece.
- 86 Drain: Elkay No. LK-35-B crumb cup strainer with 1.5-inch tailpiece.
- 89 Drain: McGuire No. 111 continuous waste, end outlet, 1.5 inch by 17 gage, centers as required.
- 104 P trap: McGuire No. 8089, 1.5 by 1.5-inch IPS outlet, cast-brass ground joint, swivel type, with cleanout, complete with NPS 1.5 cast-brass nipple and cast set-screw escutcheon.
- 106 P trap: McGuire No. 8090, 1.25 by 1.5 inch IPS outlet, cast-brass, ground joint, swivel type, with cleanout and complete with McGuire No. 2127, NPS 1-1/2 (DN 40) brass nipple with cast set screw escutcheon.

#### Trim No. Description 110 Solids interceptor drain: Zurn No. ZA-1180-CS-SS, interior and exterior acid-resistant coated, steel fabricated solids interceptor for on floor installation. Top access with gasketed and secured cover, removable 3/32-inch-perforated stainless-steel diffusing/intercepting screens and acid-resistant-coated steel sediment bucket. Provide 2inch (51 mm) threaded inlet/outlet. 115 Bolt caps: Chrome-plated acorn nuts, size as required. 119 Food disposer: In-sink-erator Model Evolution Series "PRO Cover Control Plus" stainless-steel food waste disposer, with lock cover/batch feed, automatic reversing switch, 7/8 horsepower motor and 2 stages of grind. 121 Mop hanger: Fiat Products, Inc. No. 889-CG 24 inches (610 mm) long by 3 inches (76 mm) wide, 18-gage, No. 302 stainless-steel mop hanger complete with slotted matching screws for mounting. Lavatory insulation kit: Truebro Lav-Guard 2" Series 102 E-Z fully molded interlocking 122 trap assembly and angle valve assemblies. Color: white. 200 Faucet: Chicago No. 201-AGN8AE2805-5-317CP combination hot and cold water 8-inch (203 mm) center faucet with 8-inch high rise rigid/swing gooseneck spout with 120 degree limited swing, No. 317 wristblade handles and E2805 JKCP, 0.5 gpm (1.9 L/M) vandal proof non-aerating spray outlet. 201 Faucet: Chicago No. 201-GN10ASWGJKABCP-E35JKABCP-317CP combination hot and cold, widespread, No. 317 wristblade handles with rim flanges, 140 degree restricted swing, 14.5 inch (368 mm) rigid/swing high rise gooseneck spout, E35JKABCP, 1.5 gpm (5.7L/M) vandalproof non-aerating spray outlet. 202 Faucet: Chicago No. 626-E3ABCP deck mounted GN2A spout, 5.25-inch rigid/swing spout, 2.2 gpm laminar flow aerator. 203 Foot pedal control: Chicago No. 625XSLOJKABNF.

204 Eyewash: Haws No. 7612, counter-mounted

# **END OF SECTION**

#### SECTION 23 01 00 - OPERATION AND MAINTENANCE OF HVAC SYSTEMS

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Service for heating, ventilating, and air conditioning equipment required for the work as indicated on the drawings, including the items listed in "Related Sections".
- 1.14 RELATED SECTIONS
  - A. Operating manuals: Division 01 and Section 23 01 01.
  - B. General project warranty: General Conditions
  - C. Pumps: Section 23 21 23.
  - D. Air-conditioning units: Section 23 81 27.
  - E. Heat-pump units: Section 23 81 46.
  - F. Energy recovery and dedicated outdoor air units: Section 23 72 00.
  - G. Variable-refrigerant-volume multizone system: Section 23 81 28.

#### 1.26 DESIGN REQUIREMENTS:

- A. The products specified, scheduled, and shown on drawings are the basis of the design of this project.
- B. For requirements affecting use of optional manufacturers, or substitutions, see Division 01 and Section 23 01 01, HVAC General Provisions, and Section 23 05 00, Common Work Results for HVAC.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 23 01 01.
  - B. Shop drawings:
    - 1. Refrigeration service organization: Name and address of proposed agency.
    - 2. Proposed service or test agreement of each type included in the project, showing conformance to specifications. Include detailed list of work to be performed at each visit.
  - C. Certifications:
    - 1. Qualifications of refrigeration installation and service agency.
    - 2. Each installation and service organization: A list of at least ten projects, similar to this project in type, size, and components, which have been operating satisfactorily for at least two heating and cooling seasons.

3. Include evidence of each requirement specified in article 1.41, "Qualifications," below.

# 1.40 QUALITY ASSURANCE

- A. Perform work in accordance with the plumbing, electrical, building, fire and safety codes of the state, county or city in which the work is performed.
- B. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.
- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1 Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.

#### 1.41 QUALIFICATIONS OF EACH SERVICE AND MAINTENANCE AGENCY

- A. Regularly engaged in performing installation, startup, and service work for equipment and systems of the types included in this project.
- B. Located in the Baltimore/Washington, DC, metropolitan area.
- C. Staff factory-trained by the manufacturer of the equipment included in this project.
- D. Provides emergency service on call 24 hours a day.
- E. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
- F. Has service contracts available, which can meet requirements specified for the equipment and systems of this project.

#### 1.93 REFRIGERATION EQUIPMENT WARRANTY AND SERVICE

- A. Manufacturer's authorized and factory-trained startup and service organization will be responsible for starting, adjusting, and servicing the complete refrigeration system during the term of the correction period of this contract.
- B. Ascertain that piping installation, wiring, control installation, and appurtenances of each refrigeration unit are in accordance with the recommendations of the manufacturer. Upon initial startup, operate and adjust the unit to obtain the performance specified by the manufacturer.
- C. Special warranties shall cover the replacement of all parts and components for no less than the time of the general project correction period, starting from the date of substantial completion.
- D. Compressors shall have an additional extended parts-only warranty for a total of five years including the general correction period.
- E. Refrigerant circuits of self-contained units shall have an additional extended parts-only warranty for a total of five years including the general correction period.

- F. Supply emergency service promptly upon call during correction period with no extra charge to Owner.
- G. Maintenance in addition to repair: In addition to the repair service required during the correction period, provide maintenance by the manufacturer's authorized factory-trained local agent including a visit to the project near the end of the first full cooling season. The planned maintenance program shall include:
  - 1. Inspect complete refrigerant circuit for refrigerant leaks with approved halide or electronic leak detector.
  - 2. Replace defective parts and refrigerant at no addition to the contract sum.
  - 3. Tighten belts, nuts, screws, and terminal wiring connections as required.
  - 4. Clean evaporator-condenser coils as needed.
  - 5. Lubricate moving parts as needed.
  - 6. Adjust, align, and replace belts where needed.
  - 7. Check for oil or refrigerant leaks and correct as necessary.
  - 8. Check for blockage of condensate elimination system and correct as required.
  - 9. Check and record unit starting and running amperage.
  - 10. Check and record power voltage and control voltage.
  - 11. Check and record operating temperatures and pressure. (Pressure not required on hermetic circuits.)
  - 12. Check and record thermostatic expansion valve super heat.
  - 13. Check temperature and pressure controls and adjust as required.
  - 14. Check for proper operation of limit switches and safety controls.

# PART 2 - PRODUCTS

Not used.

### PART 3 - EXECUTION

# 3.01 ELECTRIC WIRING FOR MOTORS, STARTERS, AND CONTROLS

- A. Furnish and install and in most cases factory-wire motor starters specified under each technical section in this division. Furnish and install under Division 26 magnetic starters not specifically specified with equipment. Unless specified otherwise, automatic control devices for equipment are furnished with the equipment.
- B. Unless explicitly specified otherwise, mount and completely wire under Division 26 all starters and automatic control devices, except those which are factory-mounted on equipment.
- C. Unless specified otherwise, motor disconnects, manual starters, pushbutton stations, and pilot lights are specified in Division 26, Electrical. Equipment specified in Division 23 shall be suitable for operation in conjunction therewith.
- D. Unless specified otherwise in a particular section, electric motors shall comply with the requirements of Section 23 05 13.

## 3.59 IDENTIFICATION

- A. Identify equipment as required in Section 23 05 00, Common Work Results for HVAC.
- B. Thermometers, gages, and control devices shall be identified.
- 3.61 TESTING MECHANICAL EQUIPMENT
  - A. Check and adjust all heating and cooling equipment installed.
  - B. Operate heating and cooling equipment and check controls including high and low limit controls.
  - C. Mechanical equipment shall be proven to function properly by actual operation prior to final acceptance.
- 3.71 EQUIPMENT LUBRICATION
  - A. Bearings of equipment shall be provided with adequate facilities for lubrication. Oiling devices shall be accessible. Lubricate bearings upon completion of work prior to startup of the equipment. Lubricants shall be as specified by equipment manufacturers.

# **END OF SECTION**

## SECTION 23 01 01 - HVAC GENERAL PROVISIONS

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. General provisions and requirements for all HVAC work.
- 1.14 RELATED SECTIONS
  - A. Requirements of this section generally supplement requirements of Division 01.
  - B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
  - C. Mechanical Systems Commissioning: Section 23 08 00.

#### 1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

#### 1.25 SYSTEM DESCRIPTION

- A. The full set of Contract Documents applies to work of Division 23.
- B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
- C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
- D. Except as required otherwise in Division 01, promptly obtain and pay for, including all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
- E. HVAC work of this project includes, as a brief general description, the following:
  - 1. Heating system comprised of geothermal heat pump units and miscellaneous electric heating equipment.
  - 2. Air-conditioning system comprised of geothermal heat pump units.
  - 3. The project includes commissioning under the direction of a Commissioning Agent (CxA).
  - 4. The project will be LEED certified.
- F. See Division 01 for requirements related to LEED certification, commissioning, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

### 1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 23 specifications.
- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in the article "Substitutions," below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
  - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
  - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

### 1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 23 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
  - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
  - 2. Will provide the same warranty for the substitution as for the specified product.
  - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
  - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
  - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.

- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

# 1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project, and of representative manufacture. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
  - 1. Furnish: Supply item
  - 2. Install: Mount and connect item
  - 3. Provide: Furnish and install.
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturer's instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent before starting any work which may be affected by this decision.

### 1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate HVAC work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.
- D. Coordinate location and elevation of all piping, ductwork, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractor's assistants shall include a competent foreman, who shall be on the premises at all times to check, lay out, coordinate and superintend the installation of work. The foreman shall establish all grades and lines relative to the work before starting, and be responsible for the accuracy thereof.

### 1.30 SUBMITTALS

- A. Manufacturers' and subcontractors' lists:
  - 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.
- B. Shop drawings and product data:
  - 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of shop drawings and product data for every item of equipment. Shop drawings or product data will not be considered until manufacturers' lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
  - 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.

- a. For roof-mounted equipment, submit manufacturer's certified drawings and other coordination drawings as required so that openings can be framed through the roof in accordance with structural requirements.
- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electrical items furnished as items associated with HVAC items but not specifically described in the HVAC item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the HVAC item by identification specification paragraph.
- 5. Product data sheets shall be 8.5-inch by 11-inch cut sheets for operating and maintenance manual.
- C. Submit at least three copies of the results of every test required under any section in this division.
- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.
  - 1. Include project name, address, name and phone number of owner's representative, and project type and size.
- E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

### 1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

### 1.35 CONTRACT CLOSEOUT SUBMITTALS

- A. Project record documents:
  - 1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:
    - a. Contract drawings.

- b. Specifications.
- c. Addenda.
- d. Change orders and other modifications to the Contract.
- e. Reviewed shop drawings, product data, and samples.
- 2. Maintain record documents separate from documents used for construction.
- 3. Record information concurrent with construction progress.
- 4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:
  - a. Manufacturer's name and product model and number.
  - b. Product options, substitutions, or alternates utilized.
  - c. Changes made by addenda and modifications.
- 5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:
  - a. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
  - b. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
  - c. Field changes of dimension and detail.
  - d. Details not on original Contract Drawings.
- 6. Submit documents as specified in Division 01.
- B. Operation and maintenance data:
  - 1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
  - 2. Lubrication charts: Prepare lubrication charts for each piece of HVAC equipment that requires grease or oil.
    - a. Include the following:
      - 1) Types of lubricants required.
      - 2) Locations of lubrication points.
      - 3) Frequency of lubrication.
    - b. Provide one extra set of lubrication charts mounted in plastic covers, besides those required in Operating and Maintenance Manuals.
  - 3. Binders: Three-ring binders with vinyl-covered hard covers. Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
  - 4. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", and title of project. Print on spine of binder "O & M

INSTRUCTIONS". If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.

- 5. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
- 6. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
- 7. Part 1: Directory, listing names, addresses, and telephone numbers of mechanical engineers; Contractor; mechanical subcontractors; and major mechanical equipment suppliers.
- 8. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
  - a. Significant design criteria, including pump and fan curves and similar performance charts.
  - b. List of equipment, including operating weight of each piece.
  - c. Parts list for each component, including recommended spare parts list.
  - d. Operating instructions.
  - e. Maintenance instructions for equipment and systems.
  - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
  - g. Valve charts, including locations of flow fittings.
- 9. Part 3: Project documents and certificates, including the following:
  - a. Shop drawings and product data.
  - b. Air and water balance reports.
  - c. Photocopies of certificates.
  - d. Photocopies of warranties and guarantees.
  - e. Test reports: Copies of the results of all tests required under all sections of specifications.
- 10. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
- 11. Submit final volumes revised, within ten days after final inspection.
- 12. Submit DVD optical disc storage media specified in Section 23 05 00.

### 1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.

- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
  - 1. The plumbing, mechanical, electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
  - 2. The National Electric Code, NFPA 70 (NEC).
  - 3. The National Fire Protection Association Code. (NFPA).
  - 4. International Energy Conservation, Fire, Fuel Gas, Mechanical, and Plumbing Codes (ICC).

### 1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply.
  - 1. Federal Specifications (FS)
  - 2. Military Specification (MS)
  - 3. Military Standards (Mil. Std.)
  - 4. Air Conditioning and Refrigeration Institute (ARI)
  - 5. Air Movement and Control Association (AMCA)
  - 6. Associated Air Balance Council (AABC)
  - 7. American Association State Highway and Transportation Officials (AASHTO)
  - 8. American National Standards Institute (ANSI)
  - 9. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
  - 10. ASME International (ASME)
  - 11. American Society for Testing and Materials (ASTM)
  - 12. American Society of Sanitary Engineering (ASSE)
  - 13. American Water Works Association (AWWA)
  - 14. International Code Council (ICC)
  - 15. Manufacturer's Standardization Society of the Valve and Fittings Industry Inc. (MSS)
  - 16. National Electrical Code, NFPA 70 (NEC)
  - 17. National Electrical Manufacturer's Association (NEMA)
  - 18. National Fire Protection Association (NFPA)
  - 19. National Fuel Gas Code, NFPA 54
  - 20. National Sanitary Foundation (NSF)
  - 21. National Standard Plumbing Code (NSPC)
  - 22. The Occupational Safety and Health Act (OSHA)
  - 23. Piping and Drainage Institute (PDI)
  - 24. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)
  - 25. Underwriters Laboratory Inc. (UL)
  - 26. Maryland Occupational Safety and Health Act (MOSHA)

# 1.53 TEMPORARY STORAGE

A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.

B. Area shall be maintained and shall be returned to original condition at the completion of the project.

# 1.54 PROTECTION

- A. Control dust resulting from construction work to prevent its spread beyond the immediate work area, and to avoid creation of a nuisance.
  - 1. Do not use water to control dust. Use drop cloths or other suitable barriers.
  - 2. In areas where dirt or dust is produced as a result of the work, sweep daily, or more often as required.
  - 3. Provide walk-off mats at entries and replace them at regular intervals.
  - 4. Construct dust partitions, where indicated on the drawings or as required.
  - 5. Seal off all return air registers and other mechanical systems to prevent dust from entering.
- B. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
  - 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
  - 2. Protect finished work from damage, defacement, staining, or scratching.
  - 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
  - 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
  - 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- C. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract Sum.
- D. Protect work stored in place and supplies stored in the building.
  - 1. Store materials and products subject to damage from moisture in dry locations. If necessary, protect in wraps or covers.
  - 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- E. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

### 1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

### 1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
  - 1. Promptly notify the Architect in writing.
  - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

#### 1.80 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties specified in individual sections.
- B. During the correction period, the Contractor shall promptly correct any work found to be not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. When use of the permanent equipment has been permitted for temporary heating or ventilation of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

#### 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 and Section 23 08 00.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

#### PART 2 - PRODUCTS

Not used.

### PART 3 - EXECUTION

### 3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of pipes, ducts and appurtenances. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.
- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

#### 3.14 TEMPORARY FACILITIES

A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

## 3.40 PROGRESS MEETINGS

- A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
- B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

### 3.82 COMMISSIONING

A. Comply with requirements of "Commissioning" in Part 1 above.

# END OF SECTION

### SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Basic material and equipment required for the HVAC equipment and piping work as indicated on the drawings and specified in Division 23.
- B. Other requirements applicable to more than one section of Division 23.
- C. Identification of HVAC systems and equipment.

#### 1.14 RELATED SECTIONS

- A. Division 01 includes sections specifying requirements for LEED rating, and commissioning.
- B. Project and special warranties: Division 01 and Section 23 01 01.
- C. Operation and Maintenance Manuals: Division 01 and Section 23 01 01.
- D. Painting: Division 09.

#### 1.21 DEFINITIONS

- A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.
- B. Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
  - 1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
  - 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.
- C. DN: Dimension Nominale, nominal pipe size in millimeters, in accordance with the metric system for construction, Systeme Internationale (SI).
- D. NPS: Nominal pipe size in inches, in accordance with standard U.S. designations for manufactured pipe. Pipe sizes do not change when projects are designed and built in metric units; each size has a consistent name (nominal dimension) in each system.

### 1.26 DESIGN REQUIREMENTS

A. The drawings and system performances have been designed based on using the particular manufacturer's products specified and scheduled on the drawings.

- B. Products of other manufacturers that are listed under the article "Acceptable Manufacturers", or permitted as "equal," are permitted provided:
  - 1. Product shall meet the specifications.
  - 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.
- C. Do not propose products with dimensions or other characteristics different from the design basis product that render their use impractical, or cause functional fit, access, or connection problems.
- D. The contract drawings are generally diagrammatic and do not indicate all fittings or offsets in pipe, all access panels, or other specialties required.
  - 1. Install pipe exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining proper clearances for access at all parts requiring servicing.
  - 2. Install pipe a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.
  - 3. No pipe shall be run below the head of a window or door.
    - a. Equipment, ducts, and pipes installed in areas without a suspended ceiling shall be as tight to structure as possible, but at least above a height of 6'-8", unless otherwise noted.
  - 4. Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

### 1.30 SUBMITTALS

- A. Comply with Division 01 and Section 23 01 01.
- B. Shop drawings:
  - 1. Showing proposed expansion design.
  - 2. Schedule of welding and brazing procedures proposed for each piping system included in the project.
- C. LEED submittal:
  - 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For adhesives and sealants, include printed statement of VOC content.
  - 2. Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For wood products such as plywood equipment backboards, include printed statement of non-urea-formaldehyde component present in material.
  - 3. Product data for Credit IEQ 4.2: For mastics, paints and coatings applied within the building water proofing envelope, documentations including printed statement of VOC content in g/L.

- D. Certifications: Proof of operator and testing agency personnel qualifications as required for welding and brazing in the article "Quality Assurance" below.
- E. Test reports: Field test results for each piping system as specified in Part 3 below.

# 1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the plumbing, mechanical, electrical, building, fire, health and safety, and other applicable codes and regulations of the state, county or city in which the work is performed.
- B. Welding, brazing, and soldering procedures and operator qualifications for building systems piping:
  - 1. AWS D10.9, Qualification of Welding Procedures and Welders for Piping and Tubing.
  - 2. ASME B31.9, Building Services Piping.
  - 3. Copper Development Association "Copper Tube Handbook."
  - 4. Safe Drinking Water Act.
- C. Qualifications of independent testing laboratory personnel:
  - 1. Welding inspectors: AWS QC1, Certification of Welding Inspectors.
- D. Electrical control panels, equipment, materials and devices provided or installed as work of Division 23 shall bear UL label or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70 (NEC). Provide testing, if required, without addition to the contract sum.
- E. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media format for video and audio production and editing.
- G. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.
- H. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.
- I. Products shall contain no urea-formaldehyde content.
- 1.85 COMMISSIONING
  - A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01.

# PART 2 - PRODUCTS

### 2.10 MATERIALS

- A. General piping techniques, testing, identification, painting, and operating instructions specified in this section apply to products specified in other sections of Division 23.
- B. Bituminous protective coating: Coal-tar based, self-priming on steel, applied in a wet film thickness at least 20 mils (0.5 mm) per coat; equal to 46H-413 "Hi-Build Tneme-Tar" manufactured by Tnemec Company, Inc.
- C. Rust-inhibitive paint: Alkyd based, equal to Benjamin Moore Super Spec HP D.T.M. Alkyd Low Lustre P23; white, black or bronzetone, applied in a wet film thickness of at least 2.9 mils (0.07 mm).
- D. Weldolets and thredolets: Fittings designed for installing branches on piping, with either welded or threaded connection to branch; conforming to ASTM A 234.
- E. Solder: Free of lead, antimony, and zinc. No solder containing lead is permitted.
  - 1. Tin 95.5 percent, copper 4 percent, and silver 0.5 percent; equal to "Silvabrite 100" manufactured by Engelhard Corporation.
  - 2. Tin, copper, bismuth, and silver; equal to "Oatey Silver" manufactured by Oatey.
- F. Flux: Meeting requirements of ASTM B 813 and NSF 61 certified, equal to Oatey H-20<sup>95</sup>.
- G. Pipe jointing compound:
  - 1. Polytetrafluoroethylene (PTFE) pipe thread tape, "Teflon."
  - 2. Pipe cement and oil.
- H. Wood-preservative-treated lumber: Treated by pressure process, AWPA C2, with chemicals acceptable to authorities having jurisdiction, and marked with treatment quality mark of an inspection agency approved by ALSC Board of Review.
  - 1. Application: Treat items indicated on the drawings, and the following:
    - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
    - b. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
    - c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
    - d. Wood framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.
    - e. Wood floor plates that are installed over concrete slabs-on-grade.

## 2.11 MATERIALS FOR UNDERFLOOR INSTALLATION

A. Pipe: Copper tubing, ASTM B 88, Type L soft drawn, no joints under floor.

- B. Conduit: Schedule 40 PVC pipe, size to accommodate copper tubing and insulation.
- C. Insulation: Flexible elastomeric, as specified in Section 23 07 19, HVAC Piping Insulation.
- D. Firestopping caulk: Equal to Three M CP 25 WB, intumescent caulk, which, under heat, expands to five times its original volume, creating a char which can withstand flames and smoke for at least three hours.

### 2.21 IDENTIFICATION DEVICES AND MATERIALS

- A. Stenciling materials:
  - 1. Stencils: Manufactured standard stencils prepared for required applications, conforming to ANSI A13.1 for color and size of legend letters, including arrows showing direction of flow.
  - 2. Paint: Exterior type enamel, colors conforming to ANSI A13.1, or black.
- B. Equipment identification tags:
  - 1. Laminated plastic with adhesive back, white core and black outer layers, which, when engraved, will produce white letters and numerals on a black background.
  - 2. Tags installed on curved surfaces shall be aluminum or brass.
- C. Valve tags: Brass, 1.5 inch (40 mm) in diameter with black-filled numbers not less than 0.25 inch (6 mm) high, complete with brass attachment chains.
- D. Ceiling identification tags: Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number.

### 2.23 DATE-SENSITIVE EQUIPMENT

- A. Date-sensitive equipment: Systems, equipment, or components which use or process date and time data in order to perform their functions.
- B. Each item of date-sensitive equipment used in the project shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

#### PART 3 - EXECUTION

### 3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

- A. Manufacturer's instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturer's instructions and recommendations applicable to the project conditions.
  - 1. Immediately notify Architect if a difference or discrepancy is found between manufacturer's instructions and the drawings or specifications.

### 3.20 INSTALLING PIPING UNDER FLOOR SLAB

- A. Install conduit.
- B. Insulate copper tubing and insert in conduit.
- C. Where piping rises through floor, cut conduit and insulation flush with floor.
- D. Fill annular spaces with firestopping caulk. Use fiberglass insulation as backing.

### 3.22 PIPE INSTALLATION

- A. Remove burrs resulting from cutting pipe or from any other operation.
- B. Threaded connections:
  - 1. Cut threads full and clean.
  - 2. Apply specified pipe jointing compound or tape on male threads only.
  - 3. Where piping is installed in crawl spaces and tunnels, cover exposed threads with either bituminous protective coating or rust-inhibitive paint. Apply after joints have been assembled and tested.
- C. Thoroughly clean pipe and fittings before they are installed, and keep them clean until the acceptance of the completed work. Cap or plug the ends of the lines so as to prevent earth and other debris from entering during construction.
- D. Provide for expansion and contraction of piping and connections so that no strain or breakage will occur. Provide anchors and guides of approved design where shown on drawings and where necessary to allow for proper expansion and contraction. At the time of installation, expansion loops shall be cold sprung to one-half of the calculated expansion.
- E. Provide for draining all parts of water piping systems and apparatus by installing a valved hose connection at every low point.
- F. Black steel piping NPS 2.5 (DN 65) and larger shall be welded; NPS 2 (DN 50) and smaller shall be threaded, except as required otherwise in a particular section.
- G. Do not weld galvanized piping.
- H. Use welding fittings, tees, wyes, reducers, eccentric reducers, and caps as required. Branches at least two nominal pipe sizes less than the main may be made with "Weldolets" or "Thredolets" installed with full size opening in larger pipe and in accordance with manufacturer's printed instructions. Flanges shall be welded neck or slip-on pattern of class to suit the valves or equipment connections. Flanges shall have machine bolts with hex nuts and washers.
- I. Each connection from risers to equipment shall contain at least three elbows or expansion joints. Connections shall be so arranged that movement in piping due to expansion and contraction will not be transmitted to the equipment.

- J. Install unions and flanges in the piping at each item of equipment, control valve, and appliance, so as to provide easy removal of the equipment, valve, or appliance, and to provide for easy removal of coils.
- K. Pitch water and glycol piping so that air in the system can be properly vented. Provide stop valves where necessary to isolate parts of system for repairs without draining the entire system.

# 3.23 COPPER TUBING FOR WATER INSTALLATION

- A. Solder joints for copper tubing: Clean ends of tubing and inside of fitting ends thoroughly with emery cloth before applying flux.
- B. Make flare joints in copper tubing with proper size flaring tool and in accordance with manufacturer's recommendations.
- C. Provide isolation fittings between copper and steel piping to prevent electrolysis.
- D. Cut pipe with a tubing cutter or fine-tooth saw. Cuts made with a saw shall be true and square, and the end shall be filed smooth with a fine-tooth file. Remove all marks and burrs with sandpaper.

# 3.24 PLASTIC PIPING INSTALLATIONS

- A. Cut pipe true and square with a fine-tooth saw and file the end smooth with a fine-tooth file. Remove all saw marks and burrs with sandpaper.
- B. Clean connecting surfaces of both pipe and fitting with methyl ethyl ketone or acetone.
- C. Apply solvent cement liberally with clean brush, first to fitting and then to pipe (outer surface and end). Lap cement a minimum of 0.25 inch (6 mm) over depth of fitting.
- D. Join pipe and fitting to full depth of fitting, giving fitting at least one-quarter turn on pipe to distribute cement.
- E. Pipe and fitting shall show a small fillet or bead completely around pipe without any voids, or fitting shall be cut out and new fitting made up and installed. Allow a minimum of 48 hours drying time for each joint.

### 3.25 INTERFACE WITH OTHER PRODUCTS

- A. Where it is necessary to run pipes through walls, provide finished, permanent, waterproof installation complete with inserts, sleeves, supports or hangers, seals, and other appurtenances as required. Do not pierce, cut, or notch any footing or other structural member.
- B. Waterproofing and dampproofing of the building shall be unharmed by the installation of the work. Where pipe has to pierce waterproofing or dampproofing, including outside walls, the penetration shall be made watertight. Waterproofing damaged or destroyed shall be repaired or replaced with new waterproofing.

## 3.59 IDENTIFICATION

- A. General: Do not apply identification until insulation and finish painting work is complete.
- B. Equipment:
  - 1. Stencil equipment with minimum two-inch (50-mm) -high letters or provide identification tags. Clearly identify function, equipment served, and area served.
  - 2. Firmly fasten each identification tag to its appropriate piece of equipment with drive screws, sheet metal screws, or rivets. Do not interfere with operation of, or damage the item being marked.

# C. Piping:

- 1. Mark by stenciling.
- 2. Mark to identify service with arrows showing direction of flow. Apply markings near building walls where pipes enter or leave an accessible space and in intermediate locations so that markings are no more than 30 feet (9 m) apart. They shall be readily visible to a person standing on the floor.
- 3. Fully identify all piping installed as work of the project.
- 4. Mark pipe with letters of height and with colors as required by OSHA and conforming to ANSI A13.1.
- 5. Identify every thermometer, gage, and control device.
- 6. Provide valve tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.
- D. Stencil ductwork after insulation is applied, if required, with minimum two-inch (50-mm)-high letters, clearly identifying service (supply, return, exhaust) and showing direction of flow with arrows. Mark ducts near the building walls where they enter or leave a space, and at intervals of not more than 30 feet (9 m). Identification shall be visible to a person standing on the floor.
- E. Ceiling identification tags: Provide on the access door or, in suspended ceilings, on the ceiling support adjacent to the unit.
  - 1. Valves: Identify with the same number shown on the valve tag.
  - 2. Terminal units above ceilings: Identify with unit description and number.

# 3.61 PIPING TESTS

- A. Notify Owner at least one day prior to the actual test.
- B. Test before pipes are concealed or insulated. Test the piping in sections as the work progresses, so as not to delay progress of the building construction. Furnish pumps and gages required for testing.
- C. Conduct piping tests before connecting equipment that would be subject to damage from the test pressure. Replace piping or fittings found defective with new material.

- D. Bracing and supporting: Adequately brace and support piping during the test, so that no movement, displacement, or damage results from the application of the test pressure.
- E. Refrigerant piping: Test as specified in Section 23 23 00.
- F. Test the piping systems for not less than four hours to fulfill the conditions in the Piping Systems Test Schedule at the end of this section.
- G. Documentation of tests: Prepare a test report for each portion of piping tested, identified by service, material, location, and pipe size. Include these items:
  - 1. Date of test.
  - 2. Starting and completion times.
  - 3. Initial test pressure.
  - 4. Final test pressure.
  - 5. Problems or leaks detected.
  - 6. Corrective actions taken.
  - 7. Record of successful completion of testing.
  - 8. Name, title, and signature of person conducting test.

# 3.75 CLEANING AND PAINTING

- A. Cleaning: Clean all piping and equipment. Where items are to be painted, clean ready for painting.
- B. Painting: Coordinate painting with requirements of Division 09. Paint the items identified below to be painted. Use paint materials and systems specified in Division 09.
- C. Items to be painted:
  - 1. Items identified below to have protective coating.
  - 2. Items furnished with manufacturer's prime coat.
  - 3. Mechanical rooms:
    - a. Insulation and uninsulated steel: Piping, pumps, tanks, and vessels.
    - b. Non-galvanized hangers and supports.
  - 4. Piping and ductwork exposed in finished spaces, insulated and uninsulated.
  - 5. Inside ducts behind registers, grilles, and diffusers.
- D. Items not to be painted: Copper, stainless steel, and equipment furnished with manufacturer's finish.
- E. Paint systems in mechanical rooms: Paint piping using colors in accordance with ANSI A13.1.
  - 1. Galvanized steel: One coat of primer recommended for galvanized surfaces and one coat of glossy alkyd enamel.
  - 2. Ferrous metal: One coat of primer recommended for ferrous metal and one coat of glossy alkyd enamel.
- 3. Items protected with bituminous coating or rust-inhibitive primer: Finish coat of compatible glossy enamel.
- F. Paint systems for exposed piping and ductwork: Primer compatible with the substrate, whether steel, galvanized steel, insulation jacket, or other material; one coat or two, if required to cover, to match adjacent surfaces in color and texture.
- G. Painting inside ducts behind registers, grilles, and diffusers: Matte black, compatible with substrate and suitable for the temperatures at which the duct will operate, extending from the duct opening to a depth such that no unpainted surface will be visible to a person standing on the floor or adjacent balconies.

## 3.81 OPERATING INSTRUCTIONS (DEMONSTRATION)

- A. Furnish the necessary technicians, skilled workers, and helpers to operate all the mechanical systems and equipment of the entire project for two 4- hour days. Sessions shall occur on consecutive days.
- B. Where specified in technical sections, provide longer periods required for specialized equipment.
  - 1. Session requiring time periods exceeding four-hours shall occur on multiple days. All single sessions shall not exceed a four-hour time period.
- C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of all systems and equipment.
  - 1. Instructions by manufacturer's technical representative for each type of equipment shall include the performance of the recommended preventive maintenance procedures for that equipment.
- D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by instructors and Owner personnel.
- E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.
- F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Architect.

## 3.90 SCHEDULES

A. Piping Systems Test Schedule:

(See Schedule, next page)

SYSTEM	TEST PRESSURE PSIG (kPa)	ALLOWABLE DROP	MEDIUM
Heat pump loop piping	125 (860)	None	Water Maximum 73 degrees F (22 degrees C)

## SECTION 23 05 01 - EXCAVATION AND FILL FOR HVAC WORK

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Trenching, backfilling, and compacting for HVAC work underground inside the building and extending five feet beyond exterior building walls, and outside the building as shown on drawings.
- 1.14 RELATED SECTIONS
  - A. Cutting and patching: Division 01 and Section 23 01 01.
  - B. Repairing pavements: Division 32.
  - C. Piping: Sections 23 21 13 and 23 21 16.
- 1.20 REFERENCES
  - A. ASTM D 1557: Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbs/cu ft (2700 kN-m/cu m).
- 1.30 SUBMITTALS
  - A. General: Submit in accordance with Division 01 and Section 23 01 01.
  - B. Shop drawings: At the same scale as the contract drawings, showing field verified locations of utilities and proposed detailed trenching plan.
  - C. Product data:
    - 1. Warning tape
  - D. Certifications: Test reports showing that compaction meets specified requirements.

## PART 2 - PRODUCTS

#### 2.10 MATERIALS

- A. Backfill: Earth materials, free from perceptible amounts of wood, debris, or topsoil, free of frost at the time of placement, and not containing marl or other elements which tend to stay in a plastic state.
- B. Underground warning tape: Polyethylene 0.004 inch (0.102 mm) thick for metallic lines, and for non-metallic lines polyethylene both sides with metallic lining, six inches (152 mm) wide.
  - 1. Colors: In accordance with APWA and AASHTO standards.
  - 2. Markings: Repeated continuously along the entire length, legend appropriate for line being identified.

## 2.12 EQUIPMENT

A. Mechanical tampers for compacting backfill: Capable of exerting a blow equal to 250 pounds per square foot (12 kPa) of area of the tamping face.

## PART 3 - EXECUTION

#### 3.05 PREPARATION

- A. Contact local utility company underground information service (BGE Miss Utility) before beginning excavation outside buildings.
- B. The general locations of underground utilities are indicated on the drawings and are not to be assumed to be accurate or complete. Before beginning work, field check the area with the most accurate instruments available, such as Fisher Labs' Pipe and Cable Locators.

## 3.20 INSTALLATION

- A. Perform all excavating, cutting of paved areas, trenching, sheeting, shoring, backfilling, and compacting required for the proper installation of the work. Repair of pavement is specified in Division 32.
- B. Where obstructions are encountered, obtain written approval and make necessary changes in line, grade or location.
- C. Protect existing utilities from damage during excavation and backfilling. Repair damaged new or existing work at no addition to the contract sum. Bracing, shoring and other protection of existing utilities is part of this work.
- D. Do not damage or remove existing shrubs or trees including their root systems, without prior notification to the Architect.
- E. Provide temporary roadways over trenches with railings and other safeguards, including amber blinker lamps or other warnings for night use.
- F. Note the depths of footings. In cases where piping is in close proximity to or below footings and where the natural earth under footings is disturbed, after the line is installed the voids shall be filled up to bottoms of such footings with solid concrete.

## 3.24 CUTTING

- A. Cut concrete and asphalt concrete with masonry saw prior to breaking it into smaller pieces for removal.
- B. Cut sidewalks perpendicular to the length at the closest existing joint that is a minimum of 24 inches back from either side of the top of the new trench.

## 3.25 TRENCHING

- A. Excavations inside the building shall be carefully planned. Stockpile excavated earth so as not to interfere with other construction. Dig trenches to the proper depths, providing extra depressions where required for hubs of pipes.
- B. Excavations outside the building shall generally follow the routes indicated on the drawings. Stockpile topsoil separately for later replacement. Excavations shall be of sufficient depths to provide, unless indicated otherwise on the drawings, a minimum cover as follows:
  - 1. Water piping: 42 inches (1067 mm).
  - 2. Sewer lines: Elevations shown on drawings.
- C. Trenches shall be of necessary depth and width for the proper laying of pipe with a minimum of 8 inches (205 mm) on each side of the joint.
  - 1. The sides shall be as nearly vertical as practicable. Unless local regulations are more strict, trenches 4 ft. (1220 mm) and deeper shall have shored sides as required by OSHA trenching regulations.
  - 2. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for each section of pipe on undisturbed soil at every point along its entire length, except for bell holes and for the proper sealing of the pipe joints.
  - 3. No greater length of trench shall be left open, in advance of the completed structure placed in it, than can be completed in that day's operation.
  - 4. Except where rock is encountered, do not excavate below the depths required. Where rock excavation is required, excavate to a depth of at least 6 inches (150 mm) below the trench depth and fill the overdepth with compacted crusher run or bank run stone or sand. Unauthorized overdepths in excavation shall be backfilled with crushed stone, slag or gravel, thoroughly compacted.
  - 5. Whenever wet or otherwise unstable soil is encountered, it shall be removed to the depth and extent directed, and the trench backfilled to the proper grade with crushed stone, slag or gravel.
- D. Should springs be encountered within the work area, or soft soil conditions at the elevations required for load bearing, immediately notify the Architect and do not place any portion of the work on such surfaces until instructions are received.
- E. Furnish and maintain pumps, flumes, gutters, and appurtenances if required to keep the excavations free from water. Water shall be directed to a point remote from building operations, shown on the approved shop drawing.

## 3.26 BACKFILL

- A. Place no backfill until the adjacent construction or the utility to be covered has been inspected, tested, and approved.
- B. Installing underground warning tape: Install in backfill above exterior buried lines not encased in concrete. Select legend and color appropriate for type of line. Install metallic lined tape for non-metallic lines. Install approximately 12 inches (305 mm) below grade.
- C. HVAC systems backfill:

- 1. Backfill and compact in six-inch (150-mm) layers up to spring line of the pipe. The installations shall then be inspected and tested.
- 2. Following inspection, backfill in six-inch (150-mm) layers, each compacted, until the pipe has a cover of not less than one foot (305 mm). Place the remainder of the backfill material in the trench in eight-inch (200-mm) compacted layers.
- 3. Excavations improperly backfilled shall be reopened, then refilled and compacted to the required grade and compaction, and smoothed off.
- 4. Open trenches across roadways or other areas to be paved shall be backfilled as specified above, except that the entire depth of trench shall be backfilled in six-inch (150-mm) layers, and each layer shall be mechanically compacted.
- 5. Completed work shall have uniform graded surface, in accordance with the surface and grade indicated on the drawings.
- D. Structure backfill: Do not backfill against structures with cement mortar joints until the mortar is at least twelve hours old.

## 3.27 COMPACTION

- A. Test in accordance with the requirements of ASTM D 1557.
- B. Compact under slabs, roads, and sidewalks to a 95 percent density.
- C. Compact unpaved areas to a 90 percent density.
- D. Backfill and compact trench in unpaved areas to within 4 inches (102 mm) of existing grade.
  Furnish and install compacted select topsoil for the final layer to finish even with existing grade.
  Remove surplus earth and rake unpaved areas for final planting.
- E. Take particular care in compaction of earth under joints of HVAC piping.

## 3.41 RESURFACING

A. Resurface sidewalks, roads, streets, and other paved areas as work of this section, matching the construction and finish of adjacent paving. Paving shall meet the requirements of Division 32.

## SECTION 23 05 02 - SLEEVES AND PLATES FOR HVAC PIPING

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Sleeves and escutcheon plates for piping systems.
- B. Mechanical seals for piping penetrations.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Sleeves, plates, sealants, and mechanical penetration seals.
- C. LEED Submittals: For sealants applied within the building waterproofing envelope, documentation including printed statement of VOC content in g/L.

#### PART 2 - PRODUCTS

- 2.10 SLEEVES, PLATES, AND ACCESSORIES
  - A. Steel sleeves: Schedule 40 black steel pipe, ASTM A 53.
  - B. Copper sleeves: Type L, ASTM B 88 hard drawn.
  - C. Cast-iron sleeves: Extra heavy, equal to product of U.S. Pipe Co. with mechanical penetration seals.
  - D. Plastic sleeves: Schedule 40 PVC, ASTM D 1785.
  - E. Sealing compound in walls and floors: Equal to the following:
    - 1. Bare and insulated pipes carrying fluids 150 degrees F (65 degrees C) and below: Sika Corporation "Sikaflex la."
    - 2. Bare and insulated piping carrying fluids 151 degrees F (66 degrees C) and above: Dow Corning Corporation "790 Silicone."
  - F. Floor, wall and ceiling plates: Stamped or cast brass, hinged type equal to Beaton and Caldwell Mfg. Co., Nos. 11, 40, 3A, and 36 as pipe size requires. Plates shall have chrome finish.
  - G. Mechanical penetration seals: Equal to PSI "Link-Seal Modular Seals" or Calpico Sealing Link "LINX". Seals shall be modular mechanical type, consisting of interlocking synthetic links shaped to continuously fill the annular space between the pipe and wall opening. Bolt and nut fasteners for the seals shall be stainless steel for units used in penetrations below grade.

## PART 3 - EXECUTION

#### 3.20 INSTALLING SLEEVES

- A. Install sleeves for piping, or piping with insulation continuous through sleeve, passing through walls, partitions, beams, or slabs.
  - 1. Exception: Where steel pipe penetrates a steel beam that is not part of a fire- or smokerated assembly, no sleeve is required.
- B. Do not cut, drill, or burn structural steel for installation of piping without specific instructions from the Architect.
- C. Locations in nonfire-rated construction:
  - 1. Install steel sleeves for penetrations of steel, iron, and insulated piping.
  - 2. Install copper sleeves for penetrations of uninsulated copper tubing and piping.
  - 3. Install plastic sleeves for penetrations of plastic piping. Plastic piping and sleeves are not permitted in ceiling spaces used as HVAC system plenums, nor in shafts used for building HVAC air distribution.
- D. Locations in floors and fire-rated construction: Sleeves used in piping penetrations through firerated construction shall be an acceptable component of the through-penetration firestop assembly as specified in Section 23 05 07, Firestopping for HVAC Work.
  - 1. Where firestop assembly is UL listed, sleeve material shall be as directed in the listing.
  - 2. Where other specified approval and acceptance is required, sleeve shall be as described in the approved assembly.
- E. Install sleeves through walls and partitions flush with finished surfaces.
- F. Sleeves through floors shall extend 0.375 inch (10 mm) above top of finished floor and be finished neat and level. Sleeves through mechanical or equipment room floors shall extend one inch (25 mm) above finished floor. Provide projecting sleeves with anchor clips to prevent them from being loosened and knocked down in the floor construction.
- G. Sleeves for penetrations in kitchen and food service areas shall finish 0.375 inch (10 mm) above floor or flush with wall surfaces and be neatly pointed up to fit snugly against floor or wall materials. Seal space between pipe and sleeve with waterproof sealant or fire barrier as required, and finish even with wall or floor with a light pouring of molten lead.
- H. Sleeves for insulated piping with vapor barrier shall be large enough to pass piping and insulation.
- I. Seal spaces between sleeves and pipe, or pipe insulation, in nonrated walls, with mineral wool.
- J. Penetrations in exterior masonry or concrete walls and foundations:
  - 1. Sleeves: Cast iron, or in cast concrete may be core drilled.
  - 2. Above grade: Mechanical penetration seal, at outside face of wall.

3. Below grade: Mechanical penetration seals at outside and inside faces of wall.

## 3.25 INSTALLING PLATES

- A. Piping passing through interior walls, partitions, floors, and ceilings in exposed locations shall be fitted with wall, floor, and ceiling plates of size and depth to conceal sleeves. Secure plates firmly in place with set screws.
- B. Do not install floor or wall plates on pipes in the kitchen and food service areas.

#### SECTION 23 05 03 - ACCESS DOORS FOR HVAC PIPING AND EQUIPMENT

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Access doors for concealed HVAC specialties requiring maintenance or manual operation.
- 1.14 RELATED SECTIONS
  - A. Valves: Section 23 05 23.
  - B. Specialties: Section 23 05 08.
  - C. Duct access doors: Section 23 33 00.
  - D. Controls: Sections 23 09 01 through 23 09 23.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Each type of access door.

#### PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Wall and ceiling access doors:
  - 1. Acudor Products Inc.
  - 2. Cesco Products Company
  - 3. Karp Associates, Inc.
  - 4. Milcor, Inc.
  - 5. Zurn Industries

## 2.21 WALL AND CEILING ACCESS DOORS

- A. Doors: Provide Milcor model listed, or similar type and equal quality by another acceptable manufacturer.
- B. Types:
  - 1. Fire-rated where occurring in fire-rated walls.
  - 2. Style M stainless steel where occurring in masonry or ceramic tile surfaces.
  - 3. Style DW where occurring in drywall construction.
- C. Sizes: As required for access to the particular device, but no less than 16 by 16 inches (405 by 405 mm).

D. Finish: Brushed stainless steel.

## 2.70 LABELS

- A. For access doors to fire protection devices: OSHA and NFPA approved, describing the fire protection device within.
- B. Minimum lettering size: 0.5 inch (13 mm) high.

#### PART 3 - EXECUTION

- 3.20 INSTALLATION
  - A. Provide access doors in walls and inaccessible ceilings for concealed damper operators, duct access doors, valves, and other concealed specialties and appliances that require manual operation or maintenance.
  - B. Select appropriate size door for each particular application.

## SECTION 23 05 05 - EQUIPMENT CONNECTIONS FOR HVAC

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Equipment connections for HVAC, and Owner-provided equipment.
- 1.14 RELATED SECTIONS
  - A. Piping connections: Section 23 05 00.
  - B. Lists of accessories: Suppliers of equipment specified in other divisions.
  - C. Wiring connections: Section 26 05 21.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Any product required for connection but not specified in other sections.

## PART 2 - PRODUCTS

#### 2.10 MATERIALS

Not used

## PART 3 - EXECUTION

## 3.20 INSTALLATION

- A. Connect to HVAC equipment. Install valves, balancing cocks, thermometer wells, gage tappings, control valves, air vents, strainers, and appurtenances as shown on diagrams on drawings and specified under other sections of the specifications.
- B. Connect to owner-supplied and other equipment requiring water, gas, or other piping connections, that is specified, furnished and set in place in other divisions or listed on the drawings.
- C. Provide water supply shutoff valves, and unions at each item of equipment. Where exposed adjacent to chromium-finished piping, the water shutoff valves shall be chromium plated.

#### SECTION 23 05 06 - CURBS AND FLASHINGS FOR HVAC PIPING AND EQUIPMENT

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Curbs, rails, rooftop pipe support assemblies, pipe boot assemblies, and flashing devices for HVAC items and equipment penetrating roof and mounted on roof.
- B. Sound deadening materials for curbs supporting rooftop equipment.
- 1.14 RELATED SECTIONS
  - A. Rough carpentry: Division 06.
  - B. Energy recovery and dedicated outdoor air units: Section 23 72 00.
  - C. Ductwork: Section 23 31 13.
  - D. Fans: Section 23 34 00.
  - E. Roof ventilators: Section 23 37 23.
  - F. Ductless split-system units: Section 23 81 27.
  - G. Piping: Section 23 21 13.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings: Roof curbs and rails, pipe boots, flashing assemblies and devices showing compatibility with roof membrane, insulation, and slope, and configuration for the supported equipment.
  - 1. If curbs are provided by curb manufacturer, coordinate with approved shop drawings provided as specified in related equipment sections, to determine configuration of equipment requiring curb support.
- C. Product data: Each type of manufactured unit, accessory, and accessory material.
- D. Certifications: For sound deadening materials, statement signed by the Architect stating that he or she has inspected the installation of sound deadening materials in the roof curbs for rooftop units which include compressors and that the installation is in accordance with the specifications and drawings.

## 1.40 QUALITY ASSURANCE

A. Curbs and rails may be the product of the manufacturer of the equipment they support, or of a roof curb and support manufacturer, provided they are equal to the products of the named manufacturers and meet this specification.

## 1.70 SEQUENCING

A. Coordinate installation of rooftop equipment and supports with roof structure and membrane. Loads and penetrations shall not exceed or damage structural capacity or weathertightness.

## PART 2 - PRODUCTS

#### 2.10 MATERIALS

- A. Wood-preservative-treated lumber: As specified in Division 06 and in Section 23 05 00.
  - 1. Application: Treat items indicated on the drawings, and the following:
    - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
- B. Sound control accessory materials:
  - 1. Sealant: One-part nonsag urethane sealant, equal to Sika Corp. "Sikaflex-1a," Sonneborn "Sonolastic NP1," or Tremco "Dymonic."
    - a. Bond breaker: Polyethylene, or as recommended by sealant manufacturer.
  - 2. Exterior gypsum soffit board: 0.5-inch-thick.
  - 3. Embedding compound: As recommended by gypsum board manufacturer.
  - 4. Acoustical lining: ASTM C 1071, Type II, rigid, 2 inches thick, ASTM C 423 (Type A mounting) NRC at least 0.95.

## 2.20 PENETRATIONS OF SINGLE PIPE OR VENT

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by another manufacturer.
- B. Boot for water piping through flat roof: Equal to Stoneman Engineering and Manufacturing Co. 1100-2 or 4, 4-lb (1.8 kg per 0.09 sq. m) lead boot, 8-inch (205-mm) skirt; top counterflashing fitting and waterproofing compound.

#### 2.21 PENETRATIONS OF GROUPS OF PIPES

A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by another manufacturer.

B. Where a group of pipes penetrates the roof, provide a curb assembly equal to RPS Corporation Style RC. Assembly shall include curb, cover, and boots and clamps for the number of lines shown on the drawing. Curb shall be a minimum of 18-gage galvanized steel, unitized construction with integral base plate insulated with 3-pound (48 kg/m<sup>3</sup>) density insulation, 2 by 2 inch (50 by 50 mm) nailer, acrylic-clad ABS plastic cover, and fastening screws. Boots shall be graduated step design EPDM rubber, with stainless-steel lock clamps.

## 2.22 CURBS AND RAILS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified product, or comparable product by one of the following:
  - 1. Curbs Plus, Inc.
  - 2. Pate Co.
  - 3. Roof Products & Systems (RPS) Corp.
  - 4. ThyCurb Division, ThyBar Corp.
- B. Fabricate each curb and rail in accordance with certified equipment drawings supplied by the equipment manufacturer, and with details on the drawings. Select style and configuration as required by roof membrane, insulation, and slope.
  - 1. Height: At least 12 inches (305 mm) above top of insulation, except as otherwise shown on drawings.
    - a. Fans ventilating kitchen hoods: At least 24 inches (610 mm), or more if required to place discharge of fan 40 inches (1016 mm) above roof surface.
    - b. For DOAS-1 and 2: Provide minimum 30 inch (762 mm) plenum type roof curb.
  - 2. Steel: 18 gage, galvanized.
  - 3. Construction: Monolithic, with all welded components, fully mitered corners, factoryattached wood nailer, and steel counterflashing.
  - 4. Insulation: Fiberglass board, 3 lbs (48 kg/m<sup>3</sup>) density, 1.5 inches (38 mm) thick.
    - a. Protective liner: On curbs serving duct systems made of aluminum, black steel, or stainless steel, or paint spray booth exhaust, provide liner of the same metal as the duct.
- C. Curbs for condensing units 5 tons and smaller: Equal to Pate pedestal curb with solid top and "Dektite" flashing system, size to fit each unit.
  - 1. Top: Plywood of adequate thickness and reinforcement to support unit, covered with no less than 18 gage galvanized steel counterflashing cap.
  - 2. Pipe and conduit flashings: As detailed on drawings.

## 2.72 ROOFTOP PIPE SUPPORT SYSTEM

A. Equal to Caddy Erico "Pipe Pier," UV-protected, closed -cell polyethylene foam block 10.5 by 4 inches, to which is bonded 10.5-inch pipe strut.

B. Provide manufacturer's standard pipe clamps and accessories designed for strut system, as required for size, material, and configuration of air-conditioning condensate lines across roof.

## PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Plumbing vent shall extend 8 inches (205 mm) above finished roof. Clamp devices shall be tightly sealed to vent. Space between vent hub and pipe shall be lightly caulked with lead to provide for movement in piping.
  - B. Flashing of roofing felts into clamping devices of roof drains and sleeves through roof, and flashing and counterflashing of pipe curb assemblies and of roof rails and curbs shall be as specified under Division 07.
  - C. Securely attach curb to roof construction with a 6-inch-(150-mm) wide wood frame the thickness of the roof insulation, with countersunk flat-head 0.375-inch (10-mm) diameter cadmium-plated through bolts with washer and double nuts on underside of structural framing around roof opening. Secure curb to wood frame with No. 10 cadmium-plated wood screws.
    - 1. Place bolts and screws on maximum 12-inch (305-mm) centers, with no fewer than two for each side of rail, curb, or frame.
  - D. Where dissimilar metals would come in contact with each other, coat them with bituminous protective coating or other coating compatible with adjacent materials.

## 3.21 INSTALLING ACCESSORY SOUND-DEADENING MATERIALS

- A. Inside the perimeter of the curb or dedicated outdoor air units, rooftop energy recovery units, and rooftop heat pump units, cover roof deck with gypsum board fit in tightly, joints and voids filled in with embedding compound, and edges sealed.
- B. Over gypsum board, install acoustical lining and gypsum board as detailed on the drawings. Fill joints and voids and seal edges of each layer of gypsum board.
- C. Applying sealant:
  - 1. Clean surfaces and install bond breaker.
  - 2. Install sealant to a maximum depth of 0.5 inch, minimum depth 0.25 inch. Sealant is moisture-cured; assure adequate exposure to air.
- D. Protect sound-deadening materials from weather until equipment has been installed and flashed weathertight.

## 3.22 INSTALLING ROOFTOP PIPE SUPPORT SYSTEM

- A. Where air-conditioning condensate lines cross roof from equipment to drain, support on rooftop support system.
- B. Use clamps and fasteners compatible with piping.

C. Follow manufacturer's instructions.

## 3.60 FIELD QUALITY CONTROL

A. Notify the Architect at least two days in advance of the time when the installation of sounddeadening materials will be complete. Do not cover the work until the Architect has inspected it and signed the certificate required in the article "Submittals" in Part 1 above, stating that the installation of sound deadening is in accordance with the specifications and drawings.

## SECTION 23 05 07 - FIRESTOPPING FOR HVAC WORK

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Through-penetration firestopping in fire-rated construction.
- B. Through-penetration smoke-stopping in smoke partitions.
- 1.14 RELATED SECTIONS
  - A. Sections specifying requirements for LEED rating are specified in Division 01.
  - B. Sleeves and plates: Section 23 05 02.
  - C. Ductwork: Section 23 31 13.

## 1.20 REFERENCES

- A. Underwriters Laboratories
  - 1. UL Fire Resistance Directory
  - 2. UL 1479: Through Penetration Firestops.
- B. American Society for Testing and Materials Standards:
  - 1. ASTM E 814: Standard Test Method For Fire Tests of Through-Penetration Firestops.

## 1.21 DEFINITIONS

- A. Assembly: Particular arrangement of materials specific to given type of construction described in referenced documents.
- B. Barriers: Time-rated fire walls, smoke barrier walls, time-rated ceiling/floor assemblies and structural floors.
- C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.
- D. Penetration: Opening or foreign materials passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.
- E. Sleeve: Metal fabrication or pipe section extending through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.
- F. System: Specific products and applications, classified and numbered by the rating agency to close specific barrier penetrations.

#### 1.25 SYSTEM DESCRIPTION

- A. Design requirements
  - 1. Fire-rated construction: Maintain barrier and structural floor fire resistant ratings including resistance to cold smoke at all penetrations.
  - 2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. LEED submittal:
  - 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For penetration firestopping, including printed statement of VOC content and chemical components.
- C. Product data: Manufacturer's specifications and technical data including the following:
  - 1. Detailed specification of construction and fabrication.
  - 2. Manufacturer's installation instructions.
- D. Shop drawings: Submit firestop assemblies and devices for all openings and through penetrations in fire-rated construction. Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, plus the following specific requirements.
  - 1. Details of each proposed assembly identifying intended products and applicable rating agency classification.
  - 2. Manufacturer or manufacturer's representative shall provide qualified engineering judgments and drawings relating to conditions where rated assemblies do not exist.
- E. Quality control submittals: Statement of qualifications.
- F. Applicators' qualifications statement: List past projects indicating required experience.
- G. Certifications: Letters or forms showing acceptance by local authorities for systems without acceptance by a rating agency.

#### 1.40 QUALITY ASSURANCE

- A. Products and assemblies shall be tested and labeled by an independent, nationally recognized testing and labeling authority.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installer's qualification: Firm experienced in installation or application of systems similar in complexity to those required for this project, plus the following:

- 2. Acceptable to or licensed by manufacturer, state, or local authority where applicable.
- 3. At least 2 years experience with systems.
- 4. Successfully completed at least 5 projects of comparable scale, using these systems.
- D. Local and state regulatory requirements: Obtain acceptance for proposed assemblies not conforming to specific rating agency classifications or rated assemblies.
- E. Materials shall have been tested to provide fire rating at least equal to that of the construction in which they are to be installed.
- F. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.

#### 1.50 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
  - 1. Deliver products in original unopened packaging with legible manufacturer's identification.
  - 2. Coordinate delivery with scheduled installation date, allow minimum storage at site.
- B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

#### 1.60 PROJECT CONDITIONS

- A. Verify existing conditions:
  - 1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
  - 2. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.
- B. Environmental requirements:
  - 1. Furnish adequate ventilation if using solvent.
  - 2. Furnish forced-air ventilation during installation if required by manufacturer.
  - 3. Keep flammable materials away from sparks or flame.
  - 4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
  - 5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

#### 1.80 WARRANTY

A. General project warranty and correction period, as required in general conditions and Division 01, requires repair or replacement of materials or systems which fail in joint adhesion, co-adhesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, or general durability or appear to deteriorate in any other manner not clearly

specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers and products: Those listed in the UL Fire Resistance Directory for the UL System involved, or rated for the application by Warnock Hersey or by another acceptable rating agency.

#### 2.20 THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

- A. Provide systems or devices listed and labeled by a rating agency, and conforming to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance. The system shall be symmetrical for wall applications. Systems or devices shall be asbestos-free.
  - 1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system, or by the use of a separate product included as a part of the rated system or device, and designed to perform this function.

## 2.22 SMOKE-STOPPING AT SMOKE PARTITIONS

A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

## 2.70 ACCESSORIES

A. Fill, void or cavity materials and forming materials: Classified for firestopping use, or included in a rated firestopping assembly, by a rating agency.

## PART 3 - EXECUTION

## 3.02 EXAMINATION

- A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
  - 1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.
  - 2. Do not proceed until unsatisfactory conditions have been corrected.

## 3.05 PREPARATION

A. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

## 3.20 INSTALLATION

- A. Provide firestop devices or assemblies for every opening and penetration in floors or fire-rated construction.
- B. Install penetration seal materials in accordance with printed instructions of the rating agency and in accordance with manufacturer's instruction.
- C. Ensure an effective smoke barrier in each sealed penetration. Install smoke stopping as specified for firestopping.
- D. Protect materials from damage on surfaces subject to traffic.
- E. Where large openings are created in walls or floors to permit installation of pipes, ducts, or other items, close unused portions of opening with firestopping material tested for the application.
- 3.60 FIELD QUALITY CONTROL
  - A. Examine penetration seals to ensure proper installation before concealing or enclosing them.
  - B. Keep areas of work accessible until inspection and acceptance by applicable authorities.
  - C. Before substantial completion, patch and repair firestopping cut or penetrated by other construction work.
- 3.70 ADJUSTING AND CLEANING
  - A. Clean up spills of liquid components.
  - B. Neatly cut and trim materials as required.
  - C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

## **SECTION 23 0508 - HVAC PIPING SPECIALTIES**

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Specialties for HVAC piping systems.
- 1.14 RELATED SECTIONS
  - A. Piping: Section 23 21 13.
  - B. Access doors: Section 23 05 03.
  - C. Expansion tanks and air separators: Section 23 05 09.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: For each specialty included in the work. Include rated capacities of selected equipment and manufacturer's installation instructions where applicable. Indicate materials, finishes, dimensions, required clearances, methods of assembly of components; and piping and wiring connections.
- C. Backflow preventer for fire suppression connection: Provide a copy of the approved product performance data to the subcontractor doing sprinkler system calculations for the project.

## PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Flexible connections, NPS 2.5 through 12:
  - 1. Amber/Booth
  - 2. Dunlop, Inc.
  - 3. Garlock Mechanical Packing Division
  - 4. Keflex (Flex-Weld Inc.)
  - 5. Mason Industries, Inc.
  - 6. Metraflex
  - 7. US Hose Corporation/Senior Flexonics
- B. Gaskets:
  - 1. Garlock Mechanical Packing Division
  - 2. Manville
- C. Dielectric fittings:
  - 1. Anvil International

- 2. Elster Perfection
- 3. Precision Plumbing Products, Inc.
- 4. Sioux Chief Manufacturing Company, Inc.
- 5. Victaulic Company of America
- D. Water strainers:
  - 1. Keckley
  - 2. Mueller Steam Specialty
  - 3. Spirax Sarco Inc.
  - 4. Tate Andale, Inc. "Guardian"
  - 5. Watts Industries, Inc.
- E. High-capacity automatic air vents:
  - 1. Amtrol Inc.
  - 2. Hoffman Specialty Div. of ITT Industries
  - 3. Spirax Sarco Inc.
  - 4. Spirotherm, Inc.
  - 5. Taco, Inc.
- F. Automatic air vents:
  - 1. Hoffman Specialty Div. of ITT Industries
  - 2. ITT Bell and Gossett
  - 3. Spirax Sarco Inc.
  - 4. Spirotherm, Inc.
  - 5. Taco Inc.
- G. Manual air vents:
  - 1. ITT Bell and Gossett
  - 2. Taco, Inc.
- H. Water solenoid valve:
  - 1. Automatic Switch Company (ASCO)
- I. Water pressure reducing valves:
  - 1. Spence Engineering Company Inc.
  - 2. Watts Industries Inc.
- J. Chemical feeder:
  - 1. Neptune Chemical Pump Company
  - 2. Vulcan Laboratories Inc.
- 2.21 FLEXIBLE CONNECTIONS, WATER

A Flexible connections NPS 1.5 through 12 (DN 40 through 300) for pumps only: Equal to Mason Industries, Inc. Type SFEJ. Units shall have Class 150 flanged ends with multi-layered kevlar tire cord fabric reinforced with peroxide cured EPDM cover, liner and fabric frictioning. Connectors shall be installed with control rods designed with ½ inch (12 mm) thick neoprene washer bushings large enough in diameter to withstand the thrust at 1000 psi (70 kg/cm<sup>2</sup>) maximum on the washer area. Bursting pressure shall be a minimum of three times Operating Pressures. Allowable movements and pressures shall be in accordance with the following:

Pipe Size NPS (DN)	Length Face to Face Inches (mm)	Axial Compression Inches (mm)	Axial Elongation Inches (mm)	Transverse Movement Inches (mm)	Angular Deflection Degrees (Rad)	Operating Psi ( at Operating 170F(77C)	Pressures (Bar) Temperatures 250F(121C)
1.5 (40)					21 (0.37)		
2 (50)					20 (0.35)		
2.5 (65)	4.0 (102)	0.625 (16)	0.5 (12)	0.375 (9.5)	19 (0.33)		
3 (75)					18 ( 0.31)		
4 (100)					17 (0.30)		
5 (125)					16 ( 0.28)	250 (17)	215 (14)
6 (150)					15 (0.26)		
8 (200)	6.0 (150)	1 (25)	0.625 (16)	0.625 (16)	14 (0.24)		
10 (250)					13 (0.23)		
12 (300)					12 (0.21)		

- B. Flexible connections NPS 2 (DN 50) and smaller: Equal to Senior Flexonics Series BSN stainless steel with threaded ends in steel pipe and Series BRC, bronze with solder ends in copper pipe.
- C. Flexible connections NPS 2.5 through 8 (DN 65 through 200): Equal to Metraflex Company Type MLP. Units shall have 150 psi flanged ends with corrugated Type 321 stainless-steel inner tube and stainless-steel wire braid outer shield.

## 2.24 GASKETS, UNIONS, AND DIELECTRIC NIPPLES

- A. Gaskets for flanged joints: Cross-laminated long fiber composition suitable for service, temperature, pressure and liquid with which they come in contact.
- B. Unions NPS 2.5 (DN 65) and smaller: Malleable iron, Class 150, ASME B16.39, equal to Anvil International with ground bronze seats, or soldered type brass unions of equal quality.
- C. Dielectric fittings:
  - 1. General: Completely isolate dissimilar metals so that electric current is below 1 percent of the galvanic current which would exist with metal-to-metal contact. Gaskets approved for the medium carried by the piping system.

- 2. Dielectric nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain or threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 degrees F (107 degrees C).
- 3. Grooved piping: "Dielectric Waterway Fittings" equal to Victaulic Co. "Clearflow" steel threaded ends or thread to Victaulic groove with opaque, high-temperature thermoplastic copolymer liner designed for use at temperatures up to 225 degrees F (107 degrees C) and pressure up to 300 psi (2068 kPa). Complete with ring groove to lock steel casing to plastic liner.

## 2.25 WATER SPECIALTIES

- A. Y-type strainers:
  - 1. Equal to Spirax Sarco Model IT threaded or Model CI flanged.
  - 2. For use in copper piping: Spirax Sarco Model BT threaded.
  - 3. Screens in Y-type strainers: Stainless-steel having maximum 0.045-inch (1.2-mm) perforations.
- B. High-capacity automatic air vent: For releasing air from hot or cold water lines. Float-operated type with minimum 7 cfm (3.3 L/s) capacity.
  - 1. Materials: Cast-iron body and cover; stainless-steel valve pin and seat, and float; gasket conforming to ASTM F 104; high-strength steel cap screws.
  - 2. Operating limits: Maximum pressure 250 psig (1725 kPa); maximum temperature 300 degrees F (149 degrees C); hydrostatic pressure to 350 psig (2415 kPa).
- C. Automatic air vent: Water vent designed for use on high pressure hot or cold water mains. Includes safety drain connection for discharging moisture entrained in the vented air. Tapped at top for 1/8-inch IPS (DN 6) built-in check valve.
  - 1. Materials: Cast brass body.
  - 2. Operating limits: Maximum operating pressure 150 psi (1035 kPa); hydrostatic pressure to 450 psi (3105 kPa).
- D. Manual air vent: 150 psig (1035 kPa) working pressure, 212 degrees F (100 degrees C) maximum operating temperature.
- E. Water solenoid valve: Normally closed type, PTFE seal, 120-V coil, equal to Automatic Switch Co., ASCO 8210 in sizes up to NPS 3 (DN 80).
- F. Pressure relief valves: ASME rated, NB approved, automatic reseating type conforming to ANSI Z21.22.
  - 1. Provide straight pressure type where installed in pipe lines and for protection of coils and cold water vessels.
  - 2. Provide combination pressure and temperature type where installed for hot water tanks and vessels.
- G. Water pressure-reducing valves NPS 2 (DN 50) and smaller: Equal to Spence Model D-36, high-capacity, directly operated, designed for variable flow rate while maintaining close

regulation of the reduced pressure. Construction: Single-seated, opening in the direction of flow, with a soft disc; cast bronze with threaded ends suitable for maximum inlet conditions of 300 psi (2070 kPa) at 160 degrees F (71 degrees C). Provide proper spring for range indicated on the drawings. Valve shall meet ASSE Standard 1003 and MIL-V-18146.

- H. Water pressure-reducing valves NPS 2.5 (DN 65) and larger: Equal to Spence Type D-34, single-seated, packless for dead-end service, flanged, ANSI B16.1 Class 125, sizes as shown on the drawings. The valves shall prevent pressure fluctuations without the use of surge chambers or other cushioning devices. Delivery pressure shall be adjustable within a minimum range of 20 psi (138 kPa).
- 2.27 CHEMICAL FEEDER
  - A. Five gallon capacity, cast-iron or welded-steel body, rated for pressure of 200 psi, complete with capped filling opening, connections, inlet, outlet and drain valves, and accessories, as detailed on the drawings.
- PART 3 EXECUTION
- 3.20 INSTALLATION, GENERAL
  - A. Plastic piping specialties are not permitted in HVAC system ceiling plenums or shafts used to convey building HVAC air distribution.
- 3.21 INSTALLING FLEXIBLE CONNECTIONS
  - A. Make connections to all base-mounted pumps and to heat pump unit compressors with flexible connections as detailed on the drawings. Flexible connections may also be used in connections to other equipment to provide for proper alignment of piping with connection flange on equipment. Piping on house side of flexible connections shall be securely anchored.

## 3.23 INSTALLING GASKETS AND DIELECTRIC NIPPLES

- A. Gaskets shall be installed in accordance with manufacturer's recommendations.
- B. Pipe connections to fixtures, control valves, equipment and appliances shall be provided with unions or flanges so that the units may be disconnected and replaced without damage to the pipe.
- C. Provide dielectric nipples between copper and steel piping NPS 0.5 through 2.5 (DN 15 through 65).
- 3.24 INSTALLING WATER SPECIALTIES
  - A. Provide specialties for each piping system and for heat transfer elements, as indicated.
  - B. The pressure-reducing valves and pressure relief valves shall be line size and adjusted to the pressures indicated on the drawings.

- C. Install relief valves for devices where required by governing codes. Relief valve discharge shall be piped as indicated or to the nearest floor drain or to within six inches of the floor beside unit.
- D. Install pressure-reducing valve in water service at point of entry into building arranged as indicated. Provide pressure gage on each side of the pressure-reducing valve.
- E. Install valves, Y-type strainers, balancing fittings, vacuum breakers, and appurtenances for unit heaters, heating and cooling coils, and heating and cooling elements.
- F. Automatic fill for the hydronic systems shall be as diagramed on the drawings. The pressurereducing valves and pressure-relief valves shall be line size and adjusted to the pressures indicated on the drawings.
- G. In hydronic systems, provide automatic air vents where indicated and at each high point in piping. Provide 0.375-inch (DN 10) copper tubing from each automatic vent to discharge into main relief lines which discharge into nearest service tank or floor drain. Provide high-capacity type near expansion tank or air separation tank and where indicated. Install manual air vents at each heat pump unit.

## 3.26 INSTALLING CHEMICAL FEEDER

A. Install on steel angle supports, complete with connections and accessories, as shown on the drawings. Assure that cap is in place and operable.

#### SECTION 23 05 09 - HVAC EXPANSION SYSTEM

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Precharged bladder-type expansion tank and tangential air separator with vent.
- 1.14 RELATED SECTIONS
  - A. Piping: Section 23 21 13.
  - B. Supports: Section 23 05 29.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Each type of expansion system or tank, including each relief and air separation device and all accessories.

#### PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified and scheduled products or comparable products by one of the following:
  - 1. Expansion tanks:
    - a. Amtrol, Inc.
    - b. Armstrong Pumps, Inc
    - c. Bell and Gossett Domestic Pump Div of ITT
    - d. Taco
    - e. Wessels
  - 2. Tangential air separators:
    - a. Amtrol, Inc
    - b. Bell and Gossett Domestic Pump Div of ITT
    - c. Patterson
    - d. Taco

#### 2.31 BLADDER-TYPE EXPANSION TANK

A. Pressurized bladder-type tank, Taco CA or CBX model number scheduled on the drawings, containing impermeable bladder which separates the air cushion from the system water. Operating temperature: 240 degrees F maximum. Precharge to system fill pressure.

- B. Shell: Welded steel, constructed, tested and stamped in accordance with ASME BPV for Unfired Pressure Vessels for a working pressure of 125 psi (860 kPa), lined with protective coating.
- C. Bladder: Butyl rubber, flexible but not stretchable under working conditions, removable for inspection.
- D. Size and capacity: Shown on the drawings.
- E. Supports: For horizontal or vertical support on concrete equipment foundation, as diagramed on the drawings.
- 2.34 TANGENTIAL AIR SEPARATOR
  - A. Air separator: Amtrol, Bell & Gossett, or Taco tangential type, designed to eliminate free and entrained air from the system.
  - B. Construction: Welded black steel, ASME constructed and labeled for 125 psig (860 kPa) working pressure.
    - 1. Connections:
      - a. NPS 2.5 (DN 65) and larger: Flanged.
    - 2. Air-removing element: Perforated stainless-steel air collector tube.
    - 3. Size: Line size unless otherwise noted on the drawings.

# 2.36 HIGH CAPACITY AUTOMATIC AIR VENT

A. As specified in Section 23 05 08, HVAC Piping Specialties. Float type vent, size and capacity recommended by manufacturer for tank and system.

## PART 3 - EXECUTION

- 3.21 INSTALLING EXPANSION TANKS
  - A. Follow manufacturer's instructions and recommendations.
  - B. Install piping, air separation apparatus, and vents as diagramed on drawings.
  - C. Install supports as shown on drawings.

## 3.23 INSTALLING TANGENTIAL AIR SEPARATOR

- A. Suspend from overhead hanger.
- B. Provide automatic air vent and install drain pipes between vent and floor drain.
- C. Make automatic fill connection from cold water main to system, as shown on diagrams.

## 3.75 CLEANING

- A. Remove and clean air separator air-removing element after 24 hours operation, and after 30 days operation.
- 3.81 OPERATING INSTRUCTIONS
  - A. As specified in Section 23 05 00, provide operating instructions.

#### SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Unless otherwise specified in a particular section or required for a particular application, motors shall conform to the following requirements, whether factory-installed or field-installed.
- 1.13 PRODUCT FURNISHED BUT NOT INSTALLED UNDER THIS SECTION
  - A. Motor capacitors: Section 26 05 21, Wiring Connections.

#### 1.14 RELATED WORK SPECIFIED ELSEWHERE

- A. Pumps: Section 23 21 23.
- B. Air-conditioning units: Section 23 81 27.
- C. Heat pumps: Section 23 81 46.
- D. Energy recovery and dedicated outdoor air units: Section 23 72 00.
- E. Fans: Section 23 34 00.
- F. Variable-refrigerant-volume multizone system: Section 23 81 28
- G. Variable frequency drives: Section 26 29 23

## 1.20 REFERENCES

- A. NEMA MG 1: Motors and Generators.
- B. NEMA MG 10: Energy Management Guide for Selection and Use of Polyphase Motors.
- C. NEMA MG 11: Energy Management Guide for Selection and Use of Single-Phase Motors.
- D. UL 508: Industrial Control Equipment.

#### 1.21 DEFINITIONS

- A. Energy efficient motor: Motor meeting the nominal and minimum efficiency levels listed for its horsepower and speed in Table 12-10 of NEMA MG 1.
- B. Nominal efficiency: Efficiency as defined in Table 12-8, Efficiency Levels, in NEMA MG 1, and identified on the motor nameplate.

#### 1.30 SUBMITTALS

A. General: Comply with Division 01 and Section 23 01 01.

- B. Product data:
  - 1. Motors and drives not provided with equipment: Show nameplate data and ratings; characteristics; mounting arrangements; size and location of winding termination lugs, conduit entry, and grounding lugs, and coatings.
  - 2. Motor capacitors.
- C. Wiring diagrams required for the proper installation of mechanical equipment.
- D. Submit product data which verifies compliance with ASHRAE 90.1 or provide certified performance ratings by a qualified independent testing agency.
- E. Certifications:
  - 1. Actual motor power factor for each motor, certified test results for each motor proposed for use on this project.
  - 2. Field test showing corrected power factor, if required.
  - 3. Motors controlled by variable frequency controllers: Certification that motor meets specified requirements.
- 1.40 QUALITY ASSURANCE
  - A. Actual motor power factor shall be tested and certified by an independent testing laboratory.
  - B. Where power factor is field tested as required in "Power Factor" in Part 2 below, specialist performing tests shall be acceptable to the local authorities having jurisdiction.
  - C. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.
  - D. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

## 1.44 REGULATORY REQUIREMENTS

A. Motors shall conform to the requirements of NEMA MG1 and applicable portions of the National Electric Code (NEC, NFPA 70).

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Motors:
  - 1. Baldor Electric Co.
  - 2. Marathon
  - 3. Rockwell
  - 4. Siemens
  - 5. A.O. Smith
  - 6. Toshiba International

- B. Motor capacitors:
  - 1. ABB Power Distribution
  - 2. Commonwealth Sprague
  - 3. General Electric

## 2.20 BASIC MOTOR REQUIREMENTS

- A. Capacity: Each motor shall have sufficient capacity and torque to start, accelerate, and operate the machine it drives without exceeding the motor nameplate rating at the speed specified, or at any speed and load which may be obtained by the drive actually furnished.
- B. Starting: Each automatically controlled motor shall be capable of starting as frequently as the control sequence may demand. Motors not automatically controlled shall be capable of making no fewer than 4 starts per hour.
- C. Loads: Belt-connected motors shall be equipped with shafts and bearings designed to withstand both the normal connected loads of the drive furnished, and momentary loads imposed during acceleration.
- D. Ratings: Motors shall be rated for continuous duty at 100 percent of rated capacity, and temperature rise shall be based on ambient temperature of 40 degrees C.
- E. Phase: Unless otherwise indicated, motors one-half horsepower and larger shall be polyphase and motors smaller than one-half horsepower shall be single-phase motors.
- F. Two-speed motors shall be dual winding type.
- G. Motor construction:
  - 1. Motors for fans, air handling units, and pumps, unless specified otherwise in the equipment section, shall be open drip-proof NEMA design B construction.
  - 2. Where indicated or specified, motors mounted outdoors, shall be totally enclosed, fancooled (TEFC) extra severe-duty. Motors outdoors inside weather-tight enclosures may be open drip-proof type.
- H. Efficiency: The term "energy efficient" is defined in the article "Definitions" in Part 1 above.
  - 1. Single-phase motors, alternating-current fractional horsepower, rated 1/20 to 1 horsepower, 250 volts or less: NEMA MG 11, types and efficiencies selected for their applications.
  - Polyphase motors, medium alternating-current, squirrel-cage, 1 to 500 horsepower, 600 volts or less: NEMA MG 10, energy-efficient types selected for their application. Nominal full-load efficiencies shall meet or exceed ratings of Table 12-10 of NEMA MG 1.
  - 3. Motors for packaged hermetic and semi-hermetic refrigeration compressors need not comply with these efficiency requirements but they shall comply with the requirements indicated for power factor and power consumption.

#### 2.21 SINGLE-PHASE MOTORS

- A. Permanent split-capacitor or split-phase type.
- B. Bearings: Sealed, prelubricated ball-bearing type.

## 2.22 POLYPHASE MOTORS

- A. NEMA MG1 Design B.
- B. Stator: Copper windings.
- C. Rotor: Squirrel cage.
- D. Bearings: Doubly shielded, prelubricated ball bearings suitable for radial and thrust loading of connected equipment.
- E. Temperature rise shall not exceed insulation rating.
- F. Insulation: Class F.
- G. Motors used with inrush controllers: Match wiring requirements for indicated controller with required motor leads brought to motor terminal box to suit control method.
- H. Horsepower/frame relationship: NEMA Standard for T frame motors.
- I. Motor frame and endshields: Cast iron.
- J. Conduit box: Either steel or aluminum, diagonally split and rotatable in 90-degree increments, with grounding provision.
- K. Finishes:
  - 1. External hardware: Plated to resist corrosion.
  - 2. External paint: Industrial enamel.
- L. Nameplates: Stainless steel or aluminum, and stamped in accordance with NEMA MG1. Nameplate information shall include the nominal efficiency value in accordance with NEMA MG1 and the manufacturer's minimum guaranteed efficiency value.

## 2.23 ELECTRONICALLY COMMUTATED MOTOR (ECM)

- A. Brushless direct current (DC) variable speed motor supplied with alternating current, with a permanent magnet with near zero rotor losses, permanently-lubricated ball bearings, electronic commutation, designed for synchronous rotation, and at least 70 percent efficient at all operating speeds.
- B. As a minimum, the motor shall include the following features:

- 1. Integrated controller / invertor that operates the wound stator and senses rotor position to electronically commutate the stator.
- 2. Thermal overload protection.
- 3. Built-in soft start and soft speed change ramps.
- 4. Inductors to minimize harmonic distortion and line noise.
- 5. Designed to overcome reverse rotation without affecting life expectancy.
- 6. Motor speed shall be controllable down to 20 percent of full speed. Speed shall be controlled by either a potentiometer with manual adjustment on the motor or by a 0-10Vdc analog signal from a remote source, as required by other sections of Division 23 specifications.
- 7. Software for motor control shall be as indicated or described in other Division 23 specifications.

#### 2.24 MOTORS CONTROLLED BY VARIABLE FREQUENCY DRIVES

- A. Specifically constructed and warranted by the manufacturer to meet the voltage requirements of NEMA MG 1, Part 31.4.4.2.
- B. Temperature rise: Match rating for Class B insulation.
- C. Insulation: Class B or F (TEFC), or Class F (ODP).
- D. Bearing protection: Conductive shaft grounding ring, equal to Aegis SGR by Electro Static Technology, to transmit induced current from shaft to motor frame without harming bearings.

## 2.25 POWER FACTOR

- A. Power factor for three-phase motors 10 HP and larger and packaged equipment systems totaling 10 HP and larger as noted below shall be not less than 90 percent at full rated load. Test, certify, and submit certified reports for each motor as required in "Submittals" and "Quality Assurance" in Part 1 above.
  - 1. Should the Contractor propose to provide motors with less than 90 percent power factor, provide power-factor-correcting, automatically discharging type motor capacitors. The corrected power factor of the motor-capacitor combination shall be equal to or greater than 90 percent. Submit certified test results.
  - 2. Motor capacitor: Designed for installation at the load side of motor starters; insulated, impregnated component unit completely enclosed in a grounded steel case with welded and ground seams. Where installed on outdoor equipment, case shall be weatherproof. Provide each unit with a flexible cable for connection to the starter or motor terminals. The capacitor shall be suitable for use in areas with ambient temperatures ranging from minus 10 degrees F to 115 degrees F.
- B. Where motors totaling 10 HP and larger are part of packaged equipment system, such as packaged air-conditioning unit or air-conditioning condensing unit, the overall power factor for the entire system package shall be no less than 90 percent. Provide capacitors and appurtenances required to accomplish this power factor as part of the packaged equipment, or furnish separately and wire as work of equipment installation. Capacitors shall be stepped, deenergized, or cycled when the unit is deenergized or the load is varied, to maintain 90 percent power factor.
- 1. Capacitors provided as part of packaged equipment: If the installation of the capacitors voids the UL label, unit shall be tested. Actual power factor shall be factory-tested and certified test results included in submittals.
- 2. Capacitors provided separately and wired as work of equipment installation: Unit shall then be field tested to verify actual power factor. Submit field test reports.
- 3. Tests shall be performed by an electrical testing specialist and in accordance with NFPA 70 (NEC) testing brochure.
- C. Motors and packaged equipment systems equipped with variable frequency drives shall not receive power factor correcting capacitors.

# 2.26 MOTOR DRIVES

A. Motors for belt-driven units shall have adjustable variably pitched cast-iron sheaves to allow a 10 percent increase or reduction in speed for units less than 30 HP and fixed sheaves for units 30 HP and larger. Belts shall be sized for minimum 150 percent BHP. Provide OSHA- and MOSHA-approved type belt guards. Include one change in drive sheave for each unit if necessary to obtain required air quantities and static pressure.

# PART 3 - EXECUTION

### 3.20 INSTALLATION

- A. Mount direct-connected motors securely and in accurate alignment. The drive shall be free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.
- B. Provide each belt-connected motor with a securely mounted adjustable base to permit installation and adjustment of belts.
- C. Mount capacitors shipped separately beside motor connection box as required. Connect in accordance with the requirements of Division 26, Electrical.
  - 1. Test units at full rated load after the installation of the motor capacitors, and submit reports.
- D. Provide explosion-proof motors where indicated.
- E. Provide additional drive and belt changes where required to meet requirements of testing and balancing specified in Section 23 05 93, Testing, Adjusting and Balancing.

### 3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

# **SECTION 23 05 19 - METERS AND GAGES FOR HVAC PIPING**

### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Meters and gages for HVAC systems.
- 1.14 RELATED SECTIONS
  - A. Pipe installation and testing: Section 23 05 00.
  - B. Valve tags and charts: Section 23 05 23.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings: Meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.
- C. Product data: For each type of meter, gage, device, and fitting specified.
  - 1. Scale range.
  - 2. Ratings.
  - 3. Calibrated performance curves.
- D. Show flow measurement locations on valve charts specified in Section 23 05 23, General-Duty Valves for HVAC Piping.

#### PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Meters and gages:
  - 1. AMETEK; U.S. Gage
  - 2. Ashcroft; Dresser Instrument
  - 3. Miljoco Corporation
  - 4. Taco, Inc.
  - 5. H.O. Trerice Co.
  - 6. Weiss Instruments
  - 7. Weksler; Dresser Instrument
- B. Pressure-temperature connections:
  - 1. Miljoco Corporation
  - 2. Peterson Equipment Company
  - 3. Sisco
  - 4. Texas Fairfax Company
  - 5. H.O. Trerice Co.

- 6. Utilities Materials and Controls, Inc.
- 7. Weiss Instruments

### 2.11 THERMOMETERS

- A. General: Industrial, adjustable angle type, accurate to within plus or minus one percent of range span, baked enamel finish, blue reading organic liquid tube, glass or clear acrylic plastic window, dust and moisture tight.
  - 1. Scale size: 9 inches (230 mm).
  - 2. Graduation: To the scale shown on the drawings or of a scale so that the normal working temperature of the system is near the mid-point of the scale.
  - 3. Case: Cast aluminum.
- B. Pipe-mounted thermometers: Brass well, separable sockets.
  - 1. Where mounted in insulated piping, thermometers shall have six-inch (150-mm) stem length and sockets with 2.5-inch (64-mm) lagging extension necks. Where mounted in uninsulated piping, they shall have 3.5-inch (89-mm) stem lengths and sockets without lagging extension.
  - 2. Where thermometer wells only are required, provide separable socket with 2.5-inch (64-mm) lagging extension, fitted with attached chain and cap.
- C. Duct-mounted thermometers: Perforated aluminum stem, length maximum 24 inches (610 mm) or of length to have end of bulb near center of duct. Provide union flange fitting where stem passes through duct side or unit casing. Provide lagging extension flange on insulated ductwork.

### 2.12 PRESSURE GAGES

- A. Pressure gages shall be accurate to within plus or minus one percent of range span, silver brazed bronze bourdon-tube system, bronze movement, aluminum dial with white background, black graduations and numerals and adjustable pointer, bottom connected.
  - 1. Dial diameter: 6 inches (150 mm).
  - 2. Those installed adjacent to pumps or in pulsating locations shall be provided with pulsating dampeners or snubbers.
  - 3. Case: Cast aluminum or glass filled nylon.
- B. Graduation: To the scale shown on drawings or so pointer is nearly straight up at system normal working pressure.
- C. Gages shall be straight pressure type, except gages on suction side of pumps and inlet side of suction strainers shall be compound type.
- D. Gage cock (pressure gage isolation valve):
  - 1. Needle valve: Brass bar stock needle valve, equal to Weksler No. BBV4.
  - 2. Ball valve: Bronze, three-piece body, full port, with Type 316 stainless steel trim, 150 psi (1034 kPa) saturated steam, 600 psi (4137 kPa) non-shock cold water, oil, or gas, equal to Nibco 595 or 595-T-66-LF.

### 2.13 COMBINATION PRESSURE-TEMPERATURE CONNECTIONS

A. Combination pressure-temperature connections: Equal to UMAC Universal Lancaster Test Plugs, Peterson "Pete's Plug," Sisco, Fairfax P/T Plugs, or H.O. Trerice test plugs. Plugs shall have self-closing valve which will operate at a temperature up to 300 degrees F (149 degrees C). Body and cap shall be brass, and shall receive either a temperature or pressure probe. Provide with a kit including gages and thermometers in a protective case.

### 2.15 VENTURI FLOWMETERS

- A. Basis-of design product: Subject to compliance with requirements, provide Preso Meters or comparable product by one of the following:
  - 1. Armstrong Pumps, Inc.
  - 2. Badger Meter, Inc.; Industrial Div.
  - 3. Flow Design, Inc.
  - 4. Gerand Engineering.
  - 5. Hyspan Precision products, Inc.
  - 6. Preso Meters
- B. Description: Differential-pressure design for installation in piping; with calibrated flowmeasuring element, separate flowmeter, hose or tubing, valves and extension; fittings, and conversion chart compatible with flow-measuring element, and protective case.
- C. NPS 0.5 through 1.5 (DN 15 through 40): Provide a venturi flow meter of the "Low Pressure Loss" design, differential pressure type, equal to Preso Meters V-Brass Series.
  - 1. Maximum pressure: 400 psig (2756 kPa).
  - 2. Maximum temperature: 250 degrees F (120 degrees C).
  - 3. Material: Brass, ASTM B16.
  - 4. Connections: Threaded or sweat ends.
- D. NPS 2 (DN 50) and larger: Provide a flow element of the metering design, differential pressure type, equal to Preso Meters CV Series.
  - 1. Venturi inlet: Cylindrical with a pressure sensing tap and diameter equal to the incoming pipe section.
  - 2. Precise convergence section.
  - 3. Venturi throat: Pressure sensing tap.
  - 4. Exit cone: Precise angle to prevent a permanent pressure loss not to exceed 15 percent of the generated differential pressure.
  - 5. Maximum pressure: 300 psig (2070 kPa).
  - 6. Maximum temperature: 250 degrees F (120 degrees C).
  - 7. Accuracy: Plus or minus 2 percent.
  - 8. Repeatability: Plus or minus 0.2 percent.
  - 9. Turndown: 10:1.
  - 10. Material: Carbon steel with stainless-steel ID tag.
  - 11. Mounting: 150 pound flange, ANSI 16.5.

- E. Instrument valves and connections: Brass ball valves with extensions, 1/8 inch by 1/4 inch SAE.
- F. Permanent indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (150-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
  - 1. Scale: Gallons per minute (Liters per second).
  - 2. Accuracy: Plus or minus 1 percent between 20 and 80 percent of range.
- G. Operating instructions: Include complete instructions with each flowmeter.
- 2.20 ELECTROMAGNETIC DDC FLOW METER FOR GEOTHERMAL HEAT PUMP LOOP
  - A. Inline insertion electromagnetic flow-detecting meter coupled to a wall-mounted remote meter controller, equal to Onicon F-3100 Series. Fully digital measurements for volumetric flow, totalized flow, and flow velocity via correlation transit-time mode. Suitable for chilled/heating water conditions and pipe sizes and wall thicknesses as shown on the drawings.
  - B. Construction: Carbon-steel body with AISI Type 304 stainless-steel internal flow tube and ANSI Class 150 raised-faced flanged end connections.
  - C. Controller: NEMA 250 Type 4X reinforced nylon enclosure, 64- by 128-pixel backlit 2-line alphanumeric LCD graphic display. Complete with cabling to interconnect meters, transmitters, and temperature sensors to controllers.
  - D. Process liquids:
    - 1. Heat pump loop water from 40 to 100 degrees F (4.4 to 37.8 degrees C) and 0 to 200 psig (0 to 1390 kPa).
  - E. Temperature transducer: Clamp-on or wetted surface type equal to GE GS868. Provided in thermowells, multiple-wire RTD platinum transducer compatible with flow meter, its controller, and liquid operating conditions.
    - 1. Accuracy: Plus or minus 2 percent.
    - 2. Output: Conditioned pulse and analog 4 to 20 mA current signal.
    - 3. Sizes: NPS 1-1/2 to 14 (DN 40 to 350).
  - F. Pressure transmitters: Wetted surface type equal to GE GS868. Provided in thermowells, multiple-wire transmitter compatible with flow meter, its controller, and liquid operating conditions.
    - 1. Accuracy: Plus or minus 2 percent.
    - 2. Output: Conditioned pulse and analog 4 to 20 mA current signal.
    - 3. Sizes: NPS 1-1/2 to 14 (DN 40 to 350).
  - G. Input-outputs: Meters capable of providing the following flow and energy measurements:
    - 1. Loop water temperature, conductivity, and pressure.

- 2. Loop water flow in feet per second (m/s), BTU per hour (kW/hour), and gallons per minute (l/s).
- 3. Totalized loop water flow in the above units
- H. Velocity accuracy: Plus or minus 0.4 percent of range from 3.3 to 33 feet/second (1.0 to 10.1 m/s).
- I. Velocity range: Minus 40 to 40 feet/second (minus 12.2 to 12.2 m/s).
- J. Communication: Provide BACnet communications card for DCS data transfer.
- K. Power: 120 Vac, single phase, 60 Hertz, 35 mA maximum.
- L. Output: Conditioned pulse and analog 4 to 20 mA current signals.
- M. Sizes: NPS 1 (DN 25) for maximum 85 gpm (5.4 l/s) to NPS 12 (DN 300) for maximum 11,000 gpm (694 l/s).

### PART 3 - EXECUTION

### 3.21 INSTALLING THERMOMETERS

- A. Pipe line thermometers shall be installed as indicated on the drawings.
- B. Duct thermometers for indoor energy recovery units shall be located as follows, except thermometers are not required if air system is not ducted:
  - 1. Energy recovery units: (4 per unit)
    - a. OA inlet duct: rigid bulb; minus 20 to plus 130 degrees F (minus 28.9 to plus 54.4 degrees C).
    - b. OA discharge duct: rigid bulb; minus 20 to plus 130 degrees F (minus 28.9 to plus 54.4 degrees C).
    - c. Exhaust air inlet duct: rigid bulb; minus 20 to plus 130 degrees F (minus 28.9 to plus 54.4 degrees C).
    - d. Exhaust air discharge duct: rigid bulb; minus 20 to plus 130 degrees F (minus 28.9 to plus 54.4 degrees C).
- C. Furnish and deliver to Owner at final inspection, three additional pipe line thermometers as above specified, with 6-inch (152-mm) stem lengths, for use in the thermometer wells. Ranges shall be minus 40 to plus 110 degrees F (minus 40 to 43.3 degrees C.); 20 to 120 degrees F (minus 6.7 to 48.9 degrees C.), and 50 to 550 degrees F (10 to 287.8 degrees C).

# 3.22 INSTALLING PRESSURE GAGES

- A. Each gage connection shall have a gage cock. Connections to pipe lines shall be 0.5 inch (DN 15), with 0.5 inch (DN 15) by 0.25 inch (DN 8) reducer for valve, the assembly of sufficient length to clear insulation.
- B. Where gage cocks only are called for on drawings, provide the 0.5-inch (DN 15) connections to pipe line with reducer and the gage cock.

- C. Provide one compound and one straight pressure gage of appropriate scale to Owner at final inspection.
- 3.23 INSTALLING COMBINATION PRESSURE-TEMPERATURE CONNECTIONS
  - A. Option: Provide combination pressure-temperature connections, complete with kits, where thermometer wells or gage cocks only are called for on the drawings.
- 3.24 INSTALLING FLOW METERS
  - A. Install a flow meter fitting or permanently installed meter as indicated on drawings. When locating the fittings, assure that sufficient straight run of pipe is provided both upstream and downstream from fittings as recommended by the manufacturer for accurate readings. Size of fittings shall be same as pipe size.
    - 1. Provide each fitting with an identification tag as specified for valve tags, giving station identification number, pipe size, meter scale and required flow in gpm (l/s).
    - 2. Show flow meter locations on valve charts specified in Section 23 05 23.
  - B. For DDC flow meters, provide connection to Building Automation System.

### SECTION 23 05 23 - GENERAL-DUTY VALVES FOR HVAC PIPING

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Valves for various piping systems.
- B. Chainwheel operators.

### 1.14 RELATED SECTIONS

- A. Piping installation and testing: Section 23 05 00.
- B. Piping systems: Section 23 21 13.
- C. Automatically operating valves: Section 23 05 08.
- D. Access doors: Section 23 05 03.

#### 1.20 REFERENCES

- A. ASME B16.10: Face-to-Face and End-to-End Dimensions of Valves.
- B. ASME B16.34: Valves Flanged, Threaded, and Welding End.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: For each type of valve. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.
- C. Maintenance data: For inclusion in operation and maintenance manual specified in Division 01 and Section 23 01 01. Include manufacturer's instructions for adjusting, servicing, disassembling, and repairing.
- D. Valve charts: Furnish valve charts typed on 8.5 by 11-inch (216 by 279-mm) bond paper, showing locations of all manual and automatic control valves, and flow meters. Include:
  - 1. Number
  - 2. Location
  - 3. Service
  - 4. Function
  - 5. Area served
- E. Valve numbering system shall be approved by the Owner prior to final submittal. Place one copy of approved chart in a plastic envelope and mount on wall where directed. Provide another copy for each of the Operating and Maintenance Manuals.

### 1.40 QUALITY ASSURANCE

A. Ferrous valves shall conform to ASME B16.10 and B16.34 for dimension and design criteria.

B. Copper alloy valves (brass and bronze) shall have no more than 15 percent zinc in the alloy.

# PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Ball valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:
  - 1. Apollo Valves
  - 2. Milwaukee Valve Co.
  - 3. NIBCO
  - 4. Stockham Valve & Fittings
  - 5. Victaulic Company of America
  - 6. Walworth Co.
  - 7. Watts Regulator Co.
- B. High-performance butterfly valves: Subject to compliance with requirements, provide the specified high performance Bray valve, or comparable product by one of the following:
  - 1. Bray
  - 2. NIBCO, Inc.
  - 3. Dezurik, A Unit of General Signal
  - 4. Jamesbury
  - 5. Victaulic Company of America
- C. Check valves: Subject to compliance with requirements, provide the specified NIBCO valve, or comparable product by one of the following:
  - 1. Combination Pump and Valve Co.
  - 2. Mueller Steam Specialty
  - 3. NIBCO
  - 4. Victaulic Company of America
- D. Balancing valves: Subject to compliance with requirements, provide specified venturi ball valve (readable) by Flo-Pac or NuTech Hydronic Specialty Products, or comparable product by Flow Design, Gerand Engineering, Tour & Andersson, Griswold Controls, or Taco. For sizes specified to be high performance butterfly valves with memory stop and venturi flow-measuring assembly, include specified high performance butterfly valve.
- E. Automatic flow-control valve system: Subject to compliance with requirements, provide the specified Flow Design Inc. product, or comparable products by one of the following:
  - 1. Flow Design
  - 2. Griswold Controls
  - 3. Nutech Hydronic Specialty Products
- F. Hose connections: Subject to compliance with requirements, provide the specified Zurn or NIBCO valves or comparable products by one of the following:
  - 1. Crane Co.
  - 2. Josam Manufacturing Co.
  - 3. NIBCO

4. Zurn

## 2.20 VALVES

- A. Ball valves:
  - 1. Valves NPS 2 (DN 50) and smaller: Class 150 SWP, bronze, two-piece body, full port, TFE seats and seals, stainless-steel ball and stem. Extension handles for use in insulated piping. NIBCO T-585-70-66 or S-585-70-66, threaded or soldered ends.
- B. High performance butterfly valves, NPS 2.5 (DN 65) and larger: High-performance lug body with bubble-tight shutoff in both directions 200 psi (1379 kPa), and maintains bubble-tight rating when flange on one side is removed (dead-end service). Class 150 suitable for use with ASME B16.5 Class 125 and 150 flanges. Valve shall provide Class VII shutoff against 270 psi, operating at cold working temperatures.
  - 1. Body: Carbon steel, for flanged connection with alignment bolts, holes, or guides.
  - 2. Seat: Single-piece, reinforced, Teflon, suitable for continuous operation at 121 degrees C, field-replaceable.
  - 3. Bearings: Stainless-steel, Teflon-backed, self-lubricating.
  - 4. Stem seals: Chevron.
  - 5. Shaft: Type 316 stainless steel, including shaft seat, retaining ring, and fasteners. Double offset shall reduce torque on seat.
  - 6. Disk: Type 316 stainless steel.
  - 7. Operator:
    - a. NPS 6 (DN 150) and smaller: Ten-position leverlock handle.
    - b. NPS 8 (DN 200) and larger: Gear operator (60 to 1 gear reduction).
  - 8. Provide 2-inch minimum extension handle where required in insulated piping.
  - 9. Where used for balancing, provide memory stop.
- C. Center-guided, spring-loaded silent-action type check valves:
  - 1. Valves NPS 2 (DN 50) and smaller: Class 125, bronze body, Teflon disk, Teflon seat ring, stainless-steel stem and spring, NIBCO Fig. S-480Y or T-480-Y, threaded or soldered ends.
  - 2. Valves NPS 2.5 (DN 65) through NPS 10 (DN 250): Class 125, cast-iron body, bronze trim, stainless-steel spring, NIBCO Fig. W-910, wafer style.
  - 3. Valves NPS 12 (DN 300) and larger: Class 125, cast-iron body, stainless-steel spring, NIBCO Fig. F-910, flanged.
  - 4. Valves NPS 0.375 (DN 10) through NPS 2 (DN 50); 250 psi CWP, bronze body, Teflon disk, stainless-steel stem and spring, NIBCO T-480-Y-LF or S-480-Y-LF, threaded or soldered ends.
- D. Swing check valves:
  - 1. Valves NPS 2 (DN 50) and smaller: Class 125, bronze, PTFE seat, renewable disks, Y pattern, horizontal swing, NIBCO T-413-Y or S-413-Y, threaded or soldered ends.
  - 2. Valves NPS 2.5 (DN 65) and larger: Class 125, IBBM, bolted bonnet, renewable seat and disk, horizontal swing NIBCO Fig. F-918-B, flanged ends.
  - 3. Valves NPS 0.25 (DN 8) through NPS 3 (DN 80); 200 psi CWP, bronze, PTFE seat, renewable seat and disk, Y pattern, horizontal swing, NIBCO T-413-Y-LF or S-413-Y-LF, threaded or soldered ends.

- E. Balancing valves:
  - 1. NPS 2 (DN 50) and smaller: Venturi ball valve (readable valve) with threaded or soldered ends, Flo-Pac or Nutech Hydronic Specialty Products Model MB, Taco "Accu-Flo (ACUF)," Gerand "Balvalve-Venturi (BV)," Tour & Andersson STAD Series, Griswold Controls "QuickSet" or FlowDesign Model UA.
    - a. Materials: Brass and bronze body, chrome-plated brass ball, PTFE seats and stem packing.
    - b. Ratings: Entire assembly 250 psi, 250 degrees F (1725 kPa, 121 degrees C).
    - c. Flow element: Low-loss, high-signal venturi section with schrader or quick-connect pressure-ports, reliability one to ten and accuracy 2 percent.
    - d. Stem: Blowout-proof.
    - e. Memory stop: On valve section, adjustable, with extended handle.
    - f. Bellows type meter gage kit with case, provide one for use on the entire project.
  - 2. NPS 2.5 (DN 65) and larger: High-performance butterfly valve with memory stop coupled with a venturi flow-measuring assembly.
    - a. Venturi type flow element: Low-loss, high-signal venturi with schrader or quickconnect pressure ports, accuracy plus or minus 3 percent FS.
    - b. Provide Owner, one bellows-type meter gage kit with case for use on the entire project.
- F. Automatic flow-control valve system: Automatic pressure-compensating flow control valve assembly for return line and inline strainer valve assembly for supply line.
  - 1. Flow control valve assembly NPS 0.5 to 2 (DN 15 to 50): Equal to Flow Design, Inc. Model AC with ball valve, flow regulator, union, and two temperature/pressure test ports mounted across flow regulator.
    - a. Flow rate: Factory-set at rate shown on drawings, controller capable of plus or minus
      5 percent accuracy over operating pressure differential suitable for the system at full flow.
    - b. Connections: Threaded or soldered.
    - c. Permanent marking: Flow direction and rate.
    - d. General construction:
      - 1) Materials: Brass and stainless steel.
      - 2) Pressure and temperature ratings: 400 psig at 250 degrees F.
      - 3) Unions: Allow field exchange of internal components without removing the valve body from the line.
      - 4) Combination pressure/temperature connection, with ports for pressure and temperature monitoring.
      - 5) Ports: Type commonly used by water balancing technicians for monitoring pressure and temperature. Thermometers shall be directly inserted into fluid.
  - 2. Flow control valve assembly NPS 2.5 to 14 (DN 65 to 350): Equal to Flow Design, Inc. Model WS wafer style automatic flow regulator with two temperature/pressure test ports mounted across flow regulator.
    - a. Flow rate: Factory-set at rate shown on drawings, controller capable of plus or minus

5 percent over 95 percent of the control range.

- b. Connections: Compatible with ANSI Class 150 or 300 lb. flanges.
- c. Permanent marking: Flow direction and rate.
- d. General construction:
  - 1) Materials: Ductile iron and stainless steel.
  - 2) Pressure and temperature ratings: 600 psig at 250 degrees F.
  - 3) Drain plug.
  - 4) Combination pressure/temperature connection, with ports for pressure and temperature monitoring.
  - 5) Ports: Type commonly used by water balancing technicians for monitoring pressure and temperature. Thermometers shall be directly inserted into fluid.
- e. Provide a high performance butterfly valve as specified in this section.
- 3. Strainer valve assembly NPS 0.5 to 2 (DN 15 to 50): Equal to Flow Design Inc. Model YC with ball valve and strainer, union, valved blowdown, and two temperature/pressure test ports mounted across strainer.
  - a. Strainer: Stainless steel, 20 mesh, wye configuration, removable without breaking main piping.
  - b. Permanent marking: Flow direction and strainer size.
- 4. Strainer valve assembly NPS 2.5 to 14 (DN 65 to 350): Refer to this section for the type of valve and refer to Section 15120, Piping Specialties, for the type of strainer.

#### 2.21 HOSE CONNECTIONS

- A. Hose bibbs: Compression type, with bronze body, stem, and bonnet, chrome-finished where exposed and rough brass where concealed, Class 125 WOG non-shock. Connection suitable for NPS 0.75 (DN 20) hose. Include integral vacuum breaker (if valve is disassembled, hose cannot be attached).
  - Mounted on wall with concealed connection: Angle sillcock, equal to NIBCO Figure No.
    63. Provide with removable handle where bibb is accessible to the general public.
  - 2. Connecting to exposed pipe: Drain valve, equal to NIBCO Figure No. 74.

### 2.70 CHAINWHEEL OPERATORS

- A. Manufacturers:
  - 1. Babbitt Steam Specialty Co.
  - 2. Roto Hammer Industries, Inc.
- B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
  - 1. Sprocket rim with chain guides: Ductile iron or cast iron, of type and size required for valve. Include zinc coating.
  - 2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
  - 3. Chain: Hot-dip, galvanized steel of size required to fit sprocket rim.
- C. Chain storage canisters: Non-corrosive canisters for storage of overhead chains, allow for chain loop release in a single downward movement.

- 1. Canisters: Plastic, safety yellow or orange color, with perforated bottom for drainage and integral release handle, quick-release hooking mechanism and retention lanyard.
- 2. Attach to each overhead chain loop with 6 feet minimum clearance below canister.
- 3. Equal to Roto Hammer, Model CHAW "Chain Away."

### PART 3 - EXECUTION

#### 3.20 INSTALLATION, GENERAL

- A. Install valves to be readily accessible for operation and maintenance, and with ample clearance for turning handles or operators.
- B. For valves in inaccessible locations, provide access doors as specified in a related section.
- C. Identify valves as specified in Section 23 05 00, Common Work Results for HVAC.
  - 1. Provide tags for all valves except stop valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.
  - 2. Provide ceiling identification tags where valves are above an accessible suspended ceiling. Number shall correspond to tag number.
- D. Install chainwheel operators on valves NPS 4 (DN 100) and larger and more than 7 feet (2150 mm) above floor. Extend chains to 6 feet (1850 mm) above finished floor elevation.

#### 3.21 INSTALLING SHUTOFF AND BALANCING VALVES

- A. Install shutoff and balancing valves where indicated. Generally, install balancing valves in return lines of coils and elements, and shutoff valves in supply lines.
- B. Shutoff valves for water piping systems shall be as follows:
  - 1. Sizes NPS 2 (DN 50) and smaller: Ball valves.
  - 2. Sizes NPS 2.5 (DN 65) and larger: High-performance butterfly valves.
- C. Balancing valves: Locate valve to provide 5 pipe diameters straight inlet and 2 pipe diameters straight outlet.
- 3.22 INSTALLING CHECK VALVES
  - A. Provide center-guided, spring-loaded silent-action type check valves in pumped lines, lines subject to pump pressure, and vertical lines.

# 3.23 INSTALLING AUTOMATIC FLOW CONTROL VALVE ASSEMBLIES

- A. Provide automatic flow control valve assemblies for coils, as shown on the drawings.
- B. Install automatic flow control assembly in return line and strainer in supply line as shown on the drawings.
- 3.24 INSTALLING AUTOMATIC BALANCING VALVES

- A. Install automatic balancing valves in return line pipe with flow direction arrows indicating proper flow direction as shown on the drawings.
- B. Provide access to the balancing valve for inspection, maintenance, or adjustment.
- C. Locate valve to provide 5 pipe diameters straight inlet and 2 pipe diameters straight outlet.
- 3.26 INSTALLING HOSE CONNECTIONS
  - A. Drain valves: Provide interior hose bibbs, NPS 0.75 (DN 20) or size indicated on the drawings, at every low point of a water system, and where indicated.

### SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Supports for piping systems and equipment.
- B. Equipment foundations.
- C. Accessories.

#### 1.14 RELATED SECTIONS

- A. Vibration control supports: Section 23 05 48.
- B. Duct supports: Section 23 31 13.

#### 1.20 REFERENCES

- A. ASME B31.9: Building Services Piping.
- B. MSS SP-58: Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation.

#### 1.21 DEFINITIONS

- A. Definitions are from MSS SP-58, "Classification of Piping Systems."
- B. Hot Systems: Maximum operating (service) temperatures 120 degrees F (49 degrees C) and above.
- C. Ambient Systems: Maximum operating temperatures 60 to 119 degrees F (16 to 48 degrees C).
- D. Cold Systems: Maximum operating temperatures 59 degrees F (15 degrees C) and below.

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Provide manufacturer's literature showing compliance with specifications for each type of hanger and manufactured support, including fasteners and accessory materials.

#### 1.40 QUALITY ASSURANCE

- A. Hangers and supports shall comply with the requirements of:
  - 1. MSS SP-58.
  - 2. ASME B31.9.

B. Qualifications of welders: As specified in Section 23 05 00, Common Work Results for HVAC.

# PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Hangers
  - 1. Anvil International
  - 2. Carpenter and Paterson, Inc.
  - 3. PHD Manufacturing, Inc.
  - 4. National Pipe Hanger Corporation
- B. Support systems
  - 1. Anvil International
  - 2. Unistrut
  - 3. PHD Manufacturing, Inc.
  - 4. Copper (refrigerant piping)
- C. Thermal hanger shields
  - 1. Carpenter and Patterson, Inc.
  - 2. Pipe Shields, Inc.
  - 3. Rilco Manufacturing Co., Inc.

### 2.10 CONCRETE

- A. Concrete shall be no less than 3000-lb (25,000 kPa) strength.
- B. Reinforcement: 6 by 6 inch (150 by 150 mm) welded steel wire fabric, ASTM A 185.
- 2.11 GROUT
  - A. Non-shrink grout: Premixed, consisting of non-metallic aggregate, cement, and water-reducing and plasticizing agents; capable of developing minimum compressive strength of 7,000 psi (48,000 kPa) in 28 days.
    - 1. Sonneborn-Rexnord "Sonogrout"
    - 2. L&M Construction Chemical Company "Crystex"
    - 3. US Grout Corporation "Five-Star Grout"

### 2.20 HANGERS AND SUPPORTS

- A. Types are identified by MSS type numbers in the article "Installing Pipe Hangers and Supports" below.
- B. Materials for hangers and clamps:
  - 1. For copper pipe: Copper plated.

- 2. For steel, insulated, and cast-iron pipe: Galvanized or factory-painted.
- 3. For refrigerant piping: Clamp inserts, equal to Cooper "B-Line" armafix clamps, suitable for hanger or channel supports.
- C. Insulating-insert materials and protection shields:
  - 1. Insulation-insert material for cold piping: ASTM C 552, Type II cellular glass with 100psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862kPa) minimum compressive strength and vapor barrier. Insert thickness shall match adjacent piping insulation thickness.
  - Insulation-insert material for hot piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa); ASTM C 552, Type II cellular glass with 100-psig (688-kPa); or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength. Insert thickness shall match adjacent piping insulation thickness.
  - 3. Insert and shield shall cover entire circumference of pipe.
  - 4. Insert length: Extend 2 inches (50 mm) beyond shield.
- D. Pipe covering protection saddle: Steel, meeting requirements of MSS SP-58 Type 39, with insulating material located in the space between saddle and pipe.
- E. Hanger rod nuts and washers shall be zinc-plated. Hanger rods shall be solid steel, all threaded, and zinc-plated.
- F. Channel: Slotted cold-rolled steel, equal to Grinnell PS 150 S, 12 gage with 0.406- by 3-inch (10 by 76-mm) slots on 4-inch (102-mm) centers.
- G. Wall- and floor-mounted supports: Structural support system equal to Grinnell "Power Strut."
- H. Structural shapes: ASTM A 36.
- I. Steel pipe: ASTM A 53, standard weight.
- J. Threaded rod: MSS SP-58.

# 2.22 FASTENERS

- A. Fasteners to concrete: Self-drilling type expansion shields or machine bolt drop-in anchors for drilled holes, equal to ITT Phillips Anchors "Red Head." Fasteners to ceilings shall be vibration and shock resistant. Load applied to fasteners shall not exceed 25 percent of manufacturer's stated load capacity in 3500 psi (24,000 kPa) concrete.
- B. Fasteners to drywall or cavity wall construction: Equal to ITT Phillips Anchors "Red Head" toggle bolts, with hollow wall drive anchors or nylon anchors as required.
- C. Fasteners to wood construction: Lag bolts.
- D. Bolts, nuts, and washers: ASTM A 307, or ASTM A 325 where high strength is required.

# PART 3 - EXECUTION

### 3.20 INSTALLING PIPE HANGERS AND SUPPORTS

- A. Types and locations, refer to MSS SP-58:
  - Type 1 Clevis hanger:
    - 1. Non-steam Hot Systems NPS 0.5 (DN 15) through NPS 8 (DN 200).
    - 2. Ambient Systems and Cold Systems of all sizes.
  - Type 8 Riser clamp, steel for steel or cast-iron risers and stacks, copper plated for copper risers and stacks.
  - Type 10Copper plated adjustable swivel ring for uninsulated copper piping NPS 0.5<br/>(DN 15) through NPS 4 (DN 100). Use Type 1 for insulated pipe.
  - Type 18 Malleable iron concrete inserts for supporting hangers from concrete structure.
  - Type 20Side beam clamp for attaching hanger rods to structural beams. Use proper size<br/>clamp to suit beam flange.
  - Type 23 C clamp for beams with maximum flange thickness of 0.75 inch (19 mm); for use with single pipes NPS 2 (DN 50) and smaller.
  - Type 33Heavy welded steel bracket capable of supporting up to 3,000 lbs (1360 kg),<br/>with a Type 9 or Type 1 hanger, for piping along walls.
  - Type 34Side beam bracket for storm water and sanitary lines running along walls or<br/>fastened to sides of wood beams, for pipe up to NPS 4 (DN 100).
  - Type 37Adjustable pipe stanchion saddle with U-bolt and floor flange anchored to floor,<br/>for piping NPS 2 to 12 (DN 50 to 300) supported from floor.
  - Type 39Pipe-covering protection saddle for use between roller-type hangers and Hot<br/>System piping.
  - Type 40 Pipe-covering protection shield of proper size to fit insulation, between hanger and insulation:
    - 1. Size to fit pipe, between hanger and plastic piping.
    - 2. Include structural insulation insert between protection shield and pipe for piping NPS 2.5 (DN 65) and larger.
    - 3. Option: Instead of protection shield and structural insert, provide thermal hanger shield. For piping NPS 4 (DN 100) and larger on rollers, include steel weight distribution plate.
  - Type 44 Cast-iron roll, steel roll rod, provided with steel chair, bolts, and hex nuts, for pipe in racks and at fixed structural supports such as brackets, where no vertical adjustment is required.

23 05 29 - 4

- B. Trapeze piping supports:
  - 1. Field-fabricated from ASTM A 36 steel shapes.
  - 2. Weld steel according to AWS D-1.1.
  - 3. Size threaded rods in accordance with MSS SP-58.
  - 4. Design trapeze support assembly based on supported load plus a 50 percent safety factor.
- C. For hangers requiring vibration control, see Section 23 05 48.
- D. Hanger rod sizes:

PIPE SIZE NPS (DN)	ROD SIZE Inches (mm)
Up to 2 (Up to 50)	0.375 (10)
2.5 to 3.5 (65 to 90)	0.5 (15)
4 and 5 (100 to 125)	0.625 (16)
6 and 8 (150 to 200)	0.75 (20)
8 to 12 (200 to 300)	0.875 (22)

- E. Horizontal piping generally shall be supported from above.
  - 1. Attaching to walls: Use two 0.375-inch (9.5-mm) screw-type fasteners for attaching brackets and three 0.5-inch (13-mm) bolt-type fasteners for attaching structural supports.
  - 2. Attaching to bar joists and beams:
    - a. Pipes NPS 2.5 (DN 65) and smaller running parallel with joist or beam: Hanger rods welded to top chord of joist at panel points for joists.
    - b. Pipes NPS 2.5 (DN 65) and smaller running perpendicular to joist or beam: Support from every other joist or beam by method of hanging as described above.
    - c. Pipes NPS 3 (DN 80) and larger running parallel with joist or beam: Support from a length of structural channel or angle welded to the top cords of at least two beams or joists at panel points.
    - d. Pipes NPS 3 (DN 80) and larger running perpendicular to joist or beam: Support from every joist or beams by hanger rods welded to top chord of joist at panel points for joists.
    - e. Where large numbers of pipes are grouped together, their individual hangers shall be staggered so as to distribute the load among the available joists or beams.
  - 3. Attaching to concrete slab: Secure hanger rods to malleable iron inserts properly spaced and set on the forms before concrete is poured.
- F. Hangers and supports shall be spaced as follows:
  - 1. Copper pipe:

- a. NPS 1.25 (DN 32) and smaller: At least every 6 feet (1.8 m).
- b. NPS 1.5 and 2 (DN 40 and 50): At least every 8 feet (2.4 m).
- c. NPS 2.5 (DN 65) and larger: At least every 10 feet (3 m).
- 2. Steel pipe:
  - a. NPS 1 (DN 25) and smaller: At least every 6 feet (1.8 m).
  - b. NPS 1.25 and 1.5 (DN 32 and 40): At least every 9 feet (2.7 m).
  - c. NPS 2 to 6 (DN 50 to 150): At least every 10 feet (3 m).
  - d. NPS 8 to 12 (DN 200 to 300): At least every 14 feet (4.3 m).
- 3. Plastic pipe with solvent cement or thermal-bonded joint:
  - a. NPS 2 (DN 50) and smaller: At least every 3 feet (0.9 m) when line carries liquid; for vent, 6 feet (1.8 m).
  - b. NPS 2.5 (DN 65) and larger: At least every 4 feet (1.2 m) when line carries liquid; for vent, 8 feet (2.4 m).
  - c. Provide protection shield between hanger and plastic pipe at each support point.
- 4. Trapeze hangers:
  - a. Spacing shall not exceed the requirements for the smallest pipe in the rack.
  - b. For wood roof trusses, at least every 6 feet (1.8 m).
- G. Provide additional hangers or supports for concentrated loads such as flanges, valves, expansion compensators, fittings, and other specialties.
- H. Provide hangers as required for insulated piping systems. Coordinate selection of hangers and supports with requirements and selected options for insulation continuous through hanger or butted to each side. Provide pipe covering protection shield and structural insulation insert where insulation is continuous through hangers or supports.
- I. Provide pipe risers through floor slabs with riser clamps.
- J. Support PVC vertical risers at each floor and midway between floors.
- K. Support banks of pipes along the wall on a structural support system.

#### 3.21 INSTALLING EQUIPMENT FOUNDATIONS AND SUPPORTS

- A. Provide four-inch (100-mm) -high concrete foundations (housekeeping pads) or as indicated on drawings, reinforced with welded-wire fabric, for floor-mounted equipment and where indicated. Anchor concrete foundations by dowels inserted into the floor slab.
- B. Unless otherwise specified, provide concrete foundations, bolts, sleeves, and appurtenances as work of the section where the supported equipment is specified and in accordance with the requirements of Division 03.
- C. Equipment shall be properly aligned and leveled, and grouted where necessary. Support piping independently of equipment and so as not to cause a strain or thrust.

D. Coordinate exact size, configuration and location of equipment, foundations, and supports using approved shop drawings of equipment.

### SECTION 23 05 48 - VIBRATION CONTROL SUPPORTS FOR HVAC

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Vibration control supports for mechanical equipment.
- 1.14 RELATED SECTIONS
  - A. Hangers and supports: Section 23 05 29.
  - B. Flexible pipe connections: Section 23 05 08.
  - C. Flexible duct connections: Section 23 33 00.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: For each type of vibration control support included in the work.
  - 1. For Specification D hanger, include scaled drawing showing degrees of hanger rod swing.
- C. Shop drawings: Custom-fabricated supports.

#### 1.40 QUALITY ASSURANCE

A. The vibration isolation materials manufacturer shall be responsible for the proper selection of springs to accomplish the specified minimum static deflections for all spring and pad type isolators based on the weight distribution of equipment to be isolated.

### PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Mason Industries product, or comparable product by one of the following:
  - 1. Amber/Booth Company, Inc.
  - 2. Kinetics Noise Control
  - 3. Mason Industries
  - 4. Vibration Eliminator Company, Inc.
  - 5. Vibration Mountings and Controls, Inc.

### 2.20 VIBRATION CONTROL SUPPORTS

A. Provide engineered supports for equipment and locations shown on drawings and specified in Part 3 below. The units shall prevent the transmission of vibration and mechanically transmitted sound to the building structure.

- 1. Select units in accordance with the weight distribution of the equipment, so as to produce reasonably uniform deflection. Deflections shall be as specified.
- 2. Units installed on exterior shall be galvanized.
- B. Specification A: Equal to Mason Industries ND, double-deflection neoprene type. All metal surfaces shall be covered with neoprene and have friction pads both top and bottom. Provide bolt holes for mounting. Provide steel rails where necessary to compensate for equipment overhang.
- C. Specification B: Equal to Mason Industries SLFH, free-standing spring isolators, laterally stable without housing, and with 0.5-inch-(13-mm) thick neoprene pads between baseplate and support.
  - 1. Mountings shall have leveling bolts rigidly bolted to equipment.
  - 2. Springs: Spring diameters shall not be less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal of 50 percent of the rated deflection.
- D. Specification C: Equal to Mason Industries SLRW, galvanized spring type with neoprene pad top and bottom and with a housing that includes vertical resilient limit stops to prevent spring from extending when weight is removed. The housing shall serve as blocking during erection and the shims shall be removed after spring adjustment.
  - 1. Obtain data from the manufacturer of the supported equipment, and select springs individually to provide equal deflection with uneven point loading of the equipment.
- E. Specification D: Equal to Mason Industries Type 30N hangers, combination spring and minimum 0.3-inch (8-mm) deflection neoprene in series.
  - 1. Neoprene element: Molded with a rod isolation bushing that passes through the hanger box.
  - 2. Spring diameters and hanger box lower hole sizes: Large enough to permit the hanger rod to swing through a 30-degree arc before contacting the edges of the hole.
  - 3. Springs shall have a minimum additional travel to solid equal to 50 percent of rated deflection.
- F. Specification E: Equal to Mason Industries Type PC30N, same as Specification D, except with adjustment to transfer load to spring while holding supported object at fixed elevation. Include spring deflection indicator.
- G. Specification W: Fifty-durometer neoprene waffle pads made from identical rubber grids molded back to back. The interconnections form suction pockets for gripping smooth steel as well as rough surfaces. The square waffle pattern is laid out on 0.5-inch (13-mm) centers to facilitate cutting pads to size in the field without the need for measuring.

### PART 3 - EXECUTION

### 3.20 INSTALLATION, GENERAL

A. Adjust vibration control supports as recommended by manufacturer to eliminate transmission of vibration to building structure or other systems.

- B. Replace springs that become permanently deformed with new springs.
- C. Provide 0.25-inch (6-mm) structural plate sized as required between isolator and equipment.

# 3.21 FAN VIBRATION CONTROL

A. On floors above grade and on roofs: Provide Specification C mounting, and with static deflection as scheduled below:

<u>Fan RPM</u>	Minimum Static Deflection
500 and over	1.75 (45 mm)
375 to 499	2.50 (65 mm)
300 to 374	2.75 (70 mm)
225 to 299	3.75 (95 mm)
175 to 224	4.75 (120 mm)

B. Suspended from structure: Provide Specification D hanger, selected for weight, with minimum 1.0 inch static deflection.

### 3.25 COMPRESSOR VIBRATION CONTROL

- A. Roof-mounted ductless split-system and variable refrigerant flow units: Specification W neoprene pads. Mount and set on equipment support curbs. Coordinate size and location of curbs with equipment manufacturer.
- B. Refrigeration compressors and equipment with self-contained refrigeration compressors:
  - 1. Refrigeration compressors, condensing units and other rotating equipment mounted on floor or roof decks above grade: Specification B mountings having at least 1.75 inch (45 mm) static deflection.
  - 2. Refrigeration compressors, condensing units, and other rotating equipment mounted on floor slab on earth: Specification A mountings having at least 0.35 inch (89 mm) static deflection.

### 3.26 PUMP VIBRATION CONTROL

- A. Pumps mounted on floor slab on earth: Install without isolation base.
- 3.28 HEAT PUMP UNIT VIBRATION CONTROL
  - A. Where mounted on floors or metal stands, install on Specification W mountings.

## 3.29 VIBRATION CONTROLS ON PIPING

A. Floor-mounted piping to pump: Specification A or B vibration isolator consistent with mounting of nearest isolated equipment.

- B. Piping: Provide Specification E vibration control supports in first three hangers at both the suction and discharge of pumps three hangers on pipes connected to indoor energy recovery units. The static deflection shall be the same as specified for the mountings under the connected equipment.
  - 1. If piping is connected to equipment mounted on slab on grade and hangs from structure under occupied spaces, the first three hangers shall have at least 0.75 inch (19 mm) deflection for pipe sizes up to and including NPS 3 (DN 80), 1.5 inch (38 mm) deflection for pipe sizes up to and including NPS 6 (DN 150) and 2.5 inch (64 mm) deflection thereafter.
  - 2. Other hangers and mounts shall have a minimum spring deflection of 0.75 inch (19 mm).
  - 3. Locate vibration control supports in hanger rods as close to the overhead supports as practical. On supports with double rods, use two vibration control supports.

# SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. The Contractor shall engage and the Architect shall approve an independent balancing and testing subcontractor.
- B. This section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:
  - 1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
  - 2. Adjusting total HVAC systems to provide indicated quantities.
  - 3. Measuring electrical performance of HVAC equipment.
  - 4. Setting quantitative performance of HVAC equipment.
  - 5. Verifying that automatic control devices are functioning properly.
  - 6. Reporting results of the activities and procedures specified in this section.

#### 1.14 RELATED SECTIONS

- A. Testing and adjusting requirements unique to particular systems and equipment are included in the sections that specify those systems and equipment.
- B. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment sections.
- 1.27 PERFORMANCE REQUIREMENTS
  - A. Select and obtain approval of the testing and balancing subcontractor at the earliest possible time and before beginning ductwork installation.
  - B. The testing and balancing subcontractor shall visit the job site periodically, beginning with the initial stages of construction of the mechanical systems, and shall ensure that the necessary devices are properly installed so that specified testing and balancing can be performed.

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Submit qualifications of testing and balancing subcontractor, as required in article "Quality Assurance" below.
- C. Submit certified balance report. In addition to general requirements for submittals, submit three copies of final reports and certificates, bound into a booklet.

### 1.40 QUALITY ASSURANCE

A. Testing and balancing subcontractor qualifications:

- 1. Current certified member of the Associated Air Balance Council, or certified by National Environmental Balancing Bureau for air and hydronic systems testing and balancing.
- 2. Has successfully completed at least five projects of similar size and scope.
- 3. Not affiliated with any other subcontractor participating in this project. Work performed by the subcontractor shall be limited to testing, adjusting, and balancing HVAC systems.
- B. Testing and balancing work shall comply with one of the following standards:
  - 1. National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems, published by the Associated Air Balance Council.
  - 2. Procedural Standards for Testing Adjusting Balancing of Environmental Systems, published by the National Environmental Balancing Bureau.

### PART 2 - PRODUCTS

### 2.30 EQUIPMENT

- A. Instruments: Approved and properly calibrated.
  - 1. Measure pump and coil pressure differentials with mercury manometers.
  - 2. Measure air temperature with mercury thermometers.
  - 3. Pyrometer surface temperature measurements may be used for piping system water temperatures where thermometer wells are not provided in the piping.

### PART 3 - EXECUTION

### 3.02 VERIFICATION OF CONDITIONS

A. Before beginning balancing, ascertain that systems are ready. Identify issues with the installation and areas requiring correction. Verify that filters for regular service are in place, as required in Section 23 41 00, Particulate Air Filtration.

### 3.05 PREPARATION

- A. Witness air duct leakage tests required in Section 23 31 13, Metal Ducts, and advise and approve the methods and instruments used.
- B. Using bench-calibrated instruments, field-calibrate pressure gages and dial-type duct thermometers.

### 3.21 BALANCING OF SYSTEMS, GENERAL

- A. Tabulate settings of temperature control devices and ascertain that thermostats, controllers, and valves are set at specified or approved positions. Verify and certify that the sequence of operation for each system is as shown on drawings, specified, or approved.
- B. Provide all labor and devices necessary for the testing and balancing work.

### 3.22 AIR SYSTEMS BALANCING

- A. Balance all air distribution, supply, return, exhaust, and outdoor air systems and equipment.
- B. Test and adjust fans to deliver design airflow at lowest possible speed. Adjust air-handling equipment to deliver the required air volumes. Note that air quantities scheduled on drawings do not include allowances for duct leakage. Preliminary adjustments of fan speed should be slightly in excess of scheduled airflow delivery. Make adjustments by adjusting adjustable sheaves, changing sheaves and associated belts, changing wiring connections of motors, or adjusting speed controller.
- C. Test and adjust system to design airflow requirements to the greatest extent possible. Manual volume dampers in ducts shall be adjusted to obtain required airflow rates at grilles, registers, and diffusers. Dampers integral to airflow devices should be fully open or minimally closed for airflow fine adjustments.
- D. Make pitot tube traverse of main supply, return, and outdoor air ducts to obtain total airflow for fan or air-handling unit.
- E. Adjust rooms or zones to design airflow (supply, return, and exhaust).
- F. Adjust general HVAC systems to design airflow within the following tolerances:
  - 1. Total system supply, return, and exhaust: (design to plus 10 percent).
  - 2. Outdoor air: (minus 5 percent to plus 5 percent).
  - 3. Total supply, return, and exhaust for a room or space: (minus 5 percent to plus 5 percent).
  - 4. Grilles, registers, and diffusers:
    - a. One per room or space: (minus 5 percent to plus 5 percent).
    - b. Two or more per room or space: (minus 10 percent to plus 10 percent).
- G. Grilles, registers, and diffusers:
  - 1. Identify each grille, register, and diffuser as to location and area. List manufacturer, type, and size.
  - 2. Identify type of testing equipment used.
  - 3. Test and adjust each grille, register, and diffuser to design airflow. List (design-actual) cfm (cubic meters per minute) and (design-actual) velocity in fpm (meters per second) when applicable.
  - 4. Adjust diffusers, grilles, and registers to minimize drafts. Adjust blades in supply diffuser straightening grids to assure uniform air distribution across diffuser.
- H. Test and record the following data, as applicable, for air-handling equipment:
  - 1. Manufacturer and model number.
  - 2. Total airflow (design-actual).
  - 3. Return air airflow (design-actual).
  - 4. Outdoor air airflow (design-actual).
  - 5. Total and external static pressure (design-actual). Include static pressure at suction, discharge, and between unit coil and filter components.
  - 6. Entering air temperatures (db heating, db and wb cooling).

- 7. Leaving air temperatures (db heating, db and wb cooling).
- 8. Motor horsepower (rated-actual).
- 9. Voltage and phase (rated-actual).
- 10. Fan speed, rpm (rated-actual).
- 11. Amperage (rated-actual).
- I. In cooperation with the control manufacturer's representative, set adjustments of automatically operated dampers to operate as specified.
- 3.24 HYDRONIC SYSTEMS BALANCING
  - A. Balance all hydronic piping systems.
  - B. Adjust and balance the following items listed under the various systems in accordance with the specified standards. Units with automatic flow control valves, measure and document the differential pressure across the valve to ensure it is within the specified operating range.
    - 1. Domestic hot water system:
      - a. Pump
      - b. Return piping for flow to every branch
    - 2. Geothermal heat pump loop system:
      - a. Pump
      - b. Heat pump units
      - c. Water-cooled condensing units
  - C. After the above items have been adjusted and balanced, submit a certified report listing the specification requirements and the operating conditions of these items as follows:
    - 1. Pump:
      - a. Flow gpm
      - b. Suction pressure
      - c. Discharge pressure
      - d. Pressure differential
      - e. Total dynamic head
      - f. Motor HP voltage, hertz, phase, design full load amps
      - g. Motor operating line voltage and amperage, overload heater ratings.
    - 2. Piping system:
      - a. Flow gpm reading of flow meter in various systems: See drawings for locations.
    - 3. Heat pump units and water-cooled condensing units (including dedicated outdoor air systems and energy recovery units).
      - a. Unit of mode operation heat cool
      - b. Entering loop water temperature

- c. Leaving loop water temperature
- d. Pressure drop across condenser
- e. Entering air D.B. and W.B.
- f. Leaving air D.B. and W.B.
- g. Loop water flow gpm

# 3.26 MARKING OF SETTINGS

A. Following final balance procedures, permanently mark the settings of valves, splitters, dampers, and other adjustment devices so that adjustment can be restored if disturbed at any time. Set memory stops on balancing valves. Return and make required adjustments after submittal and approval of the Certified Balance Report.

#### SECTION 23 07 00 - HVAC INSULATION

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Definitions and general requirements applicable to the insulation systems specified in "Related Sections."
- 1.14 RELATED SECTIONS
  - A. Pipe insulation: Section 23 07 19.
  - B. Duct insulation: Section 23 07 13.
  - C. Equipment insulation: Section 23 07 16.

#### 1.20 DEFINITIONS

- A. Ceiling space: The space between the ceiling and the floor of an air-conditioned space above.
- B. Roof space: The space between the ceiling and the roof, where building insulation is located at the roof level or the space between the ceiling and the floor of a non-air conditioned space above.
- C. Attic space: The space between the ceiling and the roof, where building insulation is located at the ceiling level.
- D. Air-conditioned areas or spaces: Areas or spaces where the occupied room temperature is maintained between 65 and 80 degrees F (18.3 and 26.7 degrees C).
- E. Concealed insulation shall include work:
  - 1. Above ceilings.
  - 2. Where furred in and in pipe chases.
- F. Exposed insulation shall include work:
  - 1. Below ceilings in all rooms and areas.
  - 2. In mechanical equipment rooms or mechanical closets.
  - 3. In all rooms without ceilings.
  - 4. In storage rooms.

#### 1.40 QUALITY ASSURANCE

A. Perform work in strict accordance with the building, fire and safety codes of the state, county or city in which the work is performed.

- B. Insulation, including fittings and butt strips, jackets, facings, and accessories such as adhesives, mastics, cements, tapes and cloth, shall have a fire and smoke hazard rating and label as tested by ASTM E84, NFPA 255, and UL 723, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50.
- C. All insulation and accessories shall be free of asbestos.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Deliver insulation and accessory products in manufacturers' wrapping or cartons, identified on the exterior and bearing labels showing conformance to flame and smoke rating requirements.
- PART 2 PRODUCTS
- 2.10 MATERIALS
  - A. Refer to sections listed in "Related Sections".
- PART 3 EXECUTION

Not Used.

### SECTION 23 07 13 - DUCT INSULATION

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Insulation applied to ducts.
- 1.14 RELATED SECTIONS
  - A. Sections specifying requirements for LEED rating are specified in Division 01.
  - B. Painting: Division 09.
  - C. Definitions of concealed, exposed, and other terms: Section 23 07 00.
  - D. Acoustical duct liner: Section 23 31 13.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. LEED submittal:
  - 1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
- C. Material list: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
- D. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.
- E. Samples required only upon request.

#### 1.40 QUALITY ASSURANCE

- A. Meet requirements specified in Section 23 07 00.
- B. Comply with requirements for LEED certification specified in Division 01.
- C. Installer qualifications: Firm with at least 5 years successful installation experience with mechanical insulation. Work shall be performed by mechanics skilled in this trade.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Meet requirements specified in Section 23 07 00.
  - B. Store rigid insulation products so as to protect them from breakage.

# PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 23 01 01.
- B. Insulation and accessories:
  - 1. Armstrong World Industries.
  - 2. Certain-Teed Corporation.
  - 3. Childers.
  - 3. Foster.
  - 4. Johns Manville.
  - 5. Knauf Fiber Glass Gmbh.
  - 6. Owens-Corning.

#### 2.10 MATERIALS

- A. Flexible fiberglass insulation: ASTM C 553, Type I, Class B-3, K-factor of 0.27 at 75 degrees F (0.037 at 24 degrees C) mean temperature, of thicknesses specified in Part 3 below, nominal density at least 1 lb per cubic foot (16 kg per cubic meter), with vapor-barrier jacket of reinforced kraft and aluminum foil.
- B. Rigid fiberglass insulation: ASTM C 612, Class 2, nominal density at least 6 lbs per cubic foot, with K-factor of 0.22 at 75 degrees F (0.032 at 24 degrees C) mean temperature, of thicknesses specified in Part 3 below, with factory-applied jacket composed of a reinforced white kraft and aluminum-foil laminate with the white kraft facing out, equal to Certain Teed Products Corp. IB 600-ASJ.
- C. Canvas: Eight ounces/sq. yd. (270 g/sq. m.), fire-retardant treated. Provide washable, abrasion-resistant finish coating equal to Foster "Sealfas" 30-36.
- D. Adhesives for duct insulation inside buildings: Recommended by insulation manufacturer for the application, equal to Foster Products 85-60.
- E. Mechanical fasteners: Perforated, 2 by 2 inches (51 by 51 mm) by 0.023-inch (0.6-mm)- thick, zinc-coated steel with one-inch (25-mm)-wide by 0.023-inch (0.6-mm)-thick diamond-notched tongue or No. 11 gage wire nail, complete with locking plates, holding plates, fiber washers, or speed washers as required. Provide neoprene-rubber base adhesive, Type 3. Adhesive and fastener shall be equal to the products of Stic-Klip Manufacturing Co.
- F. Glass cloth and tape: MIL-C-20079. Tape: Type II, Class 3, 4.5 ounces/sq. yd. (150 g/sq. m.) Cloth: Type I, Class 1, untreated.
- G. Self-adhesive tape: Manufacturer's standard tape of material matching insulation jacket, with peelable backing and pressure-sensitive adhesive.

# PART 3 - EXECUTION

### 3.20 INSTALLATION

- A. Apply insulation in a neat and workmanlike manner and in accordance with manufacturer's printed instructions. Butt joints tightly and apply a brush coat of adhesive to laps and joint strips. Seal laps, pulling jacketing tight and smooth. Tape joints with self-adhesive tape matching the service jacket.
- B. Tape and seal terminations of insulation to prevent "dusting".

### 3.21 INSULATION INSIDE BUILDINGS

- A. Concealed ducts: Flexible fiberglass insulation. Adhere with adhesive in sufficient quantities to prevent sagging. On ducts more than 30 inches (762 mm) wide, secure insulation on the underside with mechanical fasteners on 18 inch-(457-mm) maximum centers. Butt insulation with facing overlapping at least 2 inches (50 mm) and sealed with vapor-barrier adhesive. Adhesive must cover full 2-inch (50-mm) overlap to form an airtight seal. Seal breaks and punctures with vapor-barrier tape and vapor barrier coating.
- B. Exposed ducts: Rigid fiberglass insulation, fastened with mechanical fasteners. Fasteners shall be spaced 12 to 18 inches (305 to 457 mm) on center with a minimum of two rows per side of duct. Secure insulation in place with washers firmly embedded in insulation.
  - 1. Install corner beads on external corners.
  - 2. Seal joints. Apply canvas jacket. Cover with two coats of lagging adhesive, ready for painting. Fastener caps shall match the jacket.
- C. For curved surfaces, such as exposed elbows, score or cut insulating board in narrow strips as necessary for snug and neat fit.
- D. Ductwork which need not be insulated:
  - 1. Cooling systems:
    - a. Lined, preinsulated double wall or insulated flexible supply ducts where installed in:
      - (1) Ceiling spaces of air-conditioned spaces.
      - (2) Return air plenums, whether ceiling or roof spaces, of air-conditioned spaces.
    - b. Supply ducts where exposed in areas they serve.
    - c. Lined, preinsulated double wall or return ducts, except in attic spaces.
    - d. Return ducts in ceiling spaces of air-conditioned areas. Note that insulation is required for return ducts in roof spaces.
    - e. Return ducts exposed in areas they serve.
    - f. Return duct in return-air ceiling plenums.
  - 2. Heating systems:

- a. Lined, preinsulated double wall or insulated flexible supply ducts, except in attic spaces.
- b. Supply ducts exposed in areas they serve.
- c. Return ducts, except in attic spaces.
- d. Transfer ducts, except in attic spaces.
- E. Conditioned air ductwork from dedicated outdoor air systems and energy recovery units shall be insulated as specified for supply air ducts.
- F. Exhaust air ductwork from dedicated outdoor air systems and energy recovery units shall be insulated as specified for return air ducts.

### 3.22 INSULATION THICKNESS

- A. Outdoor air ducts: 1.5 inches (40 mm). Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).
- B. Exhaust and pressure relief air ducts to roof ventilators or to exterior openings: 1.5 inches (40 mm), starting at connection to roof curb or opening and running back to ATC dampers but not less than 10 feet (3 m).
- C. Exhaust ducts from air-conditioned areas, in roof or attic space: 1.5 inches (40 mm).
- D. Ductwork which transmits combination cooled and heated air or untempered ventilating air shall be insulated as specified below for cooling systems.
- E. Cooling systems:
  - 1. Supply air ducts: 1.5 inches (38 mm). Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).
    - a. Exception: Lined or unlined supply ducts in attic spaces: 2 inches (50 mm).
  - 2. Return air ducts: 1.5 inches (40 mm). Where necessary to conceal standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).
    - a. Exceptions:
      - (1) Return ducts in attic spaces: 2 inches (50 mm).
      - (2) Lined, preinsulated double wall or return ducts in attic spaces: Externally insulated with 1.5-inch (40-mm)-thick insulation.
  - 3. Transfer ducts shall be insulated as specified for return ducts.
- F. Heating systems:
  - 1. Supply air ducts: 1.5 inches (40 mm). Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, 2 inches (50 mm).
    - a. Exception: Supply ducts in attic spaces: 2 inches (50 mm).
- 2. Return ducts in attic spaces: 2 inches (50 mm).
- 3. Transfer ducts shall be insulated as specified for return ducts.

# SECTION 23 07 16 - HVAC EQUIPMENT INSULATION

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Equipment insulation as scheduled at end of section.
- 1.14 RELATED SECTIONS
  - A. Sections specifying requirements for LEED rating are specified in Division 01.
  - B. Definitions and general insulation requirements: Section 23 07 00.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. LEED submittal:
  - 1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
- C. Material list: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
- D. Samples required only upon request.
- E. Manufacturer's installation instructions and system recommendations.
- 1.40 QUALITY ASSURANCE
  - A. Meet requirements specified in Section 23 07 00.
  - B. Comply with requirements for LEED certification specified in Division 01.
  - C. Installer qualifications: Firm with at least 5 years successful installation experience with mechanical insulation. Work shall be performed by mechanics skilled in this trade.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Meet requirements specified in Section 23 07 00.

#### PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 23 01 01.
- B. Insulation and accessories:
  - 1. Armacell
  - 2. Certain-Teed Corporation.
  - 3. Childers.
  - 4. Foster.
  - 5. Johns Manville
  - 6. Knauf Fiber Glass GmbH.
  - 7. Owens-Corning.

# 2.10 EQUIPMENT INSULATION

- A. Insulation types refer to the Equipment Insulation Schedule at the end of the section. Thicknesses are scheduled.
- B. Type B, insulation for cooled surfaces: Flexible elastomeric insulation, ASTM C 534, Type II, with vapor barrier facing.
- C. Insulating and finishing cement: Mineral fiber cement with a hydraulic-setting binder, conforming to ASTM C 449.
- D. Insulation compounds: Provide adhesives, cements, sealers, mastics, and protective finishes recommended by manufacturers of insulation for each particular application.
  - 1. Adhesives, sealants and mastics applied within the building waterproofing envelope: Comply with low-emitting requirements in Section 01 61 16.
- E. Insulation accessories: Provide staples, bands, wire, wire mesh, tape, corner angles, anchors, and stud pins recommended by manufacturer of insulation for each particular application.
- F. Jacket material: Pre-sized glass cloth, not less than 7.8 ounces per sq.yd (271g per sq. m).

#### PART 3 - EXECUTION

## 3.20 INSTALLATION, GENERAL

- A. Insulate equipment as specified, except equipment with factory-applied insulation. Follow manufacturer's instructions.
- B. Provide removable insulation sections to cover parts of equipment which must be opened or removed periodically for maintenance, such as vessel covers, fasteners, flanges, pump casings and strainers, frames, and accessories. On large vessels, provide additional external support.
  - 1. On hot equipment, insulate equipment surface, leaving flanges, bolts, and other accessories exposed.
  - 2. On cold equipment, or equipment used for both heating and cooling, insulate flanges and accessories, and make insulation separately removable.

C. Maintain the integrity of vapor barriers.

### 3.21 INSTALLATION ON COLD SURFACES

- A. Type in accordance with Equipment Insulation Schedule.
- B. Cut, score, or miter insulation to fit contours of equipment. Secure with a full coating of adhesive. Provide weld pins or stick clips with washers spaced 18 inches apart. Stagger joints between layers.
- C. Fill voids with small pieces of insulation applied with adhesive on all sides to maintain complete vapor barrier. Seal joints, breaks, and punctures in facing.
- D. Insulation on geothermal heat pump loop pumps: For each pump, construct an insulated box assembly with removable cover, or access panels.
  - 1. Size: To surround pump housing, drive shaft, and piping, including suction diffuser, and allowing clearance for draining and adjustment of pump shaft seal.
  - 2. Construction: 18-gage galvanized steel; formed with edge returns so that insulation is not exposed; provided with openings for drive shaft and pipes; no part resting on pump.
  - 3. Access: Design box for disassembly or access. Provide fasteners such as clips or cm latches, so that access is possible without the use of tools.
  - 4. Insulation: Secured to inside of box with pins and adhesive.

#### 3.23 INSTALLING FINISHED SURFACE

A. Apply a coat of insulating cement to smooth out surface. When cement is dry apply a coating of lagging adhesive. Embed a layer of glass cloth, overlapping all seams 2 inches (50 mm), and finish with a second coat of same adhesive.

#### 3.90 EQUIPMENT INSULATION SCHEDULE

EQUIPMENT	INSULATION TYPE	THICKNESS INCHES	
Geothermal air separators	В	2 layers each 0.75	
Geothermal loop pump box assemblies	В	2 layers each 0.75	
Geothermal loop expansion tank	В	2 layers each 0.75	
Fans in air-conditioning ductwork	В	1.5	

### **SECTION 23 07 19 - HVAC PIPING INSULATION**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Mechanical piping insulation for the piping systems listed in the schedule at the end of this section.
- 1.14 RELATED SECTIONS
  - A. Sections specifying requirements for LEED rating are specified in Division 01.
  - B. Definitions and general insulation requirements: Section 23 07 00.
  - C. Painting: Division 09.
  - D. Pipe hangers and protection shields: Section 23 05 29.

#### 1.20 REFERENCES

- A. ASTM C 450: Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.
- B. ASTM C 534: Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- C. ASTM C 547: Mineral Fiber Pipe Insulation.
- D. ASTM C 553: Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 23 01 01.
  - B. LEED submittal:
    - 1. Product data for credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
  - C. Schedule of products: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
  - D. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.
  - E. Samples required only upon request.

### 1.34 QUALITY CONTROL SUBMITTALS

- A. Manufacturer's instructions: Recommended accessory materials and products; installation instructions.
- 1.40 QUALITY ASSURANCE
  - A. Meet requirements specified in Section 23 07 00.
  - B. Comply with requirements for LEED certification specified in Division 01.
  - C. Installers shall be mechanics skilled in this trade.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Meet requirements specified in Section 23 07 00.

# PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 23 01 01.
- B. Fiberglass insulation:
  - 1. Johns Manville.
  - 2. Knauf Fiber Glass GmbH.
  - 3. Owens-Corning.
- C. Flexible elastomeric insulation:
  - 1. Armacell LLC
  - 2. Rubatex
- D. Coatings, adhesives, and fabrics:
  - 1. Childers.
  - 2. Foster.
  - 3. Manville Building Materials Group.
  - 4. Rock Wool Manufacturing Company

#### 2.10 FIBERGLASS PIPE INSULATION

- A. Fiberglass insulation: Glass fibers bonded with a thermosetting resin.
  - 1. Preformed pipe insulation, ASTM C 547 Type I, with all-service jacket.
  - 2. Flexible sheet insulation, ASTM C 553 Type IV, without facing.

- B. All-service jacket (ASJ) or "Evolution" Paper-free ASJ: Factory-applied, fire-retardant, vaporbarrier foil/scrim/kraft jacket. All-service jacket with self-sealing lap (ASJ-SSL) is acceptable as Contractor's option.
  - 1. Tape: Matching jacket, pressure-sensitive.
- C. Fittings and valves: Prefabricated and field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

### 2.12 FLEXIBLE ELASTOMERIC PIPE INSULATION

- A. Flexible elastomeric tube and sheet: Equal to Armacell "AP Armaflex," or "Armaflex 2000", closed-cell, sponge- or expanded-rubber materials, ASTM C 534, Type I (tubular) and Type II (sheet).
- B. Fitting and valve covers: Field fabricated, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, and flanges.

# 2.14 ADHESIVES

- A. Joints, fittings, and general application:
  - 1. Fiberglass insulation: Foster "Quick-Tack" 85-60.
  - 2. Flexible elastomeric insulation: Foster "Drion" 85-75.
- B. Lagging adhesive: Polyvinyl acetate adhesive, equal to Foster "Lagfas" 81-42W.

#### 2.15 MASTICS AND COATINGS:

- A. Flexible elastomeric insulation: Armacell "WB Armaflex" latex enamel.
- B. Bituminous mastic: Fed. Spec. SS-C-153, Type I.
- C. Insulating and finishing cement: Mineral fiber cement with a hydraulic-setting binder, conforming to ASTM C 449.
- D. Vapor barrier coating:
  - 1. On fiberglass insulation: Foster "Vapor-Fas" 30-65.
  - 2. On flexible elastomeric insulation: Two coats of latex enamel coating.
- E. Finish coating for fiberglass insulation or lagging: Washable, abrasion-resistant, coating equal to Foster "Sealfas" 30-36.

# 2.16 LAGGING AND REINFORCING TEXTILES

- A. Canvas: Eight ounces/sq. yd. (270 g/sq. m), fire-retardant treated.
- B. Glass cloth and tape: MIL-C-20079. Tape: Type II, Class 3, 4.5 ounce/sq. yd. (150 g/sq. m). Cloth: Type I, Class 1, untreated.

### 2.17 FASTENERS

- A. Aluminum bands: 0.75 inches (19 mm) wide and 0.020 inches (0.4 mm) thick.
- B. Staples: Outward clinching type, Type 304 or 316 stainless steel.
- C. Pins: Serrated shaft, Type 304 or 316 stainless steel.
- 2.18 PROTECTIVE PIPE JACKETS
  - A. Aluminum: Smooth aluminum 0.016-inch-thick, lined with a bonded moisture barrier, equal to Childers "Aluminum Roll Jacketing."
    - 1. Aluminum straps: Same alloy as jacket.
    - 2. Elbows: Childers "Univers-Ell Jacs".
    - 3. Tees: Childers "Tee-Jacs."
    - 4. Fitting covers: Manufacturer's factory-fabricated aluminum covers suitable to size of fitting and thickness of insulation.
  - B. Polyvinyl chloride (PVC): High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming.
    - 1. Adhesive: As recommended by jacket material manufacturer.
    - 2. Color: White.
    - 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
  - C. Canvas: Finished with lagging coating, uniform, smooth, and ready for painting.

#### PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Install in accordance with the Minimum Thickness Schedule at the end of this section, as modified by specifications for each location and type.
  - B. Fiberglass insulation: Apply insulation to a neat and smooth finish. Comply with manufacturers' recommendations and installation instructions. Butt joints tightly and apply a brush coat of vapor barrier coating to each lap and joint strip. Seal or fasten laps in jacketing as specified for location, pulling jacketing tight and smooth. Coat all fittings, valves, and flanges with vapor barrier coating and reinforcing mesh before applying fitting covers.
  - C. Flexible elastomeric insulation: Apply by slipping seamless sections of tubing over the end of the piping, wherever possible. Use slit tubing only as necessary. Seal joints and slit seams with joint adhesive.

- 1. Fittings and valves: Field fabricated from insulation same thickness as on the piping. Use manufacturer's miter tubes and boxes and templates.
- D. Tape and seal with vapor barrier coating to all terminations of insulation.
- E. Staple, tape, or seal plastic pipe fitting covers by methods recommended by manufacturer.
- F. Coordination with pipe hangers and supports for the systems listed below:
  - 1. Insulation shall be continuous through hanger for all piping systems. Install pipe covering protection shield with thickness of structural insulation insert equal, under load, to that of adjoining insulation. Shield and saddle support are specified in Section 23 05 29; Hangers and Supports for HVAC Piping and Equipment.

#### 3.21 INSTALLING INSULATION AT PENETRATIONS

- A. Where the insulated piping systems pass through sleeves or openings in partitions and floors, the insulation shall be continuous through the sleeves and openings. See Firestopping specifications, for coordinating insulation and fire protection sealing.
- 3.22 INSTALLING CANVAS JACKET
  - A. Locations:
    - 1. All pipe insulation in mechanical rooms and mechanical closets on exposed piping as defined in Section 23 07 00, HVAC Insulation.
    - 2. Canvas jacket is not required where aluminum jacket is required.

#### 3.23 INSTALLING ALUMINUM JACKET

- A. Locations: All insulated pipe exposed in finished areas within 8 feet (2440 mm) of the finished floor, and as specified for weather protection.
- B. Secure jacket with aluminum bands on 12-inch (305-mm) centers and at circumferential joints.
- C. Place longitudinal joints to face a wall and overhead joints to face the ceiling.

## 3.24 INSTALLING PVC JACKET

- A. Locations: As specified for weather protection.
- B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of pipes. Seal with manufacturer's recommended adhesive.
  - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
  - 2. Seams and joints shall completely prevent the entrance of water.

### 3.27 INSTALLING GEOTHERMAL HEAT PUMP LOOP PIPING INSULATION

- A. Piping systems: Insulate supply and return with fiberglass insulation in accordance with Minimum Thickness Schedule. Seal ASJ lap to form vapor barrier.
- B. At all valves, flanges, and fittings, and at intervals of not more than 21 feet (6400 mm) on continuous runs of pipe, make a joint in insulation. Finish and seal ends with vapor barrier coating on both sides of joint.
- C. Fittings, valves, and flanges: Cover with prefabricated fitting covers.
- D. Casings and headers of cooling coils: Fiberglass of thickness equal to that of adjoining pipe insulation, finished with vapor-barrier jacket.
- E. Insulation on strainers: Removable without damage.

#### 3.28 INSTALLING REFRIGERANT PIPING INSULATION

- A. Piping systems: All refrigerant suction, hot gas and liquid piping, indoors and outdoors. Insulate refrigerant discharge lines where there is a possibility of contact by people other than service personnel.
- B. Insulation: Flexible elastomeric, thickness in accordance with Minimum Thickness Schedule.
- C. Fittings and valves:
  - 1. Coat with vapor barrier coating.
  - 2. Field-fabricated covers same thickness as on adjacent piping.

### 3.29 INSTALLING EXTERIOR PIPING INSULATION

- A. Locations: Piping systems exterior of building heated space.
- B. Insulation: As specified for the same system interior, minimum thickness 2 inches (50 mm), or 0.5 inches (13 mm) thicker than scheduled for interior insulation on similar system, whichever is greater.
- C. Start insulation 30 inches (760 mm) below grade, 30 inches (760 mm) below roof or 30 inches (760 mm) inside exterior wall. Secure insulation with aluminum bands on 12-inch (305-mm) centers.
- D. Where insulated piping is exposed to weather, apply one of the following protective jackets:
  - 1. Over fiberglass insulation:
    - a. Aluminum jacket: Apply with an overlap of 4 inches (100 mm) longitudinal and cross-joint seams. Direction of overlap shall prevent entrance of water, with longitudinal joint in horizontal piping 45 degrees down from horizontal. Install jacket tight to insulation and secure in place with aluminum straps at all joints and on

minimum 12-inch (305-mm) centers. Coat seams with mastic approved by jacket manufacturer.

- b. PVC jacket.
- 2. Over flexible elastomeric insulation: Fully adhere a layer of glass cloth to the insulation surface, with adhesive specified for elastomeric system. Apply two coats of latex enamel finish.

3.90 SCHEDULES

A. Minimum Thickness Schedule: Thicknesses scheduled are for aboveground, interior piping. See "Installing Exterior Piping Installation" for additional thicknesses required.

MINIMUM THICKNESS SCHEDULE									
PIPE SIZES (NPS)									
Piping System Types	Fluid Temp. Range (Degrees F)	Equipment Connections Up to 1-1/4	1-1/2 & less	2	3 to 4	5&6	8 and larger		
Geothermal heat pump loop supply and return	40-100	1.5	1.5	1.5	1.5	1.5	2.0		
Refrigerant	0-60		1.0	1.0	1.0	1.0	1.5		
Refrigerant	120-200		1.5	2.0	2.0	2.0	2.0		

### SECTION 23 08 00 – MECHANICAL SYSTEMS COMMISSIONING

#### PART 1 GENERAL

## 1.1 WORK INCLUDED

- A. Systems and equipment testing and start-up.
- B. Validation of proper and thorough installation of Division 23 (HVAC) systems and equipment.
- C. Systems balancing verification.
- D. Prefunctional performance testing of equipment and systems.
- E. Documentation of tests, procedures, and installations.
- F. Coordination of Training Events.
- G. Generic Start-Up Procedures for plumbing systems and equipment.
- 1.2 GENERAL DESCRIPTION
  - A. Commissioning (Cx) is the process of ensuring that all building systems are installed and perform interactively according to the design intent; that systems are efficient and cost effective and meet the Owner's operational needs; that the installation is adequately documented; and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
  - B. Commissioning Authority (CxA) is retained by the Owner shall work with the Contractor and the Design Engineer to direct and oversee the Cx process and perform functional performance testing.
  - C. This Section outlines the Cx procedures specific to the Division 23 Contractors. Requirements common to all Sections are specified in Sections 01 91 13 and 01 91 14 and the Cx Plan.

### 1.3 SCOPE

- A. The following are included in the Scope of Commissioning on this project:
- B. HVAC / Plumbing Systems
  - 1. Geothermal Water Distribution System / Pumps
  - 2. Energy Recovery Units
  - 3. Exhaust Fans
  - 4. Heat Pumps
  - 5. Fan Coil Units
  - 6. Misc. Terminal Equipment
  - 7. A/C Split Systems
  - 8. Domestic Hot Water Systems
- C. Building Automation Systems
  - 1. Refer to Section 23 09 95.

#### 1.4 RELATED WORK AND DOCUMENTS

A. Section 01 91 13 – General Commissioning Requirements: details the Cx requirements common across all divisions

- B. Section 01 91 14 Functional Testing Procedures: Outlines the generic functional testing procedures required.
- C. Individual Specification Sections: Individual sections stipulate installation, start-up, warranty, O&M documentation, and training requirements for the system or device specified in the Section.
- D. Section 23 09 95 Building Automation Systems Commissioning: Details the commissioning procedures specific to the Building Automation System.
- E. Section 26 08 00 Electrical Systems Commissioning: Details the commissioning procedures specific to Division 26 work.

# 1.5 DEFINITIONS AND ABBREVIATIONS

- A. Refer to Section 01 91 13
- 1.6 REFERENCE STANDARDS
  - A. ASHRAE Guideline 1-1996, "Guideline for Commissioning HVAC Systems"
  - B. ASHRAE Guideline 4-1993, "Preparation of operating and Maintenance Documentation for Building Systems"
  - C. NEBB Procedure Standards for Building Systems Commissioning

# 1.7 DOCUMENTATION

- A. In addition to the documentation required in Section 01 91 13, Contractor shall provide to the CxA the following per the procedures specified herein, in the Cx Plan, and in other Sections of the specification:
  - 1. Balancing Plan: The plan shall include the following:
    - a. Certification on all instrumentation to be used throughout the testing. This must document certification within the last 6 months.
    - b. Résumés and Certification of individuals who will be balancing systems
    - c. Detailed step by step plans for each procedure to be performed.
    - d. Sample forms to be used for each measurement
    - e. Sample balancing report
  - 2. Factory Test Reports: Contractor shall provide any factory testing documentation or certified test reports required by the specifications. These shall be provided prior to Acceptance Phase. Factory Test Reports should be provided in pdf electronic format. These may include but are not limited to:
    - a. Air Handling Units
    - b. Variable Frequency Drives
    - c. Fans Capacity
    - d. Pump Capacity
  - 3. Field Testing Agency Reports (other than TAB): Provide all documentation of work of independent testing agencies required by the specification. These shall be provided prior to Acceptance Phase. Field Testing Agency Reports should be provided in pdf electronic format. These may include but are not limited to:
    - a. Pipe Pressure Testing
    - b. Duct Leakage Testing
    - c. Water Treatment
  - 4. Completed Test and Balance Reports. CxA will review prior to FPT.
- 1.8 SEQUENCING AND SCHEDULING
  - A. Refer Section 01 91 13

# 1.9 COORDINATION MANAGEMENT PROTOCOLS

A. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 01 91 13 and the Commissioning Plan, but shall be refined and documented in the Construction Phase Cx Kick-Off meeting. Contractor shall have input in the protocols and all Parties will commit to scheduling obligations. The CxA will record and distribute.

# 1.10 CONTRACTOR RESPONSIBILITIES

- A. Refer to Section 01 91 13: Detailed Contractor responsibilities common to all Divisions are specified in Section 01 91 13. The following are additional responsibilities or notable responsibilities specific to Division 23.
- B. Construction Phase
  - 1. Provide skilled technicians qualified to perform the work required.
  - 2. Provide factory-trained and authorized technicians where required by the Contract Documents.
  - 3. Prepare and submit required draft Start-Up Procedures and submit along with the manufacturer's application, installation and start-up information.
  - 4. TAB: As outlined in Section 23 05 95. Specifically as it relates to Cx:
    - a. Attend Cx kick-off meeting and Cx progress meetings held within 3 months of and during Acceptance Phase.
    - b. Submit Balancing Plan as indicated above
    - c. Meet with Cx Team to review TAB procedures and documentation required.
    - d. As called by CxA, participate in CxT demonstrations of balancing procedures for repetitive procedures such as zones.
    - e. Attend a meeting convened by the C to coordinate with the Safety certifying agency. The point of the meeting will be to coordinate protocols and measurement approaches to ensure that devices such as Fume Hoods and Biosafety cabinets will be set up to achieve certification
    - f. Participate in Action List dialogue
    - g. Provide all documentation electronically.
  - 5. Provide assistance to the CxA in preparation of the specific Functional Performance Test (FPT) procedures. Contractors, subcontractors and vendors shall review FPT procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests. Damage caused to equipment performed in accordance with the approved procedures will be the responsibility of the Contractor.
  - 6. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere this Section.
  - 7. Start-up, and test/adjust/balance systems and equipment prior to functional performance testing by the CxA. Start-Up Procedures shall be in accordance with Contract Documents, reference or industry standards, and specifically elsewhere in Part I of this Section.
  - 8. Record Start-up Procedures on start-up procedure forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above. Each task or item shall be indicated with the Party actually performing the task or procedure.
- C. Acceptance Phase
  - 1. Assist CxA in functional performance testing. Assistance will generally include the

following:

- a. Manipulate systems and equipment to facilitate testing (as dictated in Section 01 91 14; in some cases this will entail only an initial sample);
- b. Provide any specialized instrumentation necessary for functional performance testing;
- c. Manipulate BAS and other control systems to facilitate functional performance testing (as dictated Section 01 91 14, Section 23 09 95, and the Cx Plan; in some cases this will entail only an initial sample).
- d. Provide a TAB technician to work at the direction of CxA.
- e. Provide a BAS technician to work at the direction of CxA.
- D. Warranty Phase
  - 1. Maintain record documentation of any configurations, set ups, parameters etc, that change throughout the period.
  - 2. Provide representative for off season testing as required by CxA.
  - 3. Respond to Warranty issues as required by Division 1 and the General Conditions.

# 1.11 EQUIPMENT SUPPLIER RESPONSIBILITIES

- A. Refer to Section 01 91 13.
- 1.12 CONTRACTOR NOTIFICATION AND SCHEDULING
  - A. Refer to Section 01 91 13.
- 1.13 START-UP PROCEDURES AND DOCUMENTATION
  - A. Refer to Section 01 91 13.
- 1.14 EQUIPMENT NAMEPLATE DATA
  - A. Refer to Section 01 91 13.
- 1.15 BAS TRENDING REQUIREMENTS
  - A. Trending requirements are specified in Section 01 91 13 and Section 23 09 95.
- 1.16 FUNCTIONAL PERFORMANCE TESTING
  - A. Contractor shall participate in the support of Functional Performance Testing as stipulated in Section 01 91 13 and Section 01 91 14.

# 1.17 FPT ACCEPTANCE CRITERIA

- A. Acceptance criteria for tests are indicated in Section 01 91 14 and in the specification Sections applicable to the systems being tested. Generally, unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device.
- 1.18 TRAINING
  - A. Contractors, Subcontractor, Vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of Section 01 91 13 and the individual Specifications.

# 1.19 O&M MANUAL CONTENT - PREPARATION AND LOGISTICS

A. Refer to Section 01 91 13 and the individual Specifications.

# PART 2 PRODUCTS

## 2.1 INSTRUMENTATION

- A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:
  - 1. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of + or  $-0.1^{\circ}$ F.
  - 2. Pressure sensors shall have an accuracy of + or 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
  - 3. All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.
- B. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems shall be provided by CxA.
- C. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

#### 2.2 WEB-BASED COMMISSIONING PORTAL

- A. All general and major subcontractors participating in the Cx process shall use the webbased Cx Portal ('Portal') to document the Cx procedures. The Portal is a Web-based Internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The Portal is hosted by the CxA and shall be accessible to all Parties participating in the Cx program. The Portal provides a common location to store Start-Up Documentation, Functional Performance Tests and results, project documents and deliverables. It also serves as a collaborative email hub to facilitate, automate, and track communications between Parties relating to the Cx process.
- B. Refer to Section 01 91 13 the individual Specifications for additional information and requirements for using the Portal.

#### 2.3 TEST KITS FOR METERS AND GAGES

- A. Test kits for meters and gages shall be provided to the Owner new and in good condition. Previously used kits will be unacceptable. Kits shall be submitted prior to the Acceptance Phase. Kits included shall be as a minimum:
  - 1. Digital indication of temperature and pressure with associated sensors to work with the P/T test ports
  - 2. Companion readout kit (with fittings) for calibrated balancing valve with ranges as required by all devices on this project

#### PART 3 EXECUTION

#### 3.1 START-UP PROCEDURES - GENERAL

A. Part III of this Section outlines 'generic' or minimally acceptable Start-Up Procedures (delineated as Start-Up Checks and Start-Up Tests) and individual systems Training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per normal quality control practices. These items shall provide a minimum or guideline for required Contractor development of Start-Up Procedures. Contractor shall synthesize

these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized Start-Up Procedures specific to the equipment and systems installed on this project.

# 3.2 PROCEDURES COMMON TO ALL SYSTEMS

- A. The following start up verifications/procedures are common to all systems
- B. Checkout shall proceed from devices to the components to the systems.
- C. Verify labeling is affixed per spec and visible
- D. Verify prerequisite procedures are done.
- E. Inspect for damage and ensure none is present.
- F. Verify system is applied per the manufacturer's recommendations
- G. Verify system has been start up per the manufacturer's recommendations
- H. Verify that access is provided for inspection, operation and repair
- I. Verify that access is provided for replacement of the equipment
- J. Verify the record drawings, submittal data and O&M documentation accurately reflect the installed systems
- K. Verify all gages and test ports are provided as required by contract documents and manufacturer's recommendations
- L. Verify all recorded nameplate data is accurate
- M. Installation is done to ensure safe operation and maintenance.
- N. Verify specified replacement material/attic stock has been provided as required by the Construction Documents
- O. Verify all rotating parts are properly lubricated
- P. Verify all monitoring and ensure all alarms are active and set per Owner's requirements
- Q. Complete all nameplate data and confirm ratings conform with the design documents
- 3.3 VALVES
  - A. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:
    - 1. Operate all valves, manual and automatic, through their full stroke. Ensure smooth operation through full stroke and appropriate sealing or shutoff.
    - 2. Verify actuators are properly installed with adequate clearance.
    - 3. Verify all valves are labeled per the construction documents. Confirm that concealed valves are indicated on the finished building surface.
    - 4. For automatic pneumatically-operated valves, verify spring range and adjust pilot positioners where applicable. For electronically operated valves, check the stroke and range. For all automated valves controlled by a program, ensure that the minimum and maximum stroke and ranges on the valves are coordinated with the limits entered in the program.

# 3.4 METERS AND GAGES

- A. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:
  - 1. Adjust faces of meters and gages to proper angle for best visibility.
  - 2. Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint. For meters and gages requiring temporary manual connection of read-out device such as pressure taps on a flow measuring device, ensure threads are clean and that connection can be made easily.
  - 3. Meters and gages requiring manual connection of readout device shall be installed with adequate access to allow connection of device with normal tools.

#### 3.5 MECHANICAL IDENTIFICATION

- A. Start-Up Checks: Perform the following checks:
  - 1. Verify all valve tags, piping, duct, and equipment labeling corresponds with drawings and indexes and meets requirements specified. Correct any deficiencies for all piping and duct systems.
  - 2. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
  - 3. Cleaning: Clean face of identification devices, and glass frames of valve charts.

# 3.6 MECHANICAL INSULATION

- A. Start-Up Checks: Examine all piping, systems and equipment specified to be insulated.
  - 1. Ensure quality of insulation. Patch and repair all insulation damaged after installation.
    - 2. Ensure the integrity of vapor barrier around all cold surfaces.

# 3.7 PIPING - GENERAL

- A. Start-Up Checks: These Procedures apply to all installed piping systems, including underground site utilities.
  - 1. Inspect all piping for proper installation, adequate support (with appropriate vibration isolation where applicable) and adequate isolation valves for required service.
  - 2. Submit welding certifications as required by the applicable specification section or referenced ASME specification.
  - 3. Submit certified welding inspection results per the applicable specification section or referenced ASME specification. ASME B31.1 requires 100% inspection based on pressure class.
  - 4. Provide notification of pipe cleaning and flushing activities
  - 5. Flush and clean all piping and clean all strainers. Provide documentation of all related procedures.
  - 6. Ensure adequate drainage is provided at low points and venting is provided at high points.
  - 7. Ensure air is thoroughly removed from the system as applicable. Ensure facilities to effectively drain and fill the system are in place.
  - 8. Ensure all piping is adequately supported and anchored to allow expansion. Bump across-the-line pumps and inspect for excessive pipe movement.
  - 9. Provide notification of pressure testing
  - 10. Pressure and/or leak test all applicable systems in accordance with the requirements in the applicable sections, ASME B 31.1 and 39.1 as applicable.

- 11. Sterilize applicable piping systems as specified in the individual Sections and as required by regulatory authorities.
- 12. Submit pressure test reports that document the pressure testing results with Certification of the results.
- 13. Verify the operation of applicable safety relief valves, operating controls, safety controls, etc. to ensure a safe installation.
- 14. Set and adjust fill, pressure, or level controls to the required setting.

# 3.8 AC MOTORS

- A. Start-Up Checks: Perform the following checks during start-up and as specified in manufacturer's instructions:
  - 1. Verify proper alignment, installation, and rotation.
  - 2. Verify properly sized overloads are in place
- B. Start-Up Tests: Perform the following tests, measurements, or procedures during startup and as specified in manufacturer's instructions:
  - 1. Measure insulation resistance, phase balance, and resistance to ground
  - 2. Measure voltage available to all phases. Measure amps and RPM after motor has been placed in operation and is under load.
  - 3. Record all motor nameplate data.

# 3.9 BEARINGS

- A. This applies to all bearings on fans, pumps, compressors, etc.
- B. Use infrared thermometer to measure temperature at peak conditions. Ensure temperature is below manufacturer's recommendations.
- C. Check alignment as applicable
- D. For bearings in drives with motors over 10 HP, use a vibration meter and measure the maximum peak to peak acceleration. Compare it to the "Vibration Severity Chart". Rectify any condition causing conditions indicated as "Rough" or worse.
- E. Lubricate all bearings per the manufacturer's instructions. When bearing is used for temporary conditioning, lubricate on manufacturer's recommended frequency and document it.

#### 3.10 VARIABLE SPEED DRIVES

- A. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.
- B. Start-Up Checks: Perform the following checks before start-up and as specified in manufacturer's start-up instructions:
  - 1. Check unit for shipping damage.
  - 2. Perform a point-to-point continuity test for all field installed wiring interconnections. Verify terminations of field installed wiring.
  - 3. Check for proper torque on connections.
  - 4. Verify use of shielded cable where specified and check that shields have been terminated properly.
  - 5. Verify grounding.
  - 6. Check motor nameplate against drive input rating.
  - 7. Manually rotate motor shaft to ensure free rotation.
  - 8. Check that motor leads are not grounded.

- C. Start-Up Tests: Perform the following tests, measurements, or procedures during startup and as specified in manufacturer's instructions:
  - 1. Ensure device and system which drive is serving is configured to withstand the device operation specified below.
  - 2. Adjust the Minimum Voltage Adjustment to enable starting but not to draw excessive power at start.
  - 3. Adjust the Volts/Hz adjustment to proper setting.
  - 4. Adjust the Acceleration and Deceleration rates to the specified times.
  - 5. Adjust Current Limiting to coordinate with the overcorrect device and protect the motor.
  - 6. Set the Maximum and Minimum speed pots.
  - 7. Manually ramp fan speed from minimum to maximum and check for excessive noise and vibration.
  - 8. Determine any critical speeds to avoid and set these in the drive.
  - 9. Check for acceptable voltage and current distortion on the power system. Record the input and output voltages and currents showing the harmonic content as a percentage of the base frequency.
  - 10. Measure and record overall efficiency at 50%, 75%, and 100%.
  - 11. Record the motor terminal voltage.
- D. Training: Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance.
  - 1. Review data in Operating and Maintenance Manuals.

# 3.11 HYDRONIC PIPING

- A. Start-Up Checks: Perform the following checks:
  - 1. Prepare hydronic and test piping in accordance with applicable Section and ASME B 31.9 and/or B 31.1
  - 2. Flush system with clean water in accordance with applicable Section.
  - 3. Clean strainers.
  - 4. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
  - 5. Set automatic fill valves for required system pressure.
  - 6. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
  - 7. Set and coordinate automatic fill pressure and relief valve settings
- B. Start-Up Tests: Perform the following tests, measurements, or procedures during startup:
  - 1. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

# 3.12 PUMPS

- A. Refer to AC Motors in this section
- B. Refer to Bearings in this section
- C. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.
- D. Start-Up Checks: Perform the following checks before start-up:
  - 1. Check suction lines connections for tightness to avoid drawing air into the pump.

- 2. Clean and lubricate all bearings.
- 3. Check motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
- 4. Check that pump is free to rotate by hand. For pumps handling hot liquids, pump shall be free to rotate with the pump hot and cold. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.
- 5. Clean associated strainers.
- 6. Check that the proper overloads have been installed in the starter and are the correct size.
- 7. Verify that the integrity of the vibration isolation is maintained throughout the support and the connections.
- 8. Align pump within manufacturers recommended tolerances.
- 9. Ensure all associated piping has been cleaned, tested, and vented.
- 10. Verify that all thermometers and gages are installed, are clean and undamaged, and are functional.
- E. Start-Up Tests: Perform the following tests, measurements, or procedures during start-up:
  - 1. Start the pump per the manufacturer's instructions.
  - 2. Check the general mechanical operation of the pump and motor.
  - 3. Verify that check valve seal is appropriate.
  - 4. Check noise and vibration levels and ensure they are within the manufacturers recommended tolerances.
  - 5. Check that the NPSH is with that allowable for the operating condition.
  - 6. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

### 3.13 AIR COOLED CONDENSING UNITS

- A. Refer to AC Motors in this section
- B. Start-Up Checks: Perform the following inspections/checks before start-up:
  - 1. Ensure unit is level
    - 2. Coils are undamaged and fins are combed
    - 3. Condenser fan rotates freely and check rotation direction
- C. Start-Up Tests: Perform the following before or during start-up:
  - 1. Start-up condensing units, in accordance with manufacturer's start-up instructions.
  - 2. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
  - 3. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.
- D. Training: [Factory-authorized representative] [Contractor] shall train Owner's maintenance personnel including:
  - 1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
  - 2. Familiarization with contents of Operating and Maintenance Manuals.

# 3.14 WATER-SOURCE HEAT PUMPS

- A. Start-Up Tests: Perform the following before or during start-up:S
  - 1. Start-up condensing units, in accordance with manufacturer's start-up instructions.
  - 2. Test controls and demonstrate compliance with requirements. Replace damaged or

malfunctioning controls and equipment.

- 3. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.
- 4. Install new filters after start up.

### 3.15 TERMINAL UNITS

- A. Start-Up Checks: Perform the following inspections/checks before start-up:
  - 1. After construction is completed, including painting if applicable, clean unit exposed surfaces.
  - 2. Vacuum-clean terminal coils and inside of cabinets.
  - 3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
  - 4. Verify adequate access for maintenance.
  - 5. Check power and control voltages.
  - 6. Check rotation of fan where applicable.
  - 7. Check calibration and operation of the controlling elements.
  - 8. Check control valves for required close-off and fail position.
  - 9. Install new filter units for terminals requiring same.

# 3.16 CENTRAL-STATION AIR-HANDLING UNITS

- A. Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.
- B. References: The following additional Sections shall also apply:
  - 1. Refer to AC Motors in this Section.
  - 2. Refer to Fans in this Section
  - 3. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.
  - 4. Refer to Division 23 09 95 Section "BAS Commissioning" for procedures for starting the controls related to the AHU.
- C. Start-Up Checks: Perform the following inspections/checks before start-up:
  - 1. Inspect the field assembly of components and installation of central-station airhandling units including piping, ductwork, and electrical connections.
  - 2. Cleaning: Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
  - 3. Adjust and lubricate dampers and linkages for proper damper operation.
  - 4. For field fabricated units, ensure the sections are properly connected within acceptable tolerances.
  - 5. Seal the all penetrations air tight and ensure access doors seat tightly.
  - 6. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete.
  - 7. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
  - 8. Ensure vibration isolation integrity is maintained throughout the AHU installation and its connections.
  - 9. Tension all belts per the drive manufacturer's recommendations.
  - 10. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.

- 11. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
- 12. Comb coil fins for parallel orientation.
- 13. Install clean filters.
- 14. Ensure condensate drains properly and that trap is adequate.
- 15. Stroke all valves and damper to ensure free and full travel
- D. Start-Up Tests: Perform the following before or during start-up:1. Pressure test units as required in the AHU specification
- E. Training: [Factory-authorized representative] [Contractor] shall train Owner's maintenance personnel including:
  - 1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
  - 2. Familiarization with contents of Operating and Maintenance Manuals.
- 3.17 FANS
  - A. References: The following additional Sections shall also apply:
    - 1. Refer to AC Motors in this Section.
    - 2. Refer to Bearings in this Section
    - 3. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.
    - 4. Refer to Division 23 09 95 Section "BAS Commissioning" for procedures for starting the controls related to the AHU.
  - B. Start-Up Checks: Perform the following inspections/checks before start-up:
    - 1. Inspect the field assembly of components and installation of central-station airhandling units including piping, ductwork, and electrical connections.
    - 2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.
    - 3. Adjust and lubricate dampers and linkages for proper damper operation.
    - 4. Verify unit is secure on mountings and supporting devices and that connections for ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
    - 5. Ensure vibration isolation integrity is maintained with the fan installation and the connections to it
    - 6. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
    - 7. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
    - 8. Stroke all dampers to ensure free and full travel
  - C. Training: Contractor shall train Owner's maintenance personnel including:
    - 1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
    - 2. Familiarization with contents of Operating and Maintenance Manuals.

### 3.18 METAL DUCTWORK

A. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of

polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

- B. Start-Up Checks: Perform the following checks before start-up and as specified:
  - 1. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
  - 2. Strip protective paper from stainless ductwork surfaces if applicable, and repair finish wherever it has been damaged.
- C. Start-Up Tests: In addition to specifications, perform the following as a minimum:
  - Leakage Tests: After each duct system which is constructed for duct classes over 3" is completed, test for duct leakage in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Repair leaks and repeat tests until total leakage is less than 1% of system design air flow.
  - 2. Balancing: Refer to Division-23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.

# 3.19 DUCTWORK ACCESSORIES

- A. Start-Up Checks: Perform the following checks before start-up and as specified:
  - 1. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- B. Start-Up Tests: In addition to specifications, perform the following as a minimum:
  - 1. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leak proof performance.
  - 2. Label access doors in accordance with Division-23 section "Mechanical Identification".
  - 3. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
  - 4. Final positioning of manual dampers is specified in Division- 23 section "Testing, Adjusting, and Balancing".
  - 5. Fire Damper Testing: For every fire damper, remove the fusible link an verify that the damper operates freely and closes tightly. Reinstall the fusible link.

# 3.20 AIR TERMINALS

- A. Start-Up Checks: Upon completion of installation and prior to initial operation, check that air terminals are:
  - 1. Properly installed with the proper airflow direction.
  - 2. Properly supported with vibration isolation integrity maintained where applicable.
  - 3. Duct connections to air terminals are leak-tight.
  - 4. Operable dampers travel free.
  - 5. Airflow measuring devices are properly installed and connected.
  - 6. Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.
  - 7. Clean exposed factory-finished surfaces. Repair any marred or scratched surfaces with manufacturers touch-up paint.

#### 3.21 BUILDING AUTOMATION AND CONTROL SYSTEMS

- A. Start-Up Checks: Perform the following checks before start-up and as specified:
  - 1. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- B. Start-Up Tests: Refer to Section 23 09 95 BAS Commissioning. This generally requires manufacturers authorized representative to start-up, test, adjust, and calibrate direct digital and other microprocessor-based control systems and demonstrate compliance with requirements. This will include verification of sequences, normal and emergency operations, calibration, interfaces, and interlocks, etc.

# 3.22 TESTING, ADJUSTING, AND BALANCING

- A. Reference: Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the respective section and the referenced standards.
- B. Start-Up Checks: In addition to specifications, perform the following as a minimum:
  - 1. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
  - 2. Patch insulation, ductwork, and housings, using materials identical to those removed.
  - 3. Seal ducts and piping, and test for and repair leaks.
  - 4. Seal insulation to re-establish integrity of the vapor barrier.
  - 5. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
  - 6. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.
  - 7. Test and adjust mechanical systems for sound and vibration in accordance with the detailed instructions of the referenced standards.
- C. Training:
  - 1. Train the Owner's maintenance personnel on troubleshooting procedures and testing, adjusting, and balancing procedures.
  - 2. Review for the Owner's personnel the locations of TAB reports and data.

# 3.23 SEQUENCING ILLUSTRATION

A. Reference Section 01 91 13.

#### SECTION 23 09 01 - AUTOMATIC TEMPERATURE CONTROL SYSTEM

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Complete new network-based automatic temperature control (ATC) system with Bacnet protocol.
- B. Sequence of operation for automatically controlled equipment is shown on drawings. ATC subcontractor shall cooperate with the unit suppliers and provide all relays and wiring required to integrate the sequence of operation.

### 1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Automatic control valves, pressure and flow switches, and insertion wells in piping: For installation under Section 23 21 13.
- B. Dampers: For installation under Section 23 31 13.
- 1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION
  - A. Duct smoke detectors: Section 28 31 00.

#### 1.14 RELATED SECTIONS

- A. Controls: Sections 23 09 01 through 23 09 23.
- B. Balancing: Section 23 05 93.
- 1.25 SYSTEM DESCRIPTION
  - A. Provide a complete system of direct digital temperature controls with electronic actuation.
  - B. The system shall consist of two levels of network communication and wiring, DDC controllers, application-specific controllers, software, operator I/O devices, sensors and other necessary input hardware, dampers, valves, actuators and other necessary output hardware, fire and smoke devices, electrical power surge protection, other necessary equipment and a complete system of wiring to fulfill the intent of the sequences of operation shown on the drawings.

#### 1.26 DESIGN REQUIREMENTS:

- A. The products specified, scheduled, and shown on drawings are the basis of the design of this project.
- B. For requirements affecting use of optional manufacturers, or substitutions, see Division 01 and Section 23 01 01, HVAC General Provisions, and Section 23 05 00, Common Work Results for HVAC.

# 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Contractor qualifications: Submit a list of a minimum of three projects similar to this project in type, size, and duty, which have been operating satisfactorily for not less than five years.
  - 1. Include project name, address, name and phone number of Owner's representative and project size and type.
- C. Shop drawings: Provide a point schedule and composite control diagram of all equipment provided for each control sequence, including factory and field controls. Include a written description of sequences, in which each control device or item of equipment is identified by the designation indicated on the diagram.
- D. Product data: See individual controls sections.
- E. Certifications:
  - 1. Factory authorization and certification of the installing company.
  - 2. Evidence of training, and certification of each supervisor and mechanic assigned to this project.
- F. Project record documents: As specified in Division 01 and Section 23 01 01, provide a drawing at the same scale as the contract drawings, showing the locations of all components installed.

# 1.40 QUALITY ASSURANCE

- A. Subcontractor qualifications: One hundred percent company-owned, full-service, local branch or authorized factory-direct contractor for one of the acceptable national temperature control manufacturing companies named below, as follows:
  - 1. Full service: Includes system engineering, shop drawing preparation, software programming, installation, commissioning, and service.
  - 2. Factory-direct contractor: Is contracted directly with manufacturer to buy components and has direct access to manufacturer's local branch office for engineering, service, and technical support without any third-party involvement.
  - 3. Experience: The branch or factory-direct contractor shall have completed at least three system installations of the same type, size, and design, which have successfully operated their sequence of operations for at least three years.
  - 4. Supervisors and mechanics: Factory-trained and certified in the type of control system (pneumatic, electric, digital, electronic) being installed, and directly employed by the subcontractor.
    - a. The programmer responsible for programming digital controllers shall have a minimum of three years' experience programming digital controllers of the manufacturer, for HVAC systems.
- B. Qualified subcontractor shall prepare control diagrams.

- C. Perform work in accordance with the plumbing, electrical, building, fire and safety codes of the state, county, or city in which the work is performed.
- D. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.

# 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a commissioning agent. Contractor's and subcontractor's responsibilities are described in Division 01.
- B. Cooperate with the commissioning agent to accomplish the requirements of the commissioning plan during construction and correction period.

# PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

- A. Direct digital system:
  - 1. Johnson Controls, Inc.; Baltimore Office
  - 2. Siemens Building Technologies, Inc. Landis Div.; Baltimore Office
  - 3. Honeywell, Inc.; Baltimore Office

# PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Coordinate with equipment suppliers to integrate controls provided by manufacturers into the control sequences shown on drawings.
  - B. Mount devices and control panels provided by equipment manufacturers, and provide required control wiring.
  - C. Operate, test, calibrate, and adjust each control system until it operates as intended by the manufacturer and as specified in the control sequence.

#### 3.61 TESTS

A. Thoroughly test and check the completed system to ascertain that all equipment is functioning as intended and that dampers and valves respond properly to their controls. Installer of work of this section shall cooperate with the equipment suppliers, and with balancing and testing work, to make necessary adjustments to ATC devices for proper operation of the completed system.

#### 3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 23 05 00, provide operating instructions.
- B. Provide at least eight hours of additional instruction time for the system specified in this section, consisting of two periods of 4 consecutive hours, separated by at least 30 days.

#### **SECTION 23 09 02 - CONTROL SYSTEMS WIRING**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Wiring for automatic temperature control system.
- 1.14 RELATED SECTIONS
  - A. Automatic temperature control system: Sections 23 09 01 through 23 09 23.
  - B. Control sequences: Shown on drawings.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Wire, cable, conduit and fittings, disconnecting switches, and transformers.
- 1.40 QUALITY ASSURANCE
  - A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.
  - B. ATC circuit shall not supply other building components such as lights or receptacles.

#### PART 2 - PRODUCTS

- 2.10 MATERIALS, GENERAL
  - A. Electrical materials and devices shall be UL listed and shall meet the requirements of NEC (NFPA 70) and Division 26, Electrical.

## 2.21 WIRING

- A. Wiring 50 V and below: Fully color coded, copper 600 V type THW or THHN, minimum No. 22 or as specified in Division 16, Electrical.
- B. Wiring above 50 V: As specified in Section 26 05 19, Wires and Cables.

# 2.22 CONDUIT AND FITTINGS

- A. Galvanized steel conduit: Minimum size 0.5 inch (16 mm), hot-dip galvanized with threads galvanized after cutting, one of the following:
  - 1. Rigid full weight, heavy-wall steel conduit (RGS) conforming to UL 6 and ANSI C80.01.
  - 2. Intermediate steel conduit (IMC) conforming to UL 1242 and ANSI C80.03.

- B. Steel conduit fittings: Cast malleable iron fittings with smooth finish and full threaded hubs. Include steel or malleable iron locknuts, bushings, and other fittings.
  - 1. Insulating bushings: Equal to Thomas and Betts Series 22.
  - 2. Hub fittings with recessed sealing ring and nylon insulated throat equal to Thomas and Betts Series 370.
  - 3. Fittings for exposed locations: Conduit outlet bodies, zinc- or cadmium-plated.
- C. Electrical metallic tubing (EMT): Minimum size 0.5 inch (16 mm), maximum 1.5 inch (41 mm), hot-dip galvanized or sherardized thin-wall steel conduit conforming to UL 797 and ANSI C 80.03.
- D. Connectors and couplings for EMT: Concrete- or rain-tight, compression or set screw type, made of cadmium-plated steel with nylon insulating throat, equal to Thomas & Betts Series 5031, 5123 and 5120.
- E. Flexible metal conduit: Minimum size 0.5 inch (16 mm), made of sheet metal strip, interlocked construction, conforming to UL 1.
- F. Liquidtight flexible metal conduit shall conform to UL 360.
- G. Connectors for flexible metal conduit: Equal to angle wedge "Tite-Bite" with nylon insulated throat, Thomas & Betts Series 3110 and 3130.
- H. Liquidtight connectors: UL 14814A, with fittings and nylon-insulated throat, equal to Thomas & Betts Series 5331.
- I. Surface metal raceway: Equal to Wiremold No. 700 minimum size, complete with fittings, connectors, and accessories.

#### 2.30 EQUIPMENT

- A. Control transformer: Designed for power sources for 24-V ac control circuits, and precision built to ensure rated power, proper voltage regulation and maximum efficiency. Units shall be equipped with integral manual reset circuit breaker for over-current protection on the secondary winding. Output regulation shall be 10 percent from no load to full load.
- B. Disconnecting switches: Specified in Section 26 28 00.

#### PART 3 - EXECUTION

#### 3.20 INSTALLATION

- A. Electrical equipment is specified in Division 26, Electrical. Include in the work of this section relays, pushbuttons, transformers, coils, power wiring, control wiring, or other equipment, meeting requirements of Division 16, so that the automatic temperature control system will function as specified and indicated on the drawings.
- B. Do not use equipment power supply as source for ATC power. Provide a circuit breaker in an electrical panelboard to make ATC connection.

- 1. Provide circuit breakers that match and are compatible with the other breakers in the panelboard.
- 2. Panelboards dedicated to computer systems are available. Connect ATC to dedicated panelboards.
- C. Install conduit and wiring as specified in Sections 26 05 19 and 26 05 33.
- D. Provide data systems, including outlets, cabling, and required infrastructure, to support the manufacturer's requirements. All data system components shall meet the requirements of Division 27.
- E. Make each run of cable or conductor connecting two points with a single continuous piece of cable or conductor. Do not splice. Cable or conductor may be extended by use of suitable connectors if approved by the Architect.
- F. When connecting to electrical wiring of equipment provided with pilot lights, connect to circuit so that pilot light is energized only when equipment is energized.
- G. Where necessary to connect conduit to motors or motor-driven equipment, or to attach conduit to fan housings or units which contain fans, use a 24-inch (610-mm) looped section of flexible metallic conduit.
- H. When connecting to electric wiring of exhaust fans with Hand/Off/Automatic (HOA) switches and exhaust dampers, connect to circuit so that damper opens in both Hand and Automatic positions.
- I. Securely attach disconnecting switches and starters to the wall with lead anchors.

#### SECTION 23 09 05 - CONTROL PANELS

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDED

- A. Control panels and accessories.
- 1.14 RELATED SECTIONS
  - A. General information: Section 23 09 01.
  - B. Control sequences: Shown on drawings.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Each type of control panel included in the project.
- C. Shop drawings: Front elevation of each control panel, drawn at a scale of 0.5 inch equals one foot.
- D. Samples: Color chips, showing complete line of colors and textures.

#### 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.
- B. Do not begin fabrication of control panels until shop drawings have been approved.

#### PART 2 - PRODUCTS

## 2.33 MECHANICAL ROOM CABINETS

A. Provide enclosed, lockable, 16 gage steel cabinets, one located in each mechanical equipment room, which shall contain all controls which are not required to be mounted at the controlled device. Manual switches and indicating gages for each switch shall be mounted inside the cabinet. Wiring and tubing in the panel shall be color-coded, and wiring shall be extended to numbered terminal strips.

PART 3 - EXECUTION

#### 3.20 INSTALLATION, GENERAL

A. Panels mounted on legs shall have the legs securely attached to floor with 0.25 inch lead anchors. Provide a 4-inch-high concrete base around legs and conduits leaving the panel where conduits pass into floor.

B. Panels attached to walls shall be secured with toggle bolts or lead anchors as required. Anchor plates shall be built into walls for large surface-mounted units.

#### SECTION 23 09 07 - CONTROL DAMPERS

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Dampers for automatic control.
- 1.12 PRODUCTS SUPPLIED BUT NOT INSTALLED UNDER THIS SECTION;
  - A. Dampers: Install under Section 23 33 00.
- 1.14 RELATED SECTIONS
  - A. Smoke detectors: Section 28 31 00.
  - B. Ductwork: Section 23 31 13.
  - C. Fire dampers and smoke dampers: Section 23 33 00.
  - D. Control system, general: Section 23 09 01.
  - E. Control sequences: Shown on drawings.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data, including test data and ratings, for each type of damper and operator included in the work.

#### PART 2 - PRODUCTS

#### 2.21 CONTROL DAMPERS AND OPERATORS

- A. Supply and return dampers: Equal to Ruskin Model CD35. Dampers for two-position control may be parallel blade type. Dampers for modulating control shall be balanced, multi-louver, opposed-blade type.
  - 1. Blades: Interlocking, minimum 16 gage galvanized steel. Maximum blade width: 8 inches (205 mm). Maximum blade length: 48 inches (1220 mm) without intermediate bearing and frame stiffener.
  - 2. Frames: Dampers shall be mounted horizontally in a welded channel angle or flat steel frame filled with solid air-stops which shall prevent air leakage between frame and blades. Provide corner braces on frames that measure more than 24 by 24 inches (610 by 610 mm). Finish: two coats of black enamel.
  - 3. Operation: Provide blades with brass pivots operating in non-stick, corrosion-resistant bearings securely mounted in damper frames. Hardware and operating linkage shall be brass or cadmium plated steel. Linkage shall be adjustable in length; joints shall be pin and clevis or ball and socket, free of excessive play. Dampers shall be capable of being

positioned accurately from 100 percent open to 100 percent closed and of maintaining any given position indefinitely. Dampers requiring 100 percent closure shall have neoprene gasketed edges.

- B. Outdoor air (OA), pressure relief (PR), and exhaust air (EA) dampers: Equal to Ruskin CD 50 low-leakage damper, AMCA-rated Class 1 in accordance with AMCA 511, leakage no more than 4 cfm per square foot at 1-inch wg when tested in accordance with AMCA 500D.
  - 1. Blades: Interlocking, minimum 0.125- inch (3.2-mm) thick extruded aluminum, airfoil shape, maximum width 6 inches.
    - a. Dampers for two-position control: May be parallel-blade type.
    - b. Dampers for modulating control: Opposed-blade type.
  - 2. Frames: Minimum 0.125-inch (3.2-mm) thick extruded aluminum, with provisions for mounting.
  - 3. Edge seals: Inflatable, replaceable, double-edge blade seal, mechanically held. Flexible metal fame seal.
  - 4. Operation: Linkage out of airstream, axles 0.5-inch (13-mm) diameter and hexagonal, molded synthetic bearings.
- C. Electric damper operators: Electric motor type with opening time of at least 30 seconds, of size to have 50 percent more power than the minimum required to operate the damper. Fail safe in the event of loss of power: Fresh air and exhaust air dampers shall close and return air dampers shall open.

#### PART 3 - EXECUTION

### 3.20 INSTALLATION

- A. Furnish dampers to be set in place under Section 23 31 13, Metal Ducts, under the supervision of the control subcontractor.
- B. Install operators on control dampers. Operation of particular dampers in conjunction with operation of air-handling equipment is described in control sequences.
- C. Set screws shall be set on a flat space on a round shaft. Provide a double set screw as a lock.

## SECTION 23 09 08 - CONTROL VALVES

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Automatic control valves, actuators, and accessories.
- 1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION
  - A. Control valves: Section 23 21 13.
- 1.14 RELATED SECTIONS
  - A. Control system, general: Section 23 09 01.
  - B. Control sequences: Shown on drawings.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Valves, devices, and actuators, each type included in project.

#### PART 2 - PRODUCTS

#### 2.21 CONTROL VALVES

- A. Two-way and three-way valves shall be sized by the control subcontractor and guaranteed to be of sufficient size to meet the heating or cooling requirements.
- B. With no electric power on the valve actuator, valve shall be in the normal position determined by the application.
  - 1. Unless indicated otherwise, valves serving heat pump unit compressors are normally open to allow full flow to compressors.
- C. Valves NPS 2 (DN 50) and smaller: Characterized equal percentage ball valve, capable of handling water at a maximum 150 psig (1035 kPa), 281 degrees F (138 degrees C). Valves shall have threaded ends.
  - 1. Bodies: Cast brass, rated at 150 psig (1035 kPa).
  - 2. Trim: Brass.
  - 3. Stem: Stainless steel, with replaceable composition disk seat. The stem packing shall be synthetic elastomer U-copper type, utilizing the system pressure to prevent packing leaks.
- D. Valves NPS 2.5 (DN 65) and larger: Single-seated with equal percentage flow characteristic valve plug.
  - 1. Bodies: Cast iron, rated 150 psig (1035 kPa).
- 2. Trim, stem, replaceable disk, and stem packing: The same as the smaller valves.
- E. Three-way valve: Mixing or diverting for modulating or two-position control of the direct-or reverse-acting type with maximum operating temperature of 250 degrees F (121 degrees C).
  - 1. Bodies: Brass or bronze, rated at 150 psi (1034 kPa), with threaded end connections or cast iron rated at 150 psi (1034 kPa) with flanged end connections .
  - 2. Trim: Bronze or brass.
  - 3. Stem: Stainless steel with replaceable bronze or brass seat. The stem packing shall be silicone U-copper Teflon V ring.
- F. High performance butterfly valves: Two-way or three-way modulating for position control of the mixing or diverting applications. Three-way assemblies shall be assembled with two valves and a flanged cast-iron tee, or dual valve pipe assemblies. Valve body shall be supplied with stainless steel stem, bronze or steel disk and synthetic rubber seat. Valve shall be suitable for electric actuation. Valves shall be rated for 150 psi (1034 kPa) and 225 degrees F (107 degrees C).
- G. Maximum pressure drop across water control valves shall be 2.0 psi (14 kPa). Isolation type control valves shall be equal to pipe size, unless pressure drop exceeds 2.0 PSF.

# 2.23 ELECTRIC VALVE OPERATORS

- A. Low or line voltage electric or electronic motor type with minimum opening and closing time of 15 seconds, sized to provide sufficient power to operate the valve, and for full shutoff against the operating pressure.
- B. Solenoid valves (quick-closing) are not acceptable.

## PART 3 - EXECUTION

- 3.21 INSTALLING VALVES
  - A. Install valves complete with operators, as indicated on drawings and as required by Control Sequences.

# **END OF SECTION**

#### SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Control devices and accessories.
- 1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION
  - A. Wells: Section 23 21 13.
  - B. Flow switches: Section 23 21 13.
  - C. Differential pressure switches: Section 23 21 13.
- 1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION
  - A. Duct-mounted smoke detectors: Section 28 31 00.
- 1.14 RELATED SECTIONS
  - A. Automatic temperature control system: Sections 23 09 01 through 23 09 23.
  - B. Sequence of operations: Shown on drawings.
  - C. DDC flow meters: Section 23 05 19.

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings:
  - 1. Each control device labeled with setting or adjustable range of control.
  - 2. Wiring diagrams. Differentiate between factory-installed and field-installed wiring.
- C. Product data:
  - 1. For each device, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes, and installation instructions.
  - 2. Each type of accessory. Include finishes.
- D. Maintenance data: As required in 23 01 01, HVAC General Provisions.

## 1.90 MAINTENANCE

A. Provide two sets of manufacturer's special tools for operating tamperproof fasteners, marked to identify their use.

- B. Calibration kit for carbon dioxide sensors: Portable, for field calibration, including nitrogen gas, tubing, regulator, and case, with manufacturer's instructions for performing calibration.
- C. Deliver maintenance products to Owner's designated storage area and store as directed.
- D. Maintenance service: On Substantial Completion and building occupancy, calibrate carbon dioxide sensors and instruct Owner's personnel in the procedure.

# PART 2 - PRODUCTS

- 2.10 CONTROL DEVICES, GENERAL
  - A. Instruments with predetermined temperature or pressure setpoints shall be provided with a means of adjustment over a reasonable range. Adjustable devices for control of temperatures shall be graduated and calibrated in degrees F. Markings such as WARMER and COOLER are not acceptable.
  - B. Devices mounted outdoors shall be weathertight construction or mounted in weathertight enclosure or inside weathertight units.
- 2.13 DIGITAL CONTROLS (ELECTRONIC)
  - A. Each room temperature sensor shall include a setpoint adjustment dial, and a terminal jack.
    - 1. The setpoint adjustment dial shall allow for modification of the temperature by the occupant. Setpoint adjustment may be locked out, overridden or limited as to time or temperature through software by an authorized operator.
    - 2. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller.
    - 3. Provide controller to accommodate sensor type. Provide room temperature sensors closely matched to the requirements of the associated controllers. Signal input and output shall be accurate, responsive, and silent. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:

Accuracy:	plus or minus 1 degree F (0.6 degrees C)
Operating range:	35 to 115 degrees F (2 to 46 degrees C)
Set point adjustment range:	55 to 95 degrees F (2 to 30 degrees C)
Set point modes:	Independent Heating, Cooling, Night Setback-Heating, Night Setback-Cooling
Calibration adjustments:	None required
Installation:	Up to 100 feet from controller

B. Humidity sensors: Range shall be 10 to 90 percent RH with ±2 percent RH accuracy; wall mounted or insertion type as required by the installation.

- C. Enthalpy sensors: Sensing element shall be combination bimetal/nylon. Span shall be 24 BTU/lb. dry air. Range shall be 16 to 40 BTU/lb. dry air. Units shall be suitable for duct mounting.
- D. Carbon dioxide sensors: Wall or duct insertion type, 0-2000 ppm range, typical accuracy of ±30 ppm or ±2 percent of reading between 60 and 90 degrees F, 0-10 VDC or 4-20 mA output, less than 5 percent drift over 5 year calibration interval; equal to Vaisala GMD20. Wall-mounted units shall be furnished with blank-off cover for LCD display with separate tamperproof wire guard.
- E. Static pressure sensors:
  - 1. Duct static pressure sensors shall be of the solid-state diaphragm type with integral 2-wire, 4-20 mA signal conditioning and high and low adjustments. Range shall be 0-5 inches wg; output shall be 4-20 mA. Accuracy shall be 0.025 percent per degree C maximum over a temperature sensitivity range of 25 to 75 degrees C.
  - Space pressure sensor: Solid-state, temperature compensated piezoresistive balanced bridge 4-20 mA output, minus 0.25 to plus 0.25 inch wg range, ±0.02 percent at 77 degrees F accuracy, ±0.2 percent drift/year stability.
- F. Differential pressure sensing in piping: Pressure sensors for control of variable frequency drives on pumping systems shall be of the solid-state type with NEMA 250 Type 1 cast aluminum housing. The static error band shall not exceed ±0.5 percent of full scale. The operating temperature range shall be minus 40 to plus 200 degrees F and shall be temperature compensated. Zero and span adjustments shall be accessible externally. The output shall be 4-20 mA. Provide three-valve manifold for each sensor.
- G. Sensors installed in pipes shall be installed in thermometer wells of bronze or stainless- steel materials. Heat transfer compounds shall be compatible with the sensor. Compression type fittings between sensors and thermometer wells are not acceptable.
- H. Temperature sensors for air systems shall be RTD type. Sensors shall have a time constant response of less than 3 seconds to a temperature change of 1 degree. Sensors shall be coupled with industrial grade adjustable span transmitters to achieve the following range with the accuracy specified: 10 to 100 degrees F, plus or minus 1 degree F. Sensors shall be suitable for insertion into air ducts and have a minimum insertion of 6 inches.
- I. Condensate overflow switches: Sensor/switch to be installed in secondary condensate pans to detect clogged drains, equal to Grainger 3XY17.

## 2.14 AUXILIARY CONTROLS

- A. Timers: Spring-wound type with automatic return, the number of hours setting as indicated in sequence of operations, time indicating dial, mounted in flush box. Provide engraved plastic nameplate, white letters on black background, for each timer.
- B. Emergency fan disconnecting switch:

- 1. Switch: Security type, operated by a keyed lock, with stainless-steel device plate, equal to The Knox Company KS-2. All emergency fan disconnect switches in the project shall be keyed alike.
- 2. Key box: Provide one key in the Owner's "Knox Box" installed near the main entry doors, and one spare to the Owner. Provide each key with a permanently fastened metal or plastic tag as specified for identification in Section 23 05 00, engraved "Emergency Fan Disconnect Switch".

## 2.70 ACCESSORIES

- A. Guards for wall-mounted thermostats, sensors, or other control devices: Size selected to suit device to be protected, designed for vertical or horizontal mounting.
  - 1. For locations accessible to the public, incuding classrooms, or provided with line voltage thermostats: Equal to Kele TG500 Series, double-wall cover, steel with manufacturer's standard white enamel finish, with wall plate, base, lock, and two keys.
  - 2. For locations in utility spaces: Equal to Kele AT1104, cast aluminum with openings on front and all sides, designed for mounting directly to wall.
  - 3. Fasteners: Tamperproof. Include 2 sets of special tools as required in Part 1 above.
  - 4. Administrative office areas shall not be considered "public space" as it relates to the requirement for guards.
- B. Plastic nameplates: As specified in Section 23 05 00, Common Work Results for HVAC, minimum plate size 0.75 by 2.5 inches, minimum letter size 0.1875 inch, properly identifying equipment and use.

## PART 3 - EXECUTION

## 3.20 INSTALLATION

- A. Where averaging type bulbs or tubing and low temperature protection thermostats are installed within ductwork or unit casings, provide a removable galvanized frame with 1-inch square mesh wire for attaching the tubing in desired pattern. Where capillary passes through duct side or unit casing, provide split flange fitting to seal hole and protect the capillary in the duct or casing.
- B. Instruments mounted on insulated ducts or equipment shall have mounting brackets arranged to permit full insulation on the duct.
- C. Room thermostats or temperature sensors mounted in unit casing or on sampling chamber shall not be an acceptable substitute for insertion thermostats.
- D. One-pipe transmitters may be used in insertion and immersion thermostat applications only as a sensing element for a receiver-controller.
- E. Bulbs for outdoor air thermostats or temperature sensors shall be shielded from the sun and reflected heat rays. These bulbs may be located behind weather louvers of OA intakes but ahead of any ATC damper.

- F. Special-purpose instruments, such as timer switches or other appurtenances shall be provided with engraved nameplates which properly identify the items. Nameplates shall be mounted with vandalproof screws on the wall immediately below the item.
- G. Thermostats, temperature sensors, humidity sensors and carbon dioxide sensors. Mount on wall, securely anchored. Mounting height from floor to top of device shall be 48 inches, as required for accessibility to persons using wheelchairs.
- H. Mount wall-mounted devices with tamperproof screws. Where devices are located in new locations, use wall boxes securely anchored flush into the wall. Use copper tubing from ceiling to device either fished through wall cavity or chased into wall and patched to match existing surface.
- I. Provide guards for all wall-mounted devices, including thermostats, temperature sensors, humidity sensors, and carbon dioxide sensors.
  - 1. Mount guard base to wall by at least four tamperproof screws, entirely independent of device wall plate and cover.
- J. Provide manual override on thermostats or temperature sensors as noted in sequence of operation.
- K. Emergency fan disconnect switch: Install in location approved by Fire Marshal.

## 3.21 INSTALLING DIGITAL CONTROLLER

- A. Provide wiring required between digital controller and equipment as scheduled on the Control Point Schedule.
- B. Cooperate with Owner to set up the digital controller to operate as shown in sequence of operations on the drawings.

# 3.70 ADJUSTING

- A. Calibrate carbon dioxide sensors: Perform zero and span calibrations, following manufacturer's recommended procedures.
- 3.81 OPERATING INSTRUCTIONS
  - A. As specified in Section 23 05 00, provide operating instructions.
  - B. Instruct Owner's personnel in use of calibration kit to perform annual calibration of carbon dioxide sensors.

# **END OF SECTION**

### SECTION 23 09 23 - DIRECT DIGITAL BUILDING SYSTEMS CONTROL

## PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Direct digital building control (DDC) system.
  - B. Network communications.
  - C. DDC panels.
  - D. System software.
  - E. Application-specific controllers.
  - F. Operator I/O devices.

#### 1.14 RELATED SECTIONS

- A. Coordination, installer qualifications, and acceptable manufacturers: Section 23 09 01.
- B. Automatic temperature control system: Sections 23 09 01 through 23 09 23.
- C. Control sequences: Shown on drawings.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Installer qualifications: Submit as required in Section 23 09 01, Automatic Temperature Control System. Include, in addition to other requirements, the location of the support facility from which warranty and service will be provided, and a list of the names, titles, and training of the individuals who will be responsible for the work of this project.
- C. Documentation: Submit complete documentation for the system hardware and software, including user's manuals and other support sufficient to enable Owner's personnel to understand and correctly operate the system. Include this documentation in Operation and Maintenance submittals in accordance with Division 01 and Section 23 01 01.
- D. Certifications:
  - 1. Data sheet or copy of government approval form showing that the system complies with FCC Regulations, Part 15, Section 15.
  - 2. Results of functional and diagnostic field tests and calibrations, specified in Part 3. Submit copies of the installing technician's checklist showing that the system has been completely set up and is ready to operate.
  - 3. Submit Compliance Inspection Checklist, initialed and dated, showing satisfactory completion of the installation tests specified in Part 3.

# 1.90 WARRANTY AND SERVICE

- A. General requirements: Provide all services, materials and equipment necessary for the successful operation and maintenance of the entire DDC system for the period of the general project correction period required by General Conditions, Division 01, and Section 23 01 01. Provide parts, software, and labor required for the work. Schedule maintenance and adjustments to minimize effects on facility operations.
- B. The adjustment and repair of the system includes computer equipment, software updates, transmission equipment, and sensors and control devices. Provide the manufacturer's required adjustments and other work necessary to maintain system operation.
- C. Personnel: Provide qualified personnel to accomplish work promptly and satisfactorily. Notify Owner in writing of the name of the designated service representative, and of changes in personnel.
- D. Schedule of work: Schedule major inspections in June and December and minor inspections in March and September. Minor inspections shall include visual checks and operational tests of each item of equipment. Major inspections shall include all work described for minor inspections and the following work:
  - 1. Clean equipment, including interior and exterior surfaces.
  - 2. Perform signal, voltage, and system isolation checks of system workstations and peripherals.
  - 3. Check and calibrate each field device. Check all analog points and digital points.
  - 4. Run diagnostics and correct diagnosed problems.
  - 5. Resolve and correct other observable problems.
- E. Emergency service: Qualified personnel shall be available to provide service to the complete system. Furnish owner with a telephone number where service representative can be reached at all times. Service personnel shall be at the site within 8 hours after receiving a request for service, and shall restore the control system to proper operating condition within 24 hours.
- F. Operation: Performance of scheduled adjustments and repair shall verify operation of the system as demonstrated by the initial performance test.
- G. Systems modifications: Make recommendations for system modification in writing to Owner. Do not make any system modifications, including operating parameters and control settings, without prior written approval of Owner. Modifications to the system shall be incorporated into the operations and maintenance manuals and other documentation.
- H. Software: During the project correction period, provide all software updates and verify operation in the system in a timely manner. Instruct the system operators, and incorporate updates into the operations and maintenance manuals and software documentation. At the end of the correction period, continue to notify Owner of software revisions.

# PART 2 - PRODUCTS

### 2.30 GENERAL PRODUCT DESCRIPTION

- A. The DDC system shall integrate multiple building functions including equipment supervision and control, alarm management, energy management, and historical data collection.
- B. The building control system shall include the following:
  - 1. Network DDC panels
  - 2. Network application-specific controllers (ASCs)
  - 3. Portable operator's terminals
  - 4. Personal computer operator workstation(s)
- C. The system shall be modular and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC panels, application-specific controllers, and operator devices.
- D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
- E. Without depending on a control processing device, DDC panels shall be able to:
  - 1. Access any data from or send control commands and alarm reports directly to any other DDC panels or combination of panels on the network.
  - 2. Send alarm reports to multiple operator workstations.

#### 2.31 NETWORKING COMMUNICATIONS

- A. The DDC system shall network operator workstations.
  - 1. A high performance peer-to-peer network.
  - 2. An application-specific local area network (LAN).
- B. Peer-to-peer network level:
  - 1. Operator workstations and DDC panels shall directly reside on a network such that communications shall be executed directly between DDC panels, directly between workstations, and between DDC panels and workstations on a peer-to-peer basis.
  - 2. Inherent in the system's design shall be the ability to expand or modify the network either via a LAN, or auto-dial telephone line modem connections, or via a combination of the two networking schemes.
  - 3. All operator devices, either network-resident or connected via dial-up modems, shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. Access to data shall be based on logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.

- 4. Network design shall include the following provisions:
  - a. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. An alarm occurring at any DDC panel shall display at one or more workstations or alarm printers within 5 seconds.
  - b. Support of any combination of DDC panels and operator workstations directly connected to the peer-to-peer network. The network shall support a minimum of 32 devices.
  - c. Message and alarm buffering to prevent information from being lost.
  - d. Error detection, correction, and retransmission to guarantee data integrity.
  - e. Synchronization of real-time clocks, to include automatic daylight savings time updating among all DDC panels.
  - f. Commonly available, multiple source, networking components and protocols shall be used to allow the DDC system to coexist with other networking applications such as office automation. ETHERNET and ARCNET are acceptable technologies.
  - g. Use of an industry standard IEEE 802.x protocol. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading.
- C. Application-specific local area network (LAN):
  - 1. This level communication shall support a family of application-specific controllers and shall communicate bidirectionally with the peer-to-peer network through DDC panels for transmission of global data.
  - 2. Application-specific controllers shall be arranged on the LANs in a functional relationship with DDC panels. For example, a VAV terminal unit controller shall be on a LAN from the DDC panel that is controlling its corresponding AHU.
  - 3. A maximum of 32 application-specific controllers may be configured on each LAN.
- D. Communication capability:
  - 1. Automatic communications shall allow DDC panels to communicate with remote operator stations and remote terminals, as indicated in the sequence of operations.
  - 2. DDC panels shall automatically communicate with workstations to report alarms or other significant events.
  - 3. Operators at the workstation shall be able to perform all control functions, all report functions, and all database generation and modification functions as described for workstations connected via the network. Routines shall automatically answer communications from remote DDC panels. The fact that communications are taking place with remote DDC panels shall be invisible to an operator.
  - 4. Communications shall use a standard web browser via local area network.

# 2.32 DDC PANEL

A. Microprocessor-based panels with a minimum word size of 16 bits: Multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Each DDC panel shall be capable of operating as a stand-alone controller, performing its specified

control functions independently of other controllers in the network. Controller size shall be sufficient to fully meet the requirements of this specification and the point list on the drawings.

- B. Each DDC controller shall have sufficient memory, a minimum of 1 megabyte, to support its own operating system and databases, including:
  - 1. Control processes
  - 2. Energy management applications
  - 3. Alarm management applications
  - 4. Historical and trend data for points specified
  - 5. Maintenance support applications
  - 6. Custom processes
  - 7. Operator I/O
  - 8. Communications
  - 9. Manual override monitoring
- C. Each DDC panel shall support:
  - 1. Monitoring of the following types of inputs, without the addition of equipment outside the DDC panel:
    - a. Analog inputs
      - (1) 4-20 mA
      - (2) 0-10 Vdc
      - (3) Thermistors
      - (4) 1000-ohm RTDs
    - b. Digital inputs
      - (1) Dry contact closure
      - (2) Pulse accumulator
      - (3) Voltage sensing
  - 2. Direct control of electronic actuators and control devices. Each DDC panel shall be capable of providing the following control outputs without the addition of equipment outside the DDC panel:
    - a. Digital outputs: Contact closure (motor starters, sizes 1-4)
    - b. Analog outputs
      - (1) 0-20 psi
      - (2) 4-20 mA
      - (3) 0-10 Vdc
- D. Additional space for future point connections, each DDC panel: Minimum 10 percent.
  - 1. Provide sufficient internal memory for the specified control sequences with at least 25 percent of the total memory available for future use.

- E. Each DDC panel shall have at least two RS-232C serial data communication ports for operation of operator I/O devices.
- F. Each DDC panel shall have point discrete, on-board, limited access Hand/Off/Auto operator override switches for digital control type points and gradual switches for analog control type points. These override switches shall be operable whether the panel processor is operational or not. DDC panels shall monitor the status of all overrides and remotely report each override control operation.
- G. DDC panels shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.
- H. Each DDC panel shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components, and provide both local and remote annunciation of detected component failures, low battery conditions, or repeated failure to establish communication.
- I. Provide isolation at each peer-to-peer network termination and each field point termination, to suppress induced voltage transients, meeting requirements of IEEE C62.41.
- J. In the event of the loss of normal power, each DDC panel shall shut down in an orderly process which shall prevent the loss of database or operating system software. Provide nonvolatile memory for critical controller configuration data and battery backup sufficient to support the real-time clock and volatile memory for a minimum of 72 hours.
  - 1. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.
  - 2. Should DDC panel memory be lost for any reason, reloading the DDC panel shall be possible via the local RS-232C port, via telephone line dial-in, or from an operator workstation.
- K. Provide a DDC panel for each AHU or other HVAC system as indicated on the drawings. It is intended that each unique system be provided with its own point-resident DDC panel.

## 2.33 SYSTEM SOFTWARE

- A. General:
  - 1. Provide all necessary software to form a complete control system as described in this specification.
  - 2. The software programs specified in this section shall be integral in DDC panels and shall not be dependent upon any higher-level computer for execution.
  - 3. Install software at building operator workstation, on the Baltimore County Public Schools Central reporting computers located at the Pulaski Highway facility, and on the Baltimore County Public Schools employee note book computers. Provide required updates to existing software package.
  - 4. Include a copy of the software package with the operations and maintenance manual.
- B. Control software:

- 1. The DDC panels shall have the ability to perform the following pre-tested control algorithms:
  - a. Two-position control
  - b. Proportional control
  - c. Proportional plus integral control
  - d. Proportional, integral, plus derivative control
  - e. Control loop tuning
- 2. Include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
- 3. Shall protect against excessive demand during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
- 4. Upon the resumption of normal power, the control software shall analyze the status of controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operations.
- C. DDC panels shall be able to perform any or all of the following energy management routines:
  - 1. Time-of-day scheduling
  - 2. Calendar-based scheduling
  - 3. Holiday scheduling
  - 4. Temporary schedule overrides
  - 5. Start-stop time optimization
  - 6. Automatic Daylight Savings Time switchover
  - 7. Night setback control
  - 8. Enthalpy switchover (economizer)
  - 9. Peak demand limiting
  - 10. Temperature-compensated duty cycling
  - 11. Fan speed/CFM control
  - 12. Heating/cooling interlock
  - 13. Geothermal heat pump water reset.
- D. DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
  - 1. It shall be possible to use any of the following in a custom process:
    - a. Any system measured point data or status
    - b. Any calculated data
    - c. Any results from other processes
    - d. User-defined constants
    - e. Arithmetic functions (+, -, \*, /,square root, exp, etc.)
    - f. Boolean logic operators (and/or, exclusive or, etc.)
    - g. On-delay/off-delay/one-shot timers
  - 2. Custom processes may be triggered based on any combination of the following:
    - a. Time interval

- b. Time of day
- c. Date
- d. Other processes
- e. Time programming
- f. Events (e.g., point alarms)
- 3. The custom control programming feature shall be documented in English.
- E. Alarm management shall monitor and direct alarm information to operator devices. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to noncritical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by operation of a PC workstation or local I/O device, or by communications among panels on the network.
  - 1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
  - 2. The user shall be able to define the specific system response to alarm at each point. Alarms shall be prioritized. Each DDC panel shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
  - 3. Alarm reports and messages shall be directed to a user-defined list of operator devices.
  - 4. In addition to the point's descriptor and the time and date, the user shall be able to print, display, or store an alarm message to more fully describe the alarm condition or direct operator response.
  - 5. Operator-selected alarms shall initiate a call to a remote operator device.
- F. A variety of historical data collection utilities shall manually or automatically sample, store, and display system data for points as specified in the I/O summary.
  - 1. DDC panels shall store and report point history data for selected analog and digital inputs and outputs. Methods of collection shall be either by a predefined time interval or upon a predefined change of value.
  - 2. DDC panels shall provide high resolution sampling for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary. Provide capability to view or print trend and tuning reports.
- G. DDC panels shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary.
- H. DDC panels shall automatically sample, calculate, and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/O summary.
- I. DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis for points as specified in the point I/O summary.

# 2.35 APPLICATION-SPECIFIC CONTROLLERS (ASC)

- A. Each DDC panel shall be able to extend its performance and capacity through the use of remote application-specific controllers (ASCs).
- B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
- C. Terminal equipment controllers:
  - 1. System shall control each piece of equipment through direct connection to a DDC or ASC. Terminal equipment shall include, but not be limited to, the following:
    - a. Heat pumps (water- or air-source heat pumps)
  - 2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50 percent of the point outputs (except for unit ventilator controllers) shall be of the universal type, either modulating or two-position. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable. Provide DDC panels or ASCs with industry standard outputs for control of terminal equipment.
  - 3. Each controller shall perform its primary control function independent of other DDC panel LAN communication, or if LAN communication is interrupted. The controller shall receive its real-time data from the DDC panel time clock and shall ensure LAN continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein.
  - 4. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in nonvolatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Operating programs shall be field-selectable for specific applications. Specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of applications are not acceptable.
  - 5. Heat pump controllers shall support the following types of heat pumps as a minimum:

Water-source heat pumps (both 2-stage and single-stage compressors)

## 2.41 PERSONAL COMPUTER OPERATOR WORKSTATION

- A. Provide personal computer operator workstations for command entry, information management, network alarm management, and database management functions. All real-time control functions shall be resident in the DDC panels.
  - 1. Provide workstation(s) of equal capability located where directed by owner.

- 2. Workstation shall consist of a flat panel color monitor, personal computer with minimum 3 GB RAM, 160-GB hard drive and controller, mouse, 16 x DVD +/ RW, 56.0 Kb modem, and 101-key enhanced keyboard. Personal computer shall have a minimum 2.5 GHZ Intel Pentium Dual Core processor or equivalent by AMD, 10/100/1000 Network Interface with RJ-45 ethernet port.
- 3. The display provided for system operation shall have a diagonal screen measurement of no less than 19 inches and a minimum display resolution of no less than 1440 x 900 pixels. Separate controls shall be provided for color, contrasts and brightness. The screen shall be nonreflective.
- B. Provide a laser printer with 600 by 600 dpi resolution at each workstation location for recording alarms, operator transactions, and systems reports.

## 2.42 PORTABLE OPERATOR'S TERMINAL (POT)

- A. Provide portable operator terminals with a minimum LCD display of 80 characters by 25 lines and a full-featured keyboard. The POT shall be handheld and plug directly into individual distributed control panels as described below. Provide a user-friendly, Englishlanguage-prompted interface, not codes requiring look-up charts.
- B. Functions of the POT connected at any DDC controller:
  - 1. Access all DDC panels on the network.
  - 2. Backup and restore DDC controller data bases for all system panels, not just the DDC Controller connected to.
  - 3. Display all point, selected point and alarm point summaries.
  - 4. Display trending and totalization information.
  - 5. Add, modify, or delete any existing or new system point.
  - 6. Command, change setpoint, enable or disable any system point.
  - 7. Program and load custom control sequences as well as standard energy management programs.
- C. Functions of the portable operator's terminal connected to any application-specific controller:
  - 1. Provide connection capability at either the ASC or a related room sensor to access controller information.
  - 2. Provide status, setup, and control reports.
  - 3. Modify, select, and store controller data base.
  - 4. Command, change setpoint, enable or disable any controller point.

## 2.43 OPERATOR WORKSTATION SOFTWARE

- A. Basic interface description:
  - 1. Operator workstation interface software shall use English-language prompting, Englishlanguage point identification, and industry standard PC application software. The software shall provide, as a minimum, the following functions.
    - a. Graphical viewing and control of environment.
    - b. Scheduling and override of building operations.

- c. Collection and analysis of historical data.
- d. Definition and construction of dynamic color graphic displays.
- e. Editing, programming, storage, and downloading of controller databases.
- 2. Provide a graphical user interface which shall use a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays with the pointing device.
  - a. Provide that all operations can also be performed using the keyboard as a backup interface device.
  - b. Provide at least 10 special function keys to perform often-used operations.
- 3. The software shall provide multi-tasking that allows the user to run several applications simultaneously. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows or similar industry standard software that supports concurrent viewing and controlling of systems operations.
- 4. Multiple-level password access protection shall be provided to allow the user manager to limit workstation control, display, and data base manipulation capabilities.
- 5. Software shall allow the operator to perform commands including, but not limited to, the following:
  - a. Start up or shut down selected equipment
  - b. Adjust setpoints
  - c. Add/modify/delete time programming
  - d. Enable/disable process execution
  - e. Lock/unlock alarm reporting for points
  - f. Enable/disable totalization for points
  - g. Enable/disable trending for points
  - h. Override PID loop setpoints
  - i. Enter temporary override schedules
  - j. Define holiday schedules
  - k. Change time/date
  - 1. Automatic daylight savings time adjustments
  - m. Enter/modify analog alarm limits
  - n. Enter/modify analog warning limits
  - o. View limits
  - p. Enable/disable demand limiting for each meter
  - q. Enable/disable duty cycle for each load
- 6. Reports shall be generated and directed to either CRT displays, printers, or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
  - a. A general listing of all points in the network
  - b. List of all points currently in alarm
  - c. List of all points currently in override status
  - d. List of all disabled points
  - e. List of all points currently locked out
  - f. DDC controller trend overflow warning
  - g. List all weekly schedules

- h. List of holiday programming
- i. List of limits and deadbands
- B. Scheduling:
  - 1. Provide a graphical spreadsheet-type format for time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum:
    - a. Weekly schedules
    - b. Zone schedules
    - c. Monthly calendars
  - 2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupied and unoccupied times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
  - 3. Provide zone schedule for each building zone. Each schedule shall include all commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.
  - 4. Monthly calendars for a 24-month period shall allow scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.
- C. Collection and analysis of historical data:
  - 1. Trending capabilities shall allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting.
  - 2. Trend data report graphics shall allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred easily to an off-the-shelf spreadsheet package. This shall allow the user to perform custom calculations such as energy use, equipment efficiency, and energy costs and shall allow for generation of these reports on high-quality plots, graphs, and charts.
- D. Dynamic color graphic displays:
  - 1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air-handling units, chilled water systems and hot water boiler systems, shall be provided as indicated in the point I/O summary to optimize system performance analysis and speed alarm recognition.

- 2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.
- 3. Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.
- 4. The environment of the PC operator workstation shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
- 5. Graphic generation software shall allow the user to add, modify, or delete system graphic displays.
- E. System configuration and definition:
  - 1. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
  - 2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
    - a. Add/delete/modify DDC panel
    - b. Add/delete/modify operator workstations
    - c. Add/delete/modify application-specific controllers
    - d. Add/delete/modify points of any type and all associated point parameters and tuning constants
    - e. Add/delete/modify alarm reporting definition for points
    - f. Add/delete/modify control loops
    - g. Add/delete/modify energy management applications
    - h. Add/delete/modify time and calendar-based programming
    - i. Add/delete/modify totalization for points
    - j. Add/delete/modify historical data trending for points
    - k. Add/delete/modify custom control processes
    - 1. Add/delete/modify any and all graphic displays, symbols and cross-reference to point data
    - m. Add/delete/modify dial-up telecommunication definition
    - n. Add/delete/modify all operator passwords
    - o. Add/delete/modify alarm messages
- F. Additional workstation software:
  - 1. Automatic communications shall include the following features as a minimum:
    - a. Manual communication from the workstation to remote networks shall be accomplishable using only a mouse to select and request the desired remote connection.
    - b. Alarms shall automatically communicate with the workstation for display at the terminal and for hard-copy printout at the associated event printer.
    - c. Alarms shall, at the operator's option, communicate with a stand-alone printer to provide for real-time alarm printouts even when the workstation is off-line (such as when it is being used to run operator-selected third party software).

d. Trend data shall be scheduled for automatic updating to the workstation at operator-selected times. The operator shall also have the option of manually collecting trend data at any time.

## PART 3 - EXECUTION

## 3.20 HARDWARE AND SOFTWARE INSTALLATION

- A. Install the control system in accordance with manufacturer's instructions, complete and operating as shown and specified.
- B. See drawings for the level of controller required for each type system control.

#### 3.61 TESTS

- A. Installer shall test, calibrate, and adjust the system and perform final field test. Engineer shall witness tests.
- B. Final field test:
  - 1. Sensors: Cross-check each sensor by comparing the reading at the sensor to a standard traceable to the National Institute of Standards and Technology (NIST).
  - 2. Control points: Cross-check each control point by comparing the control command to the field-controlled device.
  - 3. Verify that systems are operable from local controls in the specified failure mode upon panel failure or loss of power.
  - 4. Submit test results as required in "Submittals" in Part 1 above.
- C. Compliance inspection: Schedule compliance inspection only after installer has conducted all the test operations required above and successfully completed them, as substantiated by the required submittals. Conduct the compliance inspection with the Owner's designated representative and the Engineer. Conduct each activity described on the "Compliance Inspection Checklist" attached at the end of this Section. When each activity is satisfactorily completed, the Owner's representative (user) and the Engineer (A/E) will initial and date the line provided on the checklist.
  - 1. If any item on the checklist cannot be complied with, submit a written explanation.
  - 2. Complete the checklist and submit as required in "Submittals" in Part 1.

## 3.81 OPERATING INSTRUCTIONS

- A. Coordinate instruction period with requirements of Section 23 05 00.
- B. Provide competent instructors to give full instruction to designated personnel in the adjustment, operation, and maintenance of the system installed, rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. Training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays as follows:
- C. Provide two 8-hour days of training for Owner's operating personnel. Training shall include:

- 1. Explanation of drawings, operations, and maintenance manuals.
- 2. Walk-through of the job to locate control components.
- 3. Operator workstation and peripherals.
- 4. DDC panel and ASC operation/function.
- 5. Operator control functions including graphic generation and field panel programming.
- 6. Operation of portable operator's terminal.
- 7. Explanation of adjustment, calibration, and replacement procedures.
- D. Provide 4 hours of additional training quarterly for a period of one year from final completion of the project.
- E. The Owner may require personnel to have more comprehensive understanding of the hardware and software. Additional training shall be available from the installer, after completion of the work of the project. Provide description of available local and factory customer training.

# **END OF SECTION**

Compliance Inspection Checklist follows Section.

-				
Ma wo	rkstation a	erate an alarm at a remo nd alarm printer to receive	te DDC panel to dem ve alarms within 5 se	conds.
Us	er	Date	A/E	Date
Dis at a	sconnect an a remote D	operator workstation in DC panel to demonstrate	the central control re the capability of the	oom and manually generate system printer to receive also
wh	en the worl	kstation is disconnected	from the system.	
Use	er	Date	A/E	Date
Dis not the	connect or disrupt or Engineer.	halt peer-to-peer comm	inication. Panel to b	e disconnected shall be selec
Dis not the Use	connect or disrupt or Engineer. er	halt peer-to-peer comm	anication. Panel to b	e disconnected shall be selec
Dis not the Use At	a DDC par	halt peer-to-peer comm Date hel of the Engineer's cho	A/EA/E	DateDate
Dis not the Us At a.	a DDC par At least for a sys	Date Date hel of the Engineer's cho one temperature setpoin tem or piece of equipme	A/EA/Eice, display on the po t and at least one stat nt attached to that pa	Date Date ortable operator's terminal: us condition, (for example, onel), as well as for points at
Dis not the Us At a. b.	a DDC par At least for a sys DDC pa The diag	Date Date hel of the Engineer's cho one temperature setpoin tem or piece of equipme nel on the network. gnostic results as specifie	A/EA/E ice, display on the po t and at least one stat nt attached to that pa	Date Date rtable operator's terminal: us condition, (for example, o nel), as well as for points at ce of equipment attached to
Dis not the Use At a. b. c.	a DDC par At least for a sys DDC pa The diag panel as The abil	Date Date Date Date Date Date Date Date	A/EA/E ice, display on the po t and at least one stat nt attached to that pa ed for a system or pie piece of equipment at the DDC panel with	Date Date Date 
Dis not the Use At a. b. c.	a DDC par At least for a sys DDC pa The diag panel as The abil uploaded	Date Date nel of the Engineer's cho one temperature setpoint tem or piece of equipme nel on the network. gnostic results as specifie well as for a system or p ity to add a new point to d to the workstation to m	A/EA/E ice, display on the po t and at least one stat nt attached to that pa ed for a system or pie piece of equipment at the DDC panel with odify that panel's sto	Date Date ortable operator's terminal: us condition, (for example, onel), as well as for points at ce of equipment attached to tached to another DDC pane the POT and have it automated red database.
Dis not the Use At a. b. c. Use	a DDC par At least for a sys DDC pa The diag panel as The abil uploaded	Date Date nel of the Engineer's cho one temperature setpoin tem or piece of equipme nel on the network. gnostic results as specific well as for a system or p ity to add a new point to d to the workstation to m Date	A/EA/E and at least one stat and at least one stat and at least one stat and for a system or pie biece of equipment at the DDC panel with odify that panel's sto A/E	DateDate pression of the point o
Dis not the Us At a. b. c. Us At reli	a DDC par At least for a sys DDC pa The diag panel as The abil uploaded er an ASC of fance on a l	DateDate halt peer-to-peer commuDate nel of the Engineer's cho one temperature setpoint tem or piece of equipme nel on the network. gnostic results as specifie well as for a system or p ity to add a new point to d to the workstation to m Date The Engineer's choice, d DDC panel to maintain f	A/EA/E ice, display on the po- t and at least one stat nt attached to that pa- biece of equipment at the DDC panel with hodify that panel's sto A/E isconnect the LAN c full control functional	Date Date ortable operator's terminal: us condition, (for example, or nel), as well as for points at ce of equipment attached to tached to another DDC pane the POT and have it automated red databaseDate Date
Dis not the Use At a. b. c. Use At reli Use	a DDC par The diag panel as The abil uploaded an ASC of ance on a l	Date Date nel of the Engineer's cho one temperature setpoin tem or piece of equipme nel on the network. gnostic results as specific well as for a system or p ity to add a new point to d to the workstation to m Date The Engineer's choice, d DDC panel to maintain f	A/E	DateDate rtable operator's terminal: us condition, (for example, of nel), as well as for points at ce of equipment attached to tached to another DDC pane the POT and have it automatic red database. Date onnection to demonstrate its ity. Date

## SECTION 23 09 95 - BUILDING AUTOMATION SYSTEM COMMISSIONING

#### PART 1 GENERAL

- 1.1 WORK INCLUDED
  - A. BAS System and equipment testing and start-up
  - B. Validation of proper and thorough installation of BAS systems and equipment
  - C. Functional testing of control systems
  - D. Documentation of tests, procedures, and installations
  - E. Coordination of BAS training
  - F. Documentation of BAS Operation and Maintenance materials
- 1.2 GENERAL DESCRIPTION
  - A. This section defines responsibilities of the Building Automation System Contractor to Commission the BAS.
  - B. Commissioning (Cx) is the process of ensuring that all building systems are installed and perform interactively according to the design intent; that systems are efficient and cost effective and meet the Owner's operational needs; that the installation is adequately documented; and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
  - C. Commissioning Authority (CxA) is retained by the Owner and shall work with the Contractor and the Design Engineer to direct and oversee the Commissioning process and perform functional performance testing.
  - D. Requirements common to all Sections are specified in Sections 01 91 13 and 01 91 14.
  - E. The scope of the Commissioning on this project shall include the entire BAS system.
- 1.3 RELATED SECTIONS:
  - A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
  - B. The Cx process references many related Sections, particularly Section 01 91 13 General Commissioning. It is important for all Contractors subject to the Cx process to be familiar with Section 01 91 13.
  - C. Refer to Section 01 91 13 for a complete list of Sections on Related Work.
- 1.4 DEFINITIONS AND ABBREVIATIONS
  - A. Refer to Section 01 91 13.
- 1.5 REFERENCE STANDARDS
  - A. ASHRAE Guideline 1-1996, "Guideline for Commissioning HVAC Systems"
  - B. ASHRAE Guideline 4-1993, "Preparation of operating and Maintenance Documentation for Building Systems"
  - C. NEBB Procedural Standards for Building Systems Commissioning

- D. ASHRAE Standard 110 Method for Testing Laboratory Fume Hoods
- E. USGBC LEED NC 3.0 Reference Package

## 1.6 CONTRACTOR RESPONSIBILITIES

- A. General responsibilities of the Contractor are specified in Section 01 91 13. The following responsibilities indicate specific responsibilities of the BAS contractor in addition to those responsibilities
- B. Assist CxA in verification and performance testing. Assistance will generally include the following:
  - 1. Establish trend logs of system operation as specified herein
  - 2. Manipulate systems and equipment to facilitate functional performance testing as outlined in Section 01 91 14.
  - 3. Provide Portable Operators Terminals or operator workstations in locations convenient to testing activities as specified below
  - 4. Provide CxA with appropriate passwords, keys, and access to control panels and workstations.
  - 5. Where control systems do not allow a test mode or the overriding of physical input values for testing, program an interim virtual point for all inputs that can be used to represent the point and be overridden for testing
- C. Provide a Control technician to work at the direction of Commissioning Authority for software optimization assistance for a minimum of 16 hours. Refer to Part 3 for a description of the software optimization.
- D. Provide a form summarizing all setpoints and alarm parameters and alarming strategies for the Owner to complete. Organize a meeting with Owner and CxA to discuss the desired initial setpoints and alarm parameters. Contractor shall enter the requested setpoints and alarm parameters at completion of start-up and record the applicable settings in the prefunctional documentation.
- E. Train Owner's Representatives in systems operation and control equipment use, operation, maintenance and repair. Training shall be conducted as follows:
  - 1. Control system training shall be conducted by the Control Subcontractor.
- F. Compensate the Owner for site time necessitated by incompleteness of systems or equipment at time of functional performance testing. All testing failures which require on-site time for retesting will be considered actual damages to the Owner. The contract sum shall be reduced by contract modification at a rate of \$140 per man-hour of on-site time necessary to retest failures. All parties under contract with the Owner who are affected by the retesting shall be included in the contract modification. Refer to Section 01 91 13 and 01 91 14 for more details.

## 1.7 SEQUENCING:

- A. Refer Section 01 91 13.
- B. The following list outlines the general sequence of events for Commissioning of the Control systems.
  - 1. Construction Phase:
    - a. Collaborate on construction scheduling
    - b. Submit Product data and Shop Drawings, and receive approval.
    - c. Meet with Commissioning Team to coordinate with all trades
    - d. Submit Control Logic Documentation, and receive approval.
    - e. Begin controls installation.

- f. Submit refinement of generic prefunctional checklists incorporating manufacture specific start-up procedures accompanied by manufacturers preprinted start-up procedures for all equipment provided by the BAS contractor
- g. Receive BAS prefunctional checklists approval.
- h. Submit Training Plan content
- i. Receive approval of Training Plan content
- j. Provide alarm list and receive approval
- k. Provide sample graphics and receive approval
- 1. Complete BAS system installation
- m. Place systems under BAS control.
- n. Enter alarms as approved by Owner
- o. Complete BAS graphics
- p. Perform BAS system start-up and complete prefunctional documentation.
- q. Submit completed BAS prefunctional Checklists
- r. Prepare and initiate Trend Log data storage and format trend graphs.
- s. Train Owner on control system operation and maintenance for basic system offering.
- t. Formal Hand off Meeting
- u. Submit Commissioning BAS Software/Access and provide technician level (monitoring, point override/test, and setpoint adjustment) password access to Owner and CxA.
- v. Receive BAS prefunctional documentation approval and approval to schedule Commissioning Demonstrations.
- w. Demonstrate systems to Commissioning Authority and Owner.
- x. Submit trend logs in format specified
- y. Receive Demonstration approval and approval to schedule Acceptance Phase.
- 2. Acceptance Phase
  - a. Receive Operational Test approval which enables start of Functional Testing.
  - b. CxA Performs Functional Performance Testing and BAS contractor participates in initial samples.
  - c. Two week Operational Test
  - d. Receive Functional Completion approval for the BAS.
  - e. Substantial Completion
- 3. Warranty Phase
  - a. Provide administrator password access to Owner.
  - b. Train Owner on final Sequences and modes of operation.
  - c. Update facility manual content with any changes.
  - d. Revise and Re-Submit Record drawings and O&M manuals.
  - e. Install Framed Control Drawings
  - f. Final Completion
  - g. Opposite Season Operational Test and Functional Performance Testing
  - h. Receive Opposite Season Operational Test and FPT approval
  - i. Revise and Re-Submit Record drawings and O&M manuals and update framed control drawings if any changes result from opposite season operational test.
  - j. Complete owner training.
  - k. End of Warranty Period

# PART 2 PRODUCTS

# 2.1 INSTRUMENTATION

- A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:
  - 1. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of + or  $-0.1^{\circ}$ F.
  - 2. Pressure sensors shall have an accuracy of + or -2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
  - 3. All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.
- B. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems related to functional testing shall be provided by CxA.
- C. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

## 2.2 WEB-BASED COMMISSIONING PORTAL

- A. All general and major subcontractors participating in the Cx process shall use the web-based Cx Portal ('Portal') to document the Cx procedures. The Portal is a Web-based Internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The Portal is hosted by the CxA and shall be accessible to all Parties participating in the Cx program. The Portal provides a common location to store Start-Up Documentation, Functional Performance Tests and results, project documents and deliverables. It also serves as a collaborative email hub to facilitate, automate, and track communications between Parties relating to the Cx process.
- B. Refer to Section 01 91 13 the individual Specifications for additional information and requirements for using the Portal.

## 2.3 TAB & COMMISSIONING PORTABLE OPERATORS TERMINAL

- A. Provide the CxA with all software, connection devices, licenses, passwords and the like to facilitate connection to the BAS throughout the building. Provide a license to graphic software, and all operating software necessary for testing and configuration of all control elements at all levels. License may be a temporary license that will expire after the completion of the Warranty Period. Options include:
  - 1. Browser access to the full graphic software. CxA will provide laptop however BAS contractor shall set up the laptop to successfully connect.
  - 2. Licensed Client Software to be installed on CxA Computer. BAS contractor shall install the software and ensure it is functional.
- B. Access to the BAS must be provided throughout the building as more fully defined as follows:
  - 1. Full wireless connection to the graphic server throughout the building will be adequate.
  - 2. Network connection for full access to the graphic server within 50' of any point in the building

- 3. Exception to 1 and 2 above: an acceptable alternative to full building access to the graphic server relating to terminal controls shall be providing to the CxA the devices and software required to connect to local terminal controllers through a connection port in the space such as connection to a jack on the temperature sensor (basically what is required by TAB specified below). This does not apply to mechanical rooms as full graphic access is required in mechanical rooms.
- C. Provide software required by TAB to calibrate all flow sensors. TAB will provide computer to be used as a portable operator's terminal. Any manufacturer specific hardware such as connection cables, converters, hand held devices, etc. shall be provided by the contractor.
- D. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection of the operator's terminal shall be either at the sensor as well as at the box. Otherwise a wireless system shall be provided to facilitate this local functionality.

## PART 3 EXECUTION

## 3.1 BAS START-UP TESTING, ADJUSTING, CALIBRATION

- A. Work and/or systems installed under this section shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below:
  - 1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
  - 2. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
  - 3. Verify integrity/safety of all electrical connections.
  - 4. Coordinate with TAB subcontractor to obtain and CxA to fine tune control settings that are determined from balancing procedures. Record the following control settings as obtained from TAB contractor, and note any TAB deficiencies in the BAS Start-Up Report:
    - a. Optimum duct static pressure setpoints for VAV air handling units
    - b. Minimum outside air damper settings for air handling units
    - c. Optimum differential pressure setpoints for variable speed pumping systems.
    - d. Calibration parameters for flow control devices such as VAV boxes and flow measuring stations.
      - 1) BAS contractor shall provide hand held device as a minimum to the TAB and CxA to facilitate calibration. Connection for any given device shall local to it (at the VAV box or at the thermostat). HHD or portable operators' terminal shall allow querying and editing of parameters required for proper calibration and start-up.
    - e. Calibration parameters for fume hoods
  - 5. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the BAS Start-up Report.
  - 6. Check and set zero and span adjustments for all transducers and transmitters.
  - 7. For dampers and valves:
    - a. Check for adequate installation including free travel throughout range and adequate seal.

- b. Where loops are sequenced, check for proper control without overlap
- 8. For actuators:
  - a. Check to insure that device seals tightly when the appropriate signal is applied to the operator.
  - b. Check for appropriate fail position, and that the stroke and range is as required and coordinated with the programmed ranges when it is operating under normal conditions.
  - c. For pneumatic operators, adjust the operator spring compression as required to achieve close off. If positioner or volume booster is installed on the operator, calibrate per manufacturer's procedure to achieve spring range indicated. Check split range positioners to verify proper operation. Record settings for each device.
  - d. Check the stroke and range under actual loading conditions and validate that they correlate with programmed values
  - e. For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges.
- 9. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device.
- 10. For outputs to reset other manufacturers devices (VFDs) and feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.
- 11. Verify proper sequences by using the approved checklists to record results. Verify proper sequence and operation of all specified functions.
- 12. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
- 13. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Start-up Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):
  - a. Duct air temperature:  $\pm 1^{\circ}$ F.
  - b. Space Temperature:  $\pm 3^{\circ}$ F within 3 minutes and control within  $\pm 2^{\circ}$ F
  - c. Chilled Water:  $\pm 1^{\circ}$ F
  - d. Hot water temperature:  $\pm 2^{\circ}$ F.
  - e. Duct pressure:  $\pm 0.25$ " w.c.
  - f. Water pressure:  $\pm 1$  psid
  - g. Duct  $\hat{H}$ umidity:  $\pm 3\hat{\%}$  when adding humidity
  - h. Space Humidity:  $\pm 5\%$  when adding humidity to control
  - i. Terminal Air flow control:  $\pm 5\%$  of setpoint. This includes all VAV terminal control and exhausted BSCs, canopy hoods, ventilated cage racks, necropsy tables, and other scientific equipment with supply or exhaust ventilation
  - j. Fume Hoods:  $\pm 10\%$  on full sash travel (from min to max in 3 seconds) within 3 seconds.  $\pm 5\%$  when sash is positioned in the controllable range. Refer to Section 15995 for fume hood acceptance requirements
  - k. Space Pressurization (on active control systems): ±0.03" w.c. with no door or window movements. No high containment space shall go more than 0.15" w.c. positive, nor go positive at all for more than 20 seconds.

- 14. For communication interfaces and DDC control panels:
  - a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
  - b. Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
  - c. Check power supplies for proper voltage ranges and loading.
  - d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
  - e. Check for adequate signal strength and acceptable bandwidth utilization on communication networks.
  - f. Check for stand alone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at OIs. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
  - g. Ensure that all outputs and devices fail to their proper positions/states.
  - h. Ensure that buffered and/or volatile information is held through power outage
  - i. With all system and communications operating normally and all trends functioning, sample and record update/annunciation times for critical alarms fed from the panel to the OI.
  - j. Check for adequate grounding of all DDC panels and devices.
  - k. Run self diagnostic routines and ensure they are functional
  - 1. Check the memory allocation and loading to ensure adequate and excess capacity is available and that it will not affect control functionality.
- 15. Coordinate desired initial alarm strategies with Owner's Operators. Set all required alarms and document the initial settings in the start-up documentation
- 16. Coordinate all initial setpoints with Owner's Operators. Ensure those setpoints are active
- 17. For Operator Interfaces:
  - a. Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
  - b. Output all specified BAS reports for review and approval.
  - c. Verify that the alarm printing and logging is functional and per requirements.
  - d. Verify that trend archiving to disk and provide a sample to the CxA for review.
  - e. Verify alarm enunciation functionality. Time delay from actual occurrence to the time updated or enunciated on the screen. Ensure it is per the specified requirements.
  - f. Verify that real time and historical trends are accessible and viewable in graph format.
  - g. Verify that paging/dial out alarm annunciation is functional.
  - h. Verify the functionality of remote OIs and that a robust connection can be established consistently.
  - i. Verify that required third party software applications required with the bid are installed and are functional.
  - j. Demonstrate open protocol and custom third party interfaces reliably communicate and check response time.
  - k. Verify response times and screen update and refresh times are per the requirements.
  - 1. Verify that all custom programs are editable from the OI. Check upload, download, back up and restore capabilities of system configuration information as well as custom programs.

- m. Verify schedules are set up and working.
- n. Verify Owner stipulated security and permissions is set up and functional.
- o. In concert with the Building Power Outage test, validate that critical GUI installations are properly powered by UPS and emergency outlets to keep it functional during a power outage. Validate that the space has adequate lighting to manage the building in the event of an outage.
- 18. Start-up and check out control air compressors and air drying and filtering systems in accordance with the appropriate section and with manufacturer's instructions.
  - a. Validate adequate deliver and pressures
  - b. Validate adequate redundancy
  - c. Validate max run time and cycle time vs. manufacturer's recommendations
  - d. Validate that routing of the compressed air does not result in condensation at any point in the system when used with the specified drier
  - e. Check all PRVs both primary and back up to ensure adequate functionality and maintenance of downstream pressure
- 19. Verify proper interface with fire alarm system.
- 20. Verify proper interface with control panels of equipment with self contained controls that are being monitored by the BAS.
- B. Submit Start-Up/prefunctional Documentation. This shall be completed, submitted, and approved prior to demonstration and Acceptance Phase.

## 3.2 SENSOR CHECKOUT AND CALIBRATION

- A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading of each other for pressure. Tolerances for critical applications may be tighter.
- B. Calibration: Calibrate all sensors using one of the following procedures:
  - 1. Sensors without Transmitters--Standard Application: Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gage or EMCS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20% of the expected range.
  - 2. Sensors with Transmitters--Standard Application: Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or EMCS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.
- C. Sensor Tolerance: Sensors shall be within the tolerances specified for the device.

# 3.3 LOOP TUNING

- A. For all control loops, contractor shall tune the loops to ensure the fastest stable response without hunting, offset or overshoot with tolerances defined above. Contractor shall introduce upsets to the load when possible to affect response. Otherwise, setpoints can be changed to affect the response.
- B. Generally tune loops during periods of high gain.
- C. Document all parameters either by capturing text, short interval trends, or screen shots of trend graph documenting the final response.
- 3.4 COIL VALVE LEAK CHECK
  - A. Verify proper close off of the valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit. Calibrate air temperature sensors on each side of coil to be within 0.5°F of each other. Via the OI, command the valve to close. Energize fans. After 5 minutes observe air temperature difference across coil. If a temperature difference is indicated, and the piping surface temperature entering the coil is within 3°F of the water supply temp, leakage is probably occurring. If it appears that it is occurring, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

# 3.5 VALVE STROKE SETUP AND CHECK

- A. For all valve and actuator positions checked, verify the actual position against the OI readout.
- B. Set pumps to normal operating mode. Command valve closed, verify that valve is closed, and adjust output zero signal as required. Command valve open, verify position is full open and adjust output signal as required. Command valve to a few intermediate positions. If actual valve position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics)

## 3.6 ALARM SETPOINT COORDINATION

A. The Contractor shall prepare a list of all conceptual point types and recommend the types and recommended alarming strategies and setpoint for review. Owner shall use this alarm list to provide direction to Contractor for alarm strategies and setpoints. Alarm list shall be provided at least two months prior to the first functional test. Contractor shall have alarm setpoints entered prior to functional testing. Omitting an alarm setting, using the wrong strategy, or entering the wrong setpoints will be considered a failure from the perspective of the functional test.

## 3.7 GRAPHIC COORDINATION

A. The Contractor shall prepare all graphics (only one example graphic is required for typical systems like terminal units) with points embedded for review. Owner shall use these graphics to provide direction to Contractor for the required final graphic. All final graphics must be complete and active before functional testing. Any deviation from the approved graphics will be considered a failure from the perspective of the functional test.

## 3.8 BAS DEMONSTRATION

A. Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the Commissioning Agent. Schedule the demonstration with

the Owner's representative 1 week in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved. If the Work fails to be demonstrated to conform to Contract specifications, so as to require scheduling of additional site visits by the Commissioning Authority for re-demonstration, Contractor shall reimburse Owner for costs of subsequent Commissioning Authority site visits.

- B. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the job site.
- C. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner and CxA.
- D. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:
  - 1. Demonstrate that required software is installed on EMCS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
  - 2. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
  - 3. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.
  - 4. Demonstrate correct calibration of input/output devices using the same methods specified for the start-Up tests. A maximum of 10 percent of I/O points shall be selected at random by Commissioning Authority and/or Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by Commissioning Authority for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
  - 5. Demonstrate that all DDC and other software programs exist at respective field panels. The Direct Digital Control (DDC) programming and point database shall be as submitted and approved.
  - 6. Demonstrate that all DDC programs accomplish the specified sequences of operation.
  - 7. Demonstrate that the panels automatically recover from power failures, as specified.
  - 8. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
  - 9. Identify access to equipment selected by Commissioning Authority. Demonstrate that access is sufficient to perform required maintenance.
  - 10. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
- E. BAS Demonstration shall be completed and approved prior to functional testing.
- F. Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be repeated.

## 3.9 FUNCTIONAL PERFORMANCE TESTING

A. Requirements for assistance with functional performance testing are specified in the Section 01 91 14. Provide assistance during Functional Performance Testing per 01 91 14 and related Specifications.

## 3.10 BAS ACCEPTANCE PERIOD

- A. After approval of the BAS Demonstration and prior to Substantial Completion Acceptance Phase shall commence. Acceptance Period shall not be scheduled until all HVAC systems are in operation and have been started and the startup documented, all required cleaning and lubrication has been completed (i.e., filters changed, piping flushed, strainers cleaned, etc.), and draft TAB report has been submitted. Acceptance Period and its approval MAY be performed on a system-by-system basis if mutually agreed upon by contractor and Owner.
- B. Operational Test: At the end of the Acceptance Phase, the system shall operate properly for two weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. At the end of the two weeks, contractor shall forward the trend logs to the CxA for review. CxA shall determine if the system is ready for functional acceptance and document any problems requiring contractor attention.
  - 1. If the systems are not ready for functional acceptance, Contractor shall correct problems and provide notification to the Owner's representative that all problems have been corrected. The Operational Test shall be restarted at a mutually scheduled time for an additional one week period. This process shall be repeated until Commissioning Authority issues notice that the BAS is ready for functional acceptance.
- C. During the Acceptance Period, the contractor shall maintain a hard copy log of all alarms generated by the BAS. For each alarm received, contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the contractor's opinion, the cause of the alarm is not the responsibility of the contractor, contractor shall immediately notify the Owner's representative.
- D. During the Acceptance Phase, the contractor shall maintain all controller network and workstation hardware and software in a state that will allow remote access by Commissioning Agent to Trend Logs as specified below.

## 3.11 TREND LOGS

- A. Trends are historical archives on computer disks that document the operation of the systems and equipment. Trends can be interval recordings of system I/O parameters or Change of Value based trends that record when a system value changes by more than a specified threshold.
- B. CxA will analyze trend logs of the system operating parameters to evaluate normal system functionality. The requirements of the trending are specified below. Contractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the CxA.
- C. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals and be presented in a maximum of two separate two dimensional formats with time being the vertical axis and

field name being the horizontal axis. Data shall be forwarded in one of the following formats.

- 1. Microsoft ACCESS Database (.mdb)
- 2. Microsoft EXCEL Spreadsheet (.xls)
- 3. Comma Separated Value (.csv or .txt) preferably with quotes delimiting text fields and # delimiting date/time fields
- D. Sample times indicated as COV (±) or change of value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When output to the trending file, the latest recorded value shall be listed with any given time increment record. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the interval common to the unit.
- E. Contractor shall provide the CxA with required passwords, phone numbers, etc. to allow the CxA access to the trend log data and allow downloading to a remote location. Contractor shall also provide step-by-step written instructions for accessing the data.
- F. Trending Requirements: All points on primary equipment and selected sampling of terminal points unless approved otherwise. This will include, but not be limited to the following. At a minimum, trend the following on 10 min. intervals for analog values and change of value for binary values.
  - 1. Outside Air Temperature
  - 2. Outside Air Enthalpy
  - 3. Cooling Tons
  - 4. All sensed Hydronic Temperatures
  - 5. All sensed air temperatures on primary equipment
  - 6. All damper outputs on primary equipment
  - 7. All valve outputs on primary equipment
  - 8. All sensed Fan Volumes on primary equipment
  - 9. All inputs and outputs to VFDs
  - 10. Return (or exhaust) Air Temperature on each air handler
  - 11. All safety indications
  - 12. Status on all primary equipment
  - 13. All air and water pressures on primary equipment or systems
  - 14. Space Temperatures
  - 15. Steam Flow
  - 16. Electricity consumption where monitored.
  - 17. Natural Gas flows
  - 18. Converter steam valves and hot water temperatures
  - 19. Steam supply pressures and temperatures.
  - 20. Basically all points on primary equipment and selected sampling of terminal points unless approved otherwise
- G. Trending to document functional tests may typically be at a more frequent interval. Consult with the CxA to determine the required intervals for functional testing and modify intervals as required.

## 3.12 TREND GRAPHS

A. Trend graphs shall generally be used during the Acceptance Phase to facilitate and document testing. Prepare controller and workstation software to display graphical format trends during the Acceptance Period. Trend graphs shall demonstrate compliance with contract documents. Trended values and intervals shall be the same as those specified for the functional performance tests.

- B. Contractor shall establish trend graphs for every PID loop under control for the main equipment and for the terminal zones, which shows the input, output and setpoint. Where applicable, multiple graphs can be used to clearly display the data. Also, multiple PIDs can share a graph when there is correlation, such as an AHU temperature and setpoint and valve outputs for both the HW and CHW valve. Coordinate with the CxA regarding the set-up of the trend summaries.
- C. Lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.
- D. Indicate engineering units of the y-axis values; e.g. degrees F., inches w.c., Btu/lb, percent wide open, etc.
- E. The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.
- F. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended.
- G. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended during the same trend period.
- H. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.

# 3.13 WARRANTY PHASE BAS OPPOSITE SEASON TRENDING AND TESTING

- A. Trending: throughout the Warranty Phase, trend logs shall be maintained as required for the Acceptance Period. Contractor shall forward archived trend logs to the CxA for review upon CxA's request. CxA will review these and notify contractor of any warranty work required.
- B. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, CxA shall schedule and conduct Opposite Season functional performance testing. Contractor shall support this testing and remedy any deficiencies identified.

# 3.14 SOFTWARE OPTIMIZATION ASSISTANCE

- A. The contractor shall provide the services of a controls technician as specified above at the project site to be at the disposal of the CxA. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the CxA during the construction and commissioning of the project and that are beyond the specified Contract requirements. The cost for this service shall be included with the bid. Requests for assistance shall be for contiguous or non-contiguous 8 hour days, unless otherwise mutually agreed upon by contractor, Commissioning Authority, and Owner. The Owner's representative shall notify contractor 2 days in advance of each day of requested assistance.
- B. The controls technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the controls technician provided cannot perform every software task requested by the Commissioning Authority in a timely fashion, contractor shall provide additional qualified personnel at the project site as requested by the Commissioning Authority, to meet the total specified requirement on-site.

## 3.15 BAS OPERATOR TRAINING

A. Provide up to 6 complete sets of User Manuals (hard copy and one electronic copy) to be used for training.

- B. Contractor shall submit a Training Plan per the requirements of Div 1 for the scope of training he is responsible. Training Plan shall be forwarded to the CM who will forward it to the AE and CxA for review.
- C. On Site Training: Provide training as specified and as supplemented below. All training shall include the appropriate training materials and attendance documentation required by Div1.
- D. BAS Final Systems Operation Training
  - . The BAS shall participate a session to present the final sequences programmed into the control system. The session will basically present:
    - a. Control System Architecture
    - b. Addressing and location of panels
    - c. Schematic configuration of the systems
    - d. Final programmed sequences. It shall present the written sequences and illustrate the programming that accomplishes those sequences. This session is typically presented on site by the primary BAS technician that managed the installation of the controls at that facility.
  - 2. The BAS shall be use the Record Control Shop Drawings as the handout for the training. The audience for the session will be the Owner's operators and managers. The setting should be primarily classroom. Since the presentation will typically need to use a live Operator Interface, BAS shall work out the logistics of projecting the video for an effective presentation.
  - 3. Fume Hood Controls
    - a. The vendor for the fume hood controls shall present a session to occupant representatives on how the fume hood controls work and how to use the hood monitor.
    - b. The audience for this session shall be the occupants and their representatives. The setting should be in the field at a functioning hood.

# END OF SECTION
### **SECTION 23 21 13 - HYDRONIC PIPING**

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Heat pump loop water supply and return.

#### 1.13 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Control valves: Section 23 09 08.
- B. Wells: Sections 23 05 19 and 23 09 13.
- C. Flow switches: Section 23 09 13.

#### 1.14 RELATED SECTIONS

- A. Piping materials, installation, and testing: Section 23 05 00.
- B. Pipe cleaning and water treatment: Section 23 25 00.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Each specified material and product.

#### PART 2 - PRODUCTS

- 2.10 PIPE
  - A. Black steel, plain end: Schedule 40, ASTM A 53.
  - B. Black steel, grooved: Schedule 40, ASTM A 53 Type B; NPS 3 (DN 80) and smaller, rolled grooved; NPS 4 (DN 100) and larger, cut or rolled grooved.
  - C. Copper tubing ASTM B 88, Type L hard or soft drawn, plain end.

#### 2.20 FITTINGS

- A. For steel piping: Cast iron, Class 125, ASME B16.1 (flanged).
  - 1. NPS 2.5 (DN 65) and larger, flanged.
- B. Mechanical couplings and fittings for grooved steel pipe, NPS 2 (DN 50) through NPS 12 (DN 300): Equal to Victaulic Style 107 QuickVic "installation ready" rigid coupling with Grade EPH gasket, and Victaulic Style 07 standard rigid couplings with Grade E gasket and angle-pattern bolt pads. Fittings shall be ductile iron or steel with grooved ends designed to accept standard couplings. Couplings, gasket and fittings shall be able to withstand a constant

temperature of 230 degrees F (110 degrees C) and 175 psi (1200 kPa) working pressure. Elbows NPS 4 (100 mm) and larger shall be long radius type.

- C. Mechanical flange adapters for grooved steel pipe.
  - NPS 2.5 (DN 65) through NPS 12 (DN 300): Ductile iron castings, flat face, Class 125 and 150 bolt-hole pattern, equal to Victaulic Style 741; Class 300 bolt-hole pattern, equal to Victaulic Style 743.
- D. Fittings for plain end copper pipe: Solder joint, cast brass, ASME B16.18; or wrought copper, ASME B16.22.
- E. Welding fittings: Steel, 150 psi (1030 kPa), ANSI B16.9, products of Bonney Forge, Hackney Ladish, Inc., Penn Machine, The Phoenix Forge Group, Taylor Forge, or Weldbend Corporation.
- F. Companion flanges: 150-lb., welding neck or slip-on type, ANSI B16.5.
- G. Dielectric pipe fittings shall comply with Section 23 05 08.
- H. Threaded joints:
  - 1. Compound recommended by manufacturer for use at the temperature and pressure of the system, or "Teflon" pipe thread tape, specified in Section 15050, Basic Mechanical Materials and Methods.
- I. Elbows in piping NPS 4 (DN 100) and larger shall be long radius type.

### PART 3 - EXECUTION

### 3.20 INSTALLATION

- A. Install piping as indicated on the drawings and in accordance with provisions of Section 23 05 00 and the piping installation schedule at the end of the Section.
- B. Install automatic control valves, flow switches and insertion wells furnished under Automatic Temperature Controls sections, as indicated on the drawings, and in accordance with manufacturer's instructions.
- C. Provide dielectric nipples between steel and copper pipe.

# 3.60 FIELD QUALITY CONTROL

A. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be supplied by a single manufacturer. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be supplied by the grooved coupling manufacturer. Grooved end shall be cleaned and free from indentations, projections and roll marks in the area from pipe end to groove. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

- 3.75 CLEANING AND TREATMENT
  - A. Clean piping and provide water treatment as specified in Section 23 25 00, HVAC Water Treatment.
- 3.90 SCHEDULES

HYDRONIC PIPING INSTALLATION SCHEDULE				
Contractor has option where more than one x appears on a line				
	А	В	С	D
Heat pump loop water	Х	X	Х	X

- A. Schedule 40 black steel, welded; NPS 2.5 (DN 65) and larger pipe sizes with welded or flanged fittings.
- B. Schedule 40 black steel, rolled groove; NPS 2.5 and 3 (DN 65 and 80) pipe sizes with mechanical coupling and fittings.
- C. Schedule 40 black steel, cut or rolled groove; NPS 4 (DN 100) and larger pipe sizes with mechanical couplings and fittings.
- D. Copper tubing; NPS 2 (DN 50) and smaller pipe sizes with cast or wrought fittings.

# **END OF SECTION**

### SECTION 23 21 16 - GROUND HEAT EXCHANGER PIPING SYSTEM

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Polyethylene piping system for ground heat exchange. Numbers and locations of boreholes and circuits are shown on drawings.
- B. Vertical loops grouted in boreholes.
- C. Horizontal system underground, connecting at building side to heating and cooling system and water-source heat pump equipment. This section includes system to above-grade piping within mechanical room.
- 1.14 RELATED SECTIONS
  - A. Boreholes: Section 31 23 14.
  - B. Trenching: Section 23 05 01.
- 1.20 REFERENCES
  - A. ASTM D 3035: Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
  - B. ASTM D 3350: Standard Specification for Polyethylene Plastics Pipe and Fittings Material.
  - C. ASTM F 714: Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
  - D. ASTM D 2774: Standard Practice for Underground Installation of Thermoplastic Pressure Piping.
  - E. ASTM D 3261: Standard Specification for\_Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
  - F. ASTM D 2683: Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
  - G. International Ground Source Heat Pump Association (IGSHPA):
    - 1. OSU/IGSHPA-1: Grouting Procedures for Ground-Source Heat Pump Systems.
    - 2. OSU/IGSHPA-2: Closed-Loop/Ground-Source Heat Pump System/Installation Guide.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data:

- 1. Pipe.
- 2. Fittings.
- 3. Grout.
- 4. Manufacturer's instructions.
- C. Shop drawings:
  - 1. Before the system is covered or concealed, submit dimensioned as-built drawings of the complete ground heat exchanger piping system, showing relationship to other utilities and buildings in system's vicinity.
  - 2. When the drawings have been approved, laminate or store in a clear plastic envelope and attach to the wall of the mechanical room in a location approved by the Owner.
  - 3. Proposed plan and schedule for installation and field testing.
- D. Certifications:
  - 1. Qualifications of system fabricators.
  - 2. Qualifications of system installers.
  - 3. Inspection and Test Report.
- E. Operation and maintenance data: As required in Division 01 and Section 23 01 01.

# 1.40 QUALITY ASSURANCE

- A. Qualifications of system fabricators:
  - 1. Certified technicians who have completed a heat fusion school in which each participant has performed a heat fusion procedure under the direct supervision of an approved manufacturing certification program.
  - 2. Technicians shall attend a retraining school annually.
- B. Qualifications of system installers: Certified installers who have successfully completed:
  - 1. An approved manufacturer's certification program.
  - 2. At least five projects with two ground heat exchanger systems of 100 tons or more, within the last 5 years.

# PART 2 - PRODUCTS

# 2.11 GROUND HEAT EXCHANGER PIPE AND FITTINGS

- A. Pipe and fitting material: Polyethylene pipe and fittings shall be made from resin meeting the requirements of the Plastic Pipe Institute as PE 3608. The resin shall meet the requirements of ASTM D 3350 with a cell classification of 345464C.
  - 1. Pipe 3 inches (75 mm) and smaller: Standard dimension ratio (SDR) of 11.0.
  - 2. Pipe larger than 3 inches (75 mm): SDR of 15.5
- B. Fittings:

- 1. ASTM D 3261 butt and saddle fusion fittings. Barbed fittings and hose clamps not permitted.
- C. U-bends: Factory-fused, injection-molded 180-degree U-bend assemblies equipped with antibuoyancy devices.
- D. Pipe for 1/2 through 3 inches (15 through 75 mm) of diameter: ASTM D 3035.
- E. Pipe for 4 inches (100 mm) and larger diameter: ASTM F 714.
- 2.12 BOREHOLES
  - A. Thermally enhanced grout: One-part or two-part thermally enhanced cement-based or bentonite-based grout with a minimum thermal conductivity of 1.0.
  - B. For two-part thermally enhanced grout mixtures: Provide a third-party testing of the installed grout mixture's thermal conductivity through an independent testing agency. Test samples shall be obtained from the pumped discharge line utilized for grouting. A minimum of one sample shall be provided for every ten vertical boreholes installed. Additional boreholes and piping shall be provided at no additional cost to the Owner upon receipt of a failed test report.
- 2.20 BOREHOLE (WELL) ASSEMBLIES
  - A. Provide the piping for each borehole preassembled and sealed, with its length permanently marked at the top of the assembled pipe.

### PART 3 - EXECUTION

### 3.02 EXAMINATION

- A. Examine areas and conditions under which heat exchanger systems will be installed. Before beginning boring, excavations, or trenching, locate and mark buried utilities.
- 3.41 VERTICAL LOOPS IN BOREHOLES (WELLS)
  - A. Before each hole is bored, the borehole assembly shall be assembled, laid out straight, taped to reduce springback, and tested with water at 100 psi (689 kPa) for leaks and by OSU/IGSHPA-2 recommended procedures for flow.
  - B. Vertical bores: 5 feet (1.5 m) deeper than the length of the loop, clean, and of sufficient diameter to allow the installation of the U-bend assembly and a third pipe for pressure grouting.
    - 1. Bores shall contain no large, sharp, or jagged rocks and no debris.
  - C. Fill the U-bend loop with water and pressurize to 40 psi (276 kPa) to prevent the pipe from being crushed during grouting.
  - D. Grout the loops in the boreholes from the bottom up, using a tremie, with grout specified above. Comply with OSU/IGSHPA-1 material and pumping process requirements to ensure pipe contact, and with local and state requirements for sealing.

- 1. Follow manufacturer's directions for water-to-mix ratio of grout and optimum size of batches.
- 2. During installation and backfilling, prevent pipe from being crushed, kinked, or cut. Use compacting tools and methods suitable for plastic piping systems, as recommended by pipe manufacturer.

# 3.42 PIPING SYSTEMS

- A. Follow manufacturer's written instructions.
- B. Avoid sharp bends. Provide elbow fittings for changes in direction when the minimum bend radius defined by the pipe manufacturer is exceeded. Use only continuous pipe in vertical U-bend loops.
- C. Make changes in piping sizes through tapered concentric fittings.
- D. Keep trash, soil, and foreign objects out of the pipe. Tape or cap ends of pipe sections until they are joined to the circuit.
- E. On header piping 1.25 inches (32 mm) diameter and greater, vertical loop take-off tee fittings may be made using either tee fittings or the saddle fusion process. Completely remove the cutout on the saddle tees.
- F. Use bell reductions at pipe reductions. Use reducing socket tees when fabricating socket type reducing headers.
- G. Threaded connections are not permitted in directly buried piping.
- H. Heat fusion process: Join by butt or socket fusion in accordance with manufacturer's Heat Qualification Guide.
  - 1. Pipe 2 inches (50 mm) diameter and less: Socket fusion.
  - 2. Pipe greater than 2 inches (50 mm): Butt fusion.
  - 3. Do not fuse different plastics or different grades of plastic to one another.
  - 4. Saddle connections are not acceptable except as specified for header piping above.
- I. Where leaks occur, cut out the material and repair in accordance with the pipe manufacturer's recommendations.
- J. Install tracing wires attached to all buried horizontal plastic pipe. Terminate ends of wiring in Mechanical Room.

# 3.43 BOREHOLE IDENTIFICATION

- A. Provide plan view of entire geothermal well field with GPS coordinates for each borehole identified, including a hand-held GPS locating device provided with plan.
- B. Provide borehole markers at locations identified on plans.

### 3.75 CLEANING AND TESTING PIPING SYSTEMS

- A. Before connecting a loop to the header, flush it in accordance with OSU/IGSHPA-2 and leave it filled with glycol solution as specified in Section 23 21 14. If it is not immediately joined to the header, tape or cap the loop.
- B. Do not backfill the horizontal part of the system until testing and inspection are complete and approved (GHX Inspection and Test Report has been signed).
  - 1. Initial pressure testing shall utilize either air or water for testing. If air is used for initial pressure testing, all piping joints shall be fully soaped to view for leaks.
  - 2. Test pressure for initial testing shall be 125 psi (689 kPa) for continuous 30-minute test duration. Allowable pressure fluctuation throughout 30-minute test period shall be a maximum of 1 psi. Gauge utilized for pressure testing shall be provided with either 1 psi pressure increments or a digital display.
  - 3. Visually inspect welds and repair leaks discovered during testing and conduct the pressure test again.
- C. After the entire ground loop piping system has been assembled, fill the system with water, flush, and purge prior to final pressure testing.
- D. Use a portable temporary purging unit consisting of:
  - 1. High-volume, high-head purge pump.
  - 2. Open reservoir.
  - 3. Filter assembly with bypass.
  - 4. Flow meter.
  - 5. Pressure gage.
  - 6. Connecting piping and hoses.
- E. Flush and purge each circuit of air, dirt, and debris.
  - 1. Isolate the water-source heat pumps from the ground heat exchanger system by shutoff valves.
  - 2. A velocity of 2 feet/second (0.6 m/second) is required to remove the air.
  - 3. Allow purge pump to run 15 minutes after the last air bubbles have been removed.
- F. Provide final pressure and flow testing for entire heat exchange piping system once flushing and purging is complete. Testing procedures shall follow OSU/IGSHPA-2 recommendations.
  - 1. Flow test shall be observed and approved, and GHX Inspection and Test Report form signed, by the Architect.
  - 2. If the flow test indicates blockage, locate the blockage following manufacturer's recommendations, remove it, then repeat the purge procedure and conduct the flow test again.
  - 3. Final pressure testing shall utilize water for testing.
  - 4. Test pressure for final testing shall be 125 psi (689 kPa) for continuous 30-minute test duration. Allowable pressure fluctuation throughout 30-minute test period shall be a maximum of 1 psi. Gauge utilized for pressure testing shall be provided with either 1 psi pressure increments or a digital display.
  - 5. Repair all leaks discovered during testing and conduct the pressure test again.

G. Complete GHX Inspection and Test Report (form attached at the end of this Section).

# 3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

# **END OF SECTION** (Inspection and Test Report Form follows Section)

# GROUND HEAT EXCHANGER (GHX) INSPECTION AND TEST REPORT

Building:			
Inspection Date:			
Ground Heat Exchanger No. or Description:			
List the WSHP Unit No.'s served by this GHX:			
Ground Heat Exchanger Design Water Flowliters/sec gpm			
Calculated purging flow and press to achieve 0.61 m 2 feet/sec			
Purging: Flow liters/sec gpm Head kPa psi, Duration of test min.			
Hydrostatic test pressurekPa psi; Duration min.			
Did the system pass the pressure test?			
Is antifreeze required in system? If yes, was antifreeze measured?			
Has a dimensioned drawing been prepared, completely and accurately showing the layout of the ground heat exchanger?			
Does the layout differ substantially from the contract documents? If so is the deviation approved?			
Depth of installed vertical loops is m feet. (Design is m feet.)			
Depth of horizontal piping is m feet. (Design is m feet.)			
Are the trenches clear of sharp bends, rocks, or other sharp objects that could restrict flow?			
Are all joints head fused (butt-, socket-, or saddle-fusion)? Do the joints have the proper amount of roll-out?			
Has the piping material been cut out and properly removed from saddle-fusion tees?			
Was the system backfilled properly with good clean backfill material?			
Comments:			
Inspected and approved this date by			
Title:			

#### SECTION 23 21 23 - HVAC PUMPS

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Base-mounted pumps.
- 1.14 RELATED SECTIONS
  - A. Motor: Section 23 05 13.
  - B. Vibration-control supports: Section 23 05 48.
  - C. Variable frequency drives: Section 26 29 23.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Base-mounted pumps.
  - 1. Include description of all options and accessories.
- C. Include data verifying compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
- D. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, and sections, showing any changes in the wiring, arrangement, or access necessary to accommodate the unit furnished.
- E. Shop drawings shall show complete dimensions of complete assembled unit with accessories.
- F. Include wiring diagram showing factory and field wiring for each unit.

### 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.
- B. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

### PART 2 - PRODUCTS

- 2.01 ACCEPTABLE MANUFACTURERS
  - A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled product, or comparable product by one of the following:

- B. Base-mounted end-suction pumps
  - 1. Armstrong Pump Co.
  - 2. Aurora Pumps
  - 3. ITT Bell and Gossett
  - 4. Paco Pumps; Grundfos Group
  - 5. Patterson Pump Co.
  - 6. Taco Inc.
- 2.30 BASE-MOUNTED PUMPS, GENERAL
  - A. Pump shall have capacities and current characteristics as shown on the drawings.
  - B. Pumps shall be factory-assembled and -tested. Casings shall allow removal and replacement of impellers without disconnecting piping.
  - C. Motors: Comply with requirements of Section 23 05 13.
  - D. Pump seals shall be internally flushed (self-flushing) type:
    - 1. On closed circuits such as heating water, use mechanical seals.
    - 2. Mechanical seals shall consist of carbon steel rotating ring, stainless steel spring, ceramic seat, and flexible bellows and gasket rated for 250 degrees F (120 degrees C).
  - E. Pump couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment, complete with metal coupling guard. For pumps operating with variable-frequency drives, provide couplings suitable for variable-speed duty.
  - F. Mounting frame: Factory-welded frame and cross members, fabricated of steel channels and angles conforming to ASTM B 36. Fabricate for mounting pump casing, coupler guard, and motor. Grind welds smooth prior to application of factory finish. Mounting holes for field-installed motors shall be field-drilled.
  - G. Motor: Secure to mounting frame with adjustable alignment.

### 2.31 BASE-MOUNTED END-SUCTION PUMPS

- A. Taco FI Series, or Bell and Gossett 1510. Comply with general requirements for base-mounted pumps above.
- B. General description: Pumps shall be base-mounted, centrifugal, separately-coupled, endsuction, single-stage, bronze-fitted, vertical (radially) split-case design, and rated for 175 psig (1200 kPa) working pressure and 250 degrees F (120 degrees C) continuous water temperature.
- C. Casing construction: Cast iron, with flanged piping connections, and threaded gage tappings at inlet and outlet flange connections.

- D. Impeller construction: Statically and dynamically balanced, closed, single-suction, fabricated from cast bronze conforming to ASTM B 584, keyed to shaft and secured by a locking capscrew.
- E. Pump shaft and sleeve: Steel shaft, with bronze sleeve.
- F. Bearings: Ball.
- G. Provide suction diffuser with adjustable support foot, inlet connection to suit pipe size, outlet to suit pump suction size, angle-type body with inlet vanes, and stainless steel combination diffuser/strainer with 3/16-inch (4.8-mm) diameter openings. The flow direction shall be from inside to outside. Include disposable fine mesh bronze strainer.

### 2.35 DRIVE PROTECTION

A. Pumps shall be provided with guard over belt drive or flexible couplings as required by OSHA and MOSHA.

## PART 3 - EXECUTION

## 3.20 INSTALLATION

- A. Base-mounted pumps:
  - 1. On slab on grade, anchor to concrete equipment foundation.
  - 2. Section 23 05 48, Vibration Control Supports for HVAC.
  - 3. Set preliminary pump alignment and grout pump base.
  - 4. When grout is set and hardened, make final pump alignment.
- B. Provide balancing valves with a memory stop in discharge piping for setting proper flow and head.
- C. Provide check valves in discharge lines with non-slam spring-loaded type.
- D. Provide valves for isolating pump on both suction and discharge sides of each pump.

### 3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 23 05 00, provide operating instructions.
- B. Provide at least one hour of additional instruction time for the equipment specified in this section.

# END OF SECTION

#### SECTION 23 23 00 - REFRIGERANT PIPING

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Refrigerant piping and accessories for equipment in related sections.
- 1.14 RELATED SECTIONS
  - A. Piping materials and methods: Section 23 05 00.
  - B. Split-system air conditioning units: Section 23 81 27.
  - C. Variable-refrigerant-volume multizone system: Section 23 81 28.
  - D. Supports and insulation inserts: Section 23 05 29.

#### 1.26 DESIGN REQUIREMENTS

- A. Refrigerant piping shall be sized by the manufacturer of the refrigeration compressor, as specified in sections describing refrigeration equipment.
- B. Design pressures: Calculated in accordance with "System Design Pressure" in ASHRAE 15.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data:
  - 1. Piping, fittings, solder, flux, and pipe joint compound.
  - 2. Each type of valve, including materials, classifications, arrangement, dimensions and required clearances, and installation instructions.
  - 3. Each type of device and accessory.
- C. Shop drawings:
  - 1. Precharged tubing, including sizes and approximate lengths of lines.
  - 2. Built-up system piping diagram, including sizes, details, and accessories.
  - 3. Submit system design pressures for use in testing system. In accordance with the International Mechanical Code, "Field Test" for refrigeration systems, include the pressures listed on the condensing unit, compressor, or compressor unit nameplate, and the settings of pressure relief devices.
- D. Certifications: Provide certificate of field tests in a form acceptable to the authority having jurisdiction, as part of the permit and inspection records. Certificate shall include no less than:
  - 1. Name of refrigerant.
  - 2. Field test pressure applied to high and low sides of the system.

3. Signature and printed name of the installer.

#### PART 2 - PRODUCTS

- 2.10 MATERIAL
  - A. Refrigerant: As required by unit.
- 2.11 PIPING (PRECHARGED TUBING SYSTEM)
  - A. Refrigerant pipe: Precharged Type L soft drawn, preinsulated seamless copper tubing, ASTM B 280.
- 2.12 PIPE AND FITTINGS (BUILT-UP SYSTEMS)
  - A. Refrigerant pipe: ASTM B 280 Type ACR hard-drawn seamless copper tubing.
  - B. Fittings: Wrought copper, solder-joint type, ANSI B16.22. Flare fittings shall conform to SAE J513d.
- 2.13 ACCESSORIES (BUILT-UP SYSTEMS)
  - A. System: Provide the listed accessories as a minimum on each built-up system, in accordance with approved shop drawings. Items provided by the equipment manufacturer with the equipment are acceptable.
  - B. Brazing solder: Minimum 15 percent silver content.
  - C. Flux: Non-corrosive.
  - D. Stop valve: Refrigerant type globe valve, either packless or with sealed cap, UL listed. Connections: threaded, flared, or soldered. Valves meeting this specification are manufactured by the Henry Valve Company.
  - E. Charging valves: Packless globe-valve type, balanced action, solder outlet with male flare inlet, equal to Henry Type 623.
  - F. Expansion valves: Refrigerant type equal to products of Alco, Mueller, or Sporlan.
  - G. Solenoid valves: Rising-stem type.
  - H. Flexible connectors: Equal to Anaconda Series FY with a working pressure rating of 450 psi.(3,103 kPa), high tensile braid covering, and female ends compatible with copper tubing.
  - I. Sight glass: Equal to Sporlan "See-All" moisture indicating Type SA-ODF solder.
  - J. Filter-drier: Equal to Sporlan "Catch-All," with replaceable core of highly efficient desiccant that will not powder or pack.
  - K. Make threaded joints with pipe joint compound approved for the service, or "PTFE" tape.

# PART 3 - EXECUTION

### 3.20 INSTALLATION (PRECHARGED TUBING)

- A. Install piping as shown on drawings and in accordance with manufacturer's instructions and approved shop drawings.
- B. Provide hangers, supports, and insulation inserts as specified in Section 23 05 29.
- 3.21 INSTALLATION (BUILT-UP SYSTEM)
  - A. Drawings indicate routing of refrigerant piping. Install in accordance with approved shop drawings.
  - B. Install piping with all joints flared or brazed.
  - C. Install flexible connectors at condensing unit and at air-handling unit, unless flexibility is otherwise properly built into piping system.
  - D. Purge oil-pumped dry nitrogen through refrigerant piping while brazing to prevent scale forming inside the tubing. (To permit flow and to avoid pressure build-up, always make sure the other end of the line is open.)
  - E. Vent relief valves to the atmosphere in accordance with ASHRAE 15 and 34.
  - F. Provide system with charging valve, expansion device, moisture-indicating sight glass, filterdrier with three-valve bypass, and solenoid valve.
- 3.61 LEAK TEST
  - A. After the refrigeration systems have been installed, perform a leak test before evacuating the systems.
    - 1. The cylinder of oil-pumped nitrogen shall be equipped with a shutoff valve, pressure reducing valve, cylinder pressure gage, line pressure gage, and bleed valve.
  - B. Remove controls or relief valves which could be damaged by test pressures.
  - C. Separate the high side from the low side and bleed in enough refrigerant to raise the system pressure to 12 to 15 psig (83 to 103 kPa). Then, using oil-pumped dry nitrogen, raise the pressures to the test pressures established as required in "Submittals" in Part 1 above.
  - D. With the test pressures in the system, tap each connection sharply with a rubber or rawhide mallet.
  - E. Test the entire system for leaks.

- F. Bleed off the pressure into cylinders, in accordance with ASHRAE Guideline 3, and repair leaks. Do not attempt to repair a leak while the system is under pressure. Do not repair bad joints by remelting and adding more brazing material. Take joint apart, thoroughly clean, and remake as a new joint.
- G. Retest the system if a leak is found.
- H. When tests and repairs are complete, replace valves or controls removed for protection.
- I. Submit test certificate required in "Submittals" in Part 1 above.

### 3.64 EVACUATION

- A. To evacuate the system, use a vacuum pump capable of producing at least 1 mm (0.039 inches) mercury absolute vacuum. Proceed as follows:
  - 1. Connect an accurate high vacuum gage (Micron), such as a Stoke's or Zimmerli gage, to the system. Do not use compound gages.
  - 2. Connect the vacuum pump to both the high and low sides of the system. Leave the compressor suction and discharge valves closed. Evacuate the system to 2.5 mm (0.098 inches) mercury absolute. Keep ambient air temperatures above 60 degrees F (15.6 degrees C). during the evacuation process.
  - 3. Break the system vacuum with oil-pumped dry nitrogen. Open the compressor suction and discharge service valves and re-evacuate the system to 2.5 mm (0.098 inches) mercury absolute.
  - 4. After the system has been double evacuated to 2.5 mm (0.098 inches) mercury absolute, close the vacuum-pump suction valve and stop the pump. Allow the system to stand under a vacuum a minimum of 12 hours and recheck the vacuum. Notify the Architect in time for him to verify the test pressure at beginning and end of time limit, before proceeding to charge the system.

### 3.65 CHARGING

A. Charge the system with refrigerant through the liquid-line charging valve. Use a clean strainer-drier in the charging line, along with a pressure gage and shut-off valve to control pressures. Before starting the compressor, ascertain that the oil sight glass, if provided, is 75 percent full, and suction and discharge valves back-seated.

### 3.66 FINAL START-UP PROCEDURE

- A. Check out operating and safety controls in accordance with the compressor manufacturer's recommendations.
- B. Recheck the oil level in the sight glass at frequent intervals. It should not drop below 50 percent level.
- C. Adjust compressor suction unloaders, if provided, for proper evaporator-compressor balance to maintain the scheduled minimum discharge temperature.

D. Reinspect the system after it has been in normal operation for at least 72 hours. At this time, instruct the Owner in the operation and maintenance of the equipment, as required in the equipment section.

# 3.71 LUBRICATION

A. If it becomes necessary to add oil to the system, use only the oil recommended by the compressor manufacturer.

# **END OF SECTION**

### SECTION 23 25 00 - HVAC WATER TREATMENT

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Clean heating and cooling piping systems: Geothermal heat pump loop piping.
- B. Test water and provide chemical treatment.
- C. Provide supplies and maintenance for 2 years after the date of Substantial Completion.

### 1.14 RELATED SECTIONS

- A. Chemical feeder: Section 23 05 08.
- B. Heating and cooling piping: Section 23 21 13.

#### 1.27 PERFORMANCE REQUIREMENTS

- A. There shall be no chromates, polyphosphates, or heavy metals in the chemical formulation.
- B. Water treatment shall not in any way affect the life of any part of the water cooling or heating equipment, pipe, valves, fittings, and other appurtenances.
- C. Water treatment system shall introduce chemicals into each system only when the system is operating.
- D. Heat pump systems shall maintain these conditions:

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings: Chemicals proposed for each treated system, with calculations showing that treatment will produce the levels required in "Performance Requirements" above.
- C. Product data: Chemicals and concentrations proposed for system cleaning.
- D. Certifications: Qualifications of water treatment supplier, including:
  - 1. Names and qualifications of staff proposed to be assigned to the project.
  - 2. List of at least five projects meeting the requirements described in the article "Quality Assurance" below, each with name, address, and telephone number of contact person who can confirm satisfactory installation and operation of the system.
- E. Water analysis.

- F. Test reports required below for service visits. Submit one copy of each report directly to the Owner, and one to the Architect.
- 1.40 QUALITY ASSURANCE
  - A. Water treatment subcontractor shall supervise the cleaning of the piping systems and submit a certificate of compliance with the specification.
- 1.41 QUALIFICATIONS OF WATER TREATMENT SUBCONTRACTOR
  - A. Contractor shall engage and the Architect shall approve an independent water treatment subcontractor, who shall provide the water treatments specified in this section.
  - B. Is located in the Baltimore/Washington, DC, metropolitan area.
  - C. Is regularly engaged in providing and servicing systems of similar type and capacity to that installed on this project.
  - D. Has a record of at least five projects similar to this project in type and size, which have been in place and operating satisfactorily for at least 5 years.
  - E. Offers 24-hour emergency service.
  - F. Maintains locally an adequate stock of parts and supplies to service this system and equipment.
  - G. Has service contracts available.
- 1.60 PROJECT CONDITIONS
  - A. Obtain water analysis from the local agency supplying water to the site, or by a test.
- 1.91 MAINTENANCE SERVICE
  - A. For 2 years after Substantial Completion, test and maintain systems with monthly service calls. Provide chemicals and labor necessary to maintain each system's conditions as specified in "Performance Requirements."
  - B. Perform an analysis at the time of each visit, or within 72 hours at the firm's laboratory, and submit report as required in "Submittals."
  - C. During the final 30 days of the project 2-year service period, water treatment supplier's representative shall test each closed system.
    - 1. Make minor adjustments if required to correct chemical balance.
    - 2. If system conditions indicate significant leaks, notify Contractor. After piping corrections or repairs, adjust system chemical balance.

## PART 2 – PRODUCTS

#### 2.01 ACCEPTABLE SUPPLIERS AND MANUFACTURERS

- A. Water treatment system subcontractors:
  - 1. ARC Water Treatment Company, Inc.
  - 2. Ecolab (Water Management)
  - 3. Water Chemical Service, Inc.
  - 4. Olin Water Services

#### 2.10 MATERIALS

- A. For cleaning heating- and cooling-piping systems: Detergent, dispersant, and other required chemicals, in accordance with approved product data.
- B. For each system's chemical treatment: Chemicals in accordance with approved product data, to maintain the conditions specified in "Performance Requirements" above.

#### PART 3 - EXECUTION

#### 3.05 CLEANING PIPING SYSTEMS

- A. Before flushing and cleaning the system, isolate coils by closing valves to heating and cooling equipment, and open bypass valves.
- B. Flushing portions of the system:
  - 1. After a piping loop has been completed and prior to the installation of strainer baskets, flush that portion of the system. Connections shall be same size as piping being flushed, or one size smaller.
  - 2. When a major section of the building has been completed, repeat the same procedure, except that pipe connections shall be limited to NPS 1.5 (DN 40).
  - 3. Flushing shall remove sediment, scale, rust and other foreign substances.
  - 4. After flushing, install strainers and pressure-test system and repair leaks.
- C. Flushing building system: After various portions of the piping system have been tested and flushed and system is substantially completed, fill the system completely with water, venting all trapped air, and operating the pump.
  - 1. Open a drain at the system low point while replacing the water at the same rate.
  - 2. Continue flushing until clean water shows at the drain, but for not less than two hours.
  - 3. After flushing, remove strainers and clean and replace them.
- D. Chemical cleaning: Fill system with sufficient detergent and dispersant to remove dirt, oil, and grease.
  - 1. Circulate for at least 48 hours.
  - 2. Open a drain valve at the lowest point and bleed while the system continues to circulate. Assure that the automatic makeup valve is operating.

- 3. Continue until water runs clear and all chemicals are removed. Sample and test the water until pH is the same as pH of makeup water.
- 4. After chemical cleaning, remove strainers and clean and reinstall them.
- E. After flushing and cleaning the system, open valves to coils of heating and cooling equipment and close bypass valves.
- F. Submit certificate and test results.
- 3.22 INSTALLING CHEMICAL TREATMENT
  - A. Perform water analysis and submit recommended chemicals for treatment.
  - B. Using the chemical feeder specified in Section 23 05 08, HVAC Piping Specialties, install chemicals.
  - C. At the end of the project correction period, test the closed system and correct concentration of chemicals if required. Submit test and adjustment report.
- 3.81 OPERATING INSTRUCTIONS
  - A. As specified in Section 23 05 00, provide operating instructions.
  - B. Treatment representative shall start up equipment and instruct Owner's representative on its operation.

# **END OF SECTION**

### SECTION 23 31 13 - METAL DUCTS

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. HVAC supply, return, and exhaust metal ductwork and plenums in pressure classes from minus 2 to plus 10 inches wg (minus 500 to plus 2490 Pa).
- B. Single-wall round duct.
- C. Double-wall round duct.
- D. Rectangular double-wall duct.
- E. Insulated flexible ducts in HVAC systems.
- F. Special ductwork for kitchen canopies and kilns.
- G. Sealants.
- H. Acoustical lining.
- I. Duct leakage testing.
- 1.14 RELATED WORK SPECIFIED ELSEWHERE
  - A. Firestopping: Section 23 05 07.
  - B. Flashing ducts through roof: Section 23 05 06.
  - C. Insulation: Section 23 07 13.
  - D. Louvers and vents: Division 08.
  - E. Balancing: Section 23 05 93.

### 1.20 REFERENCES

- A. SMACNA HVAC DCS: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- B. SMACNA RIDCS: SMACNA Round Industrial Duct Construction Standards.
- C. SMACNA: HVAC Air Duct Leakage Test Manual.
- D. ASHRAE Handbook: Fundamentals.
- E. ASTM C 423: Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
- F. ASTM C 1071: Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).

- G. ASTM D 1330: Rubber Sheet Gaskets.
- H. ASTM G 21: Determining Resistance of Synthetic Polymeric Materials to Fungi.
- I. ASTM G 22: Determining Resistance of Synthetic Polymeric Materials to Bacteria.
- J. ACGIH-01: American Conference of Governmental Industrial Hygienists, Industrial Ventilation: A Manual of Recommended Practice.
- K. UL 181: Factory-Made Air Ducts and Air Connectors.

## 1.21 DEFINITIONS

- A. Seam: Joining of two longitudinal (parallel to the direction of airflow) edges of duct surface material. All other duct surface connections are joints.
- B. Joints: Transverse joints (perpendicular to the direction of airflow); branch and subbranch intersections; duct collar tap-ins; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

## 1.27 SYSTEM PERFORMANCE REQUIREMENTS

A. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Do not change the layout or configuration of the duct system except as specifically approved in writing. Accompany requests for modifications with calculations showing that the proposed design will provide the original design results without increasing the system total pressure.

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings:
  - 1. Schedule of duct systems with applicable pressure classes and leakage classes.
  - 2. Fabrication, assembly, and installation for each duct system: Indicate duct dimensions, sheet metal thickness, reinforcement spacing, and seam and joint construction; and components and attachments to other work.
  - 3. Calculations when required as specified in the article "System Performance Requirements" above.
  - 4. Include layout drawings for the entire ductwork system, drawn at the same scale as the contract drawings, except no smaller than 0.125 inch equals one foot.
  - 5. Schedule of sealing methods for each type of seam and joint.
- C. Product data:
  - 1. Hangers and supports.
  - 2. Manufactured ducts and fittings.
  - 3. Joint and sealing materials.
  - 4. Manufacturer's installation instructions.

- D. Test reports: Air Duct Leakage Test Summary: Submit data on forms as indicated in the SMACNA HVAC Duct Leakage Test Manual. (See sample form at end of section.)
- E. LEED Submittals: For adhesives, sealants and mastics applied within the building waterproofing envelope, documentation including printed statement of VOC content in g/L.

### 1.40 QUALITY ASSURANCE

- A. Specified and scheduled duct construction exceeds SMACNA requirements. Comply with specifications and schedules, and for materials or methods not specified or scheduled, comply with SMACNA HVAC DCS and RIDCS.
- B. Comply with NFPA 90A and 90B.

## PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design products: Subject to compliance with requirements, provide specified or noted products, or comparable product by one of the following:
  - 1. Manufactured ducts and fittings:
    - a. Eastern Sheet Metal
    - b. Hamlin Sheet Metal
    - c. LaPine Metal Products
    - d Lindab, Inc.
    - e. McGill Airflow Corp.
    - f. Semco Mfg. Inc.
    - g. SPIRAmir
  - 2. Manufactured joint connectors:
    - a. Ductmate Industries
    - b. Ward Duct Connector Industries
- B. Special use ducts and fittings: Scheduled manufacturers and named products are intended to set a standard for materials, quality of construction, and performance.

### 2.10 MATERIALS

- Galvanized steel sheets: Lock-forming quality, ASTM A 653/A 653M, coating designation G90 (Z275).
- B. Stainless steel sheets: ASTM A 480/A 480M, Type 304.
  - 1. Ducts exposed to view: No. 4 finish on exposed surface.
  - 2. Concealed ducts: No. 2B finish.

- C. Reinforcement shapes and plates: Galvanized steel where installed on galvanized sheet steel ducts; carbon steel on carbon steel ducts and compatible materials on aluminum and stainless steel ducts.
- D. Tie rods: Galvanized steel, minimum diameter 0.25 inch (6 mm) for ducts up to 36 inches (900 mm); 0.375 inch over 36 inches (900 mm).
- E. Vapor barrier: Polyethylene sheet, 6 mils (0.15 mm) thick, conforming to Federal Specification UU-P-147 for permeability.
- 2.11 JOINT AND SEALING MATERIALS
  - A. Flexible joint material for connections to vibrating equipment: Specified in Section 23 33 00, Duct Accessories.
  - B. Duct joint and seam sealants: UL classified, fire-resistive, conforming to NFPA 90A and 90B, high pressure type (up to 10 inches (2490 Pa) SMACNA pressure class) equal to the following products:
    - 1. Indoor application: Hardcast "Iron Grip" (IG-601) brush-on water-based vinyl acrylic sealing mastic.
    - 2. Outdoor application:
      - a. Hardcast "Versa-Grip" (VG-102) brush-on indoor/outdoor water-based polyester/synthetic resin sealant with UV inhibitors.
      - b. Hardcast "Aluma-Grip" (AFT-701) pressure sensitive sealant on a roll. Two-mil (0.05-mm) aluminum foil backing, peel-off release liner, 33-mil (0.8-mm) modified elastomeric butyl sealant (100 percent solids). To be used outdoors only.
    - 3. Flange gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.
  - C. Adhesives, sealants and mastics applied within the building waterproofing envelope. Comply with low-emitting requirements in Section 01 61 16.

# 2.12 CLOSED-CELL ACOUSTICAL LINING FOR RECTANGULAR DUCTWORK

- A. Fiber-free, closed cell, flexible foam acoustical insulation, ASTM C 1534; meeting requirements of NFPA 90A and 90B at specified thickness. Equal to K-Flex Duct Liner Gray or equal product by Armacell.
- B. Density: Nominal 2 lbs per cu ft (32 kg per cu m).
- C. Vapor transmission without jacketing: Less than 0.06 per inch.
- D. Thermal performance: 0.25 k-value at 75 degrees F.
- E. Resistance to microbial growth: Tested and shown to support no growth of the following:
  - 1. Fungi in accordance with ASTM G 21.
  - 2. Bacteria in accordance with ASTM G 22.

### F. Thickness:

- 1. Typical: One inch (25 mm) thick, ASTM C 423 (Type A mounting) noise reduction coefficient (NRC) at least 0.50.
- 2. Where indicated: Two inches (51 mm) thick, ASTM C 423 (Type A mounting) NRC at least 0.85.
- G. Adhesive for acoustical lining: LEED compliant, non-flammable elastomer contact adhesive designed for attaching closed cell insulation to sheet metal.

### 2.20 ROUND DUCTS AND FITTINGS

- A. Single-wall, spiral round duct and fittings: Equal to McGill Airflow "Uni-Seal" spiral duct with "Uni-form" fabricated fittings.
  - 1. Material: Galvanized steel.
  - 2. Fittings for branch connections shall be conical type. Centerline radius of elbows shall be 1.5 times the diameter. Duct access door shall be equal to type AR-W.
  - 3. Metal thickness:

Round Ducts	Steel Gage
Up to 14 inches diameter	26
15 through 26 inch diameter	24
27 through 36 inch diameter	22
37 through 50 inch diameter	20
51 through 60 inch diameter	18
61 inches and over	16 welded joints
Fittings up to 36 inch diameter	20
Fittings 37 to 50 inch diameter	18
Fittings 51 inches and over	16

- B. Single-wall, longitudinal-seam round duct and fittings: Fabricate of galvanized steel according to SMACNA HVAC DCS.
  - 1. Seam: Flat lock; snap-lock seam not permitted.
- C. Double-wall, insulated, spiral round duct and fittings: Equal to McGill Airflow Corporation "Acousti-K27." Dimensions indicated are outer dimensions of outer wall.
  - 1. Walls: galvanized steel, inner duct perforated (minimum 30 percent open area).
  - 2. Construction: Spiral lock seam.
  - 3. Insulation: Fiberglass blanket between the two walls, one inch (25 mm) thick.

### 2.21 RECTANGULAR DOUBLE-WALL DUCTS

- A. Equal to McGill Airflow "Rectangular-k27" with an outer shell, an inner liner, and insulation between.
- B. Thermal conductivity: 0.26 at 75 degrees F (0.037 at 24 degrees C) mean temperature.

- C. Outer shell: Galvanized steel, 22 gage, Pittsburgh lock construction, with "TDC" end connectors.
- D. Insulation: Fiberglass, coated to prevent particles from penetrating the fiberglass, resistance to microbial growth of fungi in accordance with ASTM G 21 and bacteria in accordance with ASTM G 22, maximum 1.5 pounds per cubic foot density, 1 inch thick unless otherwise noted on drawings.
- E. Inner liner: Perforated galvanized steel sheet, 22 gage, Pittsburgh lock construction.
- F. End connections: Manufactured joint connectors.

### 2.22 MANUFACTURED SPECIAL FLEXIBLE DUCTS AND FITTINGS

- A. Insulated flexible duct for HVAC systems: Factory pre-insulated, complying with NFPA 90A, listed as Class 1 air duct in conformance with UL 181, and UL rated for a positive pressure of 10 inches of water (2490 Pa) (through 18-inch (457-mm) size).
  - 1. Core: Non-metallic airtight polyester with galvanized wire helix.
  - 2. Insulation: Fiberglass blanket, 1.5 inches (38 mm) thick, 0.75 lb density, and k factor 0.28 at 75 degrees F (23.9 degrees C).
    - a. Vapor barrier: Aluminized and reinforced.
  - 3. Connections: Accessories required by manufacturer's published instructions.

### 2.24 HANGERS AND SUPPORTS

- A. Hangers: Galvanized sheet steel, or round, galvanized steel, threaded rod.
  - 1. Hangers installed in corrosive atmospheres: Electro-galvanized, all-thread rod; or hotdipped-galvanized rods with threads painted with zinc-rich paint after installation.
  - 2. Straps and rod sizes: Conform to SMACNA HVAC DCS for sheet steel width and gage and steel rod diameters.
- B. Duct attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

### 2.80 FABRICATION

- A. Dimensions indicated on drawings are outer dimensions of ducts. Dimensions indicated for double-wall ducts are outer dimensions of outer wall.
- B. Verify field measurements and resolve conflicts, before beginning to fabricate ductwork, as specified in Part 3 below.

### 2.81 DUCT CONSTRUCTION:

A. Construct ductwork using the Duct Construction Schedule on the drawings. Schedule includes duct system pressure class requirements, minimum sheet metal gages, leakage allowances, and

maximum reinforcement spacing. These requirements exceed the requirements of SMACNA HVAC DCS.

- B. Construct ductwork of galvanized steel, except where another material is noted on drawings or specified.
- C. Construct gravity duct systems (nonfan-powered), such as pressure relief and transfer, in accordance with SMACNA HVAC DCS minimum one inch pressure class unless otherwise scheduled.
- D. Crossbreak or bead ducts of dimensions of 12 inches (305 mm) and over in pressure classes under 2 inches (500 Pa).
- E. Plenums, casings, and access doors: Construct in accordance with SMACNA HVAC DCS.
  - 1. Casings and plenums for negative pressures greater than 3 inches wg (747 Pa): Construct in accordance with SMACNA RIDCS.
  - 2. Where casings and plenums are on the suction side of fans, and negative pressure which exceeds their construction class may occur, provide safety relief panels or dampers as indicated on drawings.
- F. Joint connections shall be constructed in accordance with SMACNA HVAC DCS, or with a manufactured duct connection system equal to Ductmate Industries "Ductmate," selected to assure compliance with leakage factors indicated on the drawings. Snap-lock or flat-lock seams are not acceptable.
- G. Engineered duct systems using metal gages or reinforcing less than required in the schedules on the drawings are not acceptable.
- H. Where not otherwise specified, scheduled, or detailed, construct ductwork in accordance with SMACNA HVAC DCS.
- PART 3 EXECUTION
- 3.20 INSTALLATION, GENERAL
  - A. Before fabricating ductwork, make field measurements and coordinate layout of ductwork shown on the drawings with building components and work of other trades. Resolve conflicts and obtain written approval for deviations before fabrication.
  - B. Provide duct systems complete with built-in accessories as specified herein, in other sections of the specifications, as indicated on the drawings, and, where not otherwise indicated, in accordance with SMACNA HVAC DCS.

### 3.21 INSTALLING METAL DUCTWORK

- A. Provide ductwork shown on drawings and specified herein.
- B. Ductwork shall not penetrate rated partitions where fire or smoke dampers are indicated on the drawings. Connect ductwork only after the damper installation is complete and accepted, as specified in Section 15820, Duct Accessories.

- C. Connecting duct to louver: Provide angles or damper collars as required. Slope duct down toward louver. Blank off any part of louver not required to be open, with double pan panels constructed of the same material as the connecting duct, 1.5 inches (38 mm) thick and insulated with 1.5 inches (38 mm) of fiberglass insulation. Seal connection.
- D. Install metal ductwork neat in appearance. Interior surfaces shall be smooth and free of obstructions. Duct lines shall be true and smooth. Where ducts pass through openings in partitions, ceilings and floors, fit them with trim angles to close joint between duct and construction.
- E. Support ductwork on metal straps or rods in accordance with SMACNA HVAC DCS and as specified. Comply with manufacturers' load ratings and application data for each type of support and fastener.
  - 1. Connections to substrate:
    - a. Bar joists: Suspend from top chord or panel points.
    - b. Concrete: Inserts or fasteners specified in Section, Hangers, Supports, and Anchors. Install inserts before placing concrete.
    - c. Structural steel: Beam clamps.
    - d. Do not support ductwork from gypsum roof deck supports or metal deck.
  - 2. Ducts 54 inches (1372 mm) wide and under: Strap hangers shall extend down sides of ducts and attach to underside with at least two sheet metal screws per strap. Straps shall be made of the same metal as the ducts they are attached to.
  - 3. Ducts over 54 inches (1372 mm) wide: Support on trapeze hangers formed of structural angle irons and hanger rods in accordance with SMACNA HVAC DCS.
  - 4. Round ducts: Support on rods or galvanized straps, and bands, as shown in SMACNA HVAC DCS and in accordance with manufacturer's recommendations.
  - 5. Support horizontal ducts within 2 feet (610 mm) of each elbow and within 4 feet (1220 mm) of each intersection, in addition to spacing required by SMACNA.
  - 6. Support vertical ducts at a maximum interval of 16 feet (4.9 m) and at each floor.
- F. Except in systems with minimum velocity standards, contractor has the option to eliminate reducing transitions and extend ductwork full size, providing space is available and conflict with work of other trades does not occur.
- G. Make bends and turns in ductwork using offsets and curved or square elbows as indicated on the drawings. Provide full radius elbows (centerline radius equals 1.5 times duct width). Provide turning vanes in square elbows, as specified in Section 15820, Duct Accessories. Make 90-degree branch duct connections using 45-degree entry fittings where indicated.
- H. Provide for and install in ductwork all automatic control systems dampers, thermometers, coils, duct accessories and similar equipment furnished under this or other sections of the specifications. Where ATC dampers with frames and other accessories are mounted in ductwork, the ducts shall connect to the accessory frame in manner to provide 100 percent free area for air passage. Seal duct connections to frames with gaskets or duct sealant. Secure connections with pop rivets or sheet metal screws spaced no more than 3 inches (75 mm) on centers around both sides of entire frame. Provide angle iron or channel frames as required for

mounting ATC dampers and manual dampers over weatherproof louvers for air intakes and exhaust.

- I. Generally, it is intended that all horizontal ductwork be a minimum of 10 inches (255 mm) above suspended ceiling (where applicable) to allow for removal of ceiling panels and ceiling-mounted light fixtures and devices.
- J. Large ductwork in mechanical equipment rooms, such as outdoor air, return air, and exhaust air duct connections to fans, air handling units, plenums, and appurtenances, shall be sufficiently braced with angle irons to prevent vibration and duct damage, and to reduce noise level.
- K. Assemble round ducts and fittings using duct sealant and sheet metal screws as recommended by the manufacturer.
- L. Flashing of ducts through outside walls shall be as detailed on the drawings.
- M. Where noted on the plumbing drawings, provide stainless-steel sheet metal drain troughs under piping.
- 3.22 INSTALLING ROUND DUCT
  - A. Single-wall: Single-wall, spiral duct and fittings.
    - 1. Exception: Single-wall, longitudinal-seam duct is permitted where concealed, in systems of 2 inches wg pressure class or less, for connections to individual air outlets.
  - B. Double-wall: Where double-wall duct is indicated, provide double-wall, insulated spiral duct and fittings.

### 3.23 SEALING DUCTWORK

- A. Ducts shall be sealed so that they meet leakage factors scheduled on the drawings.
- B. Prior to sealing, ductwork shall be clean and dry, free of oil or grease.
- C. Apply sealant in accordance with the manufacturer's recommendations.
- D. Product application:
  - 1. Galvanized steel: Brush-on or pressure sensitive sealant, as applicable.
- E. Allow time for sealant to dry or cure, in accordance with manufacturer's recommendations, before leak testing.

### 3.24 INSTALLING INSULATED FLEXIBLE DUCT (HVAC SYSTEMS)

A. Provide insulated flexible duct where shown on drawings. Install fully extended and route as directly as possible to supply outlets. Lengths shall not exceed 5 feet.

- B. Lay out bends and turns with the longest practicable radius, as a minimum exceeding SMACNA standards for radius of rigid duct radius elbows. Ends shall extend straight for at least 6 inches before beginning of bend.
- C. Connections: Coat at least 3 inches inside the end of the flexible duct core with duct sealant, install over the rigid duct, and secure with a duct clamp. After replacing the insulation and vapor barrier, secure with another duct clamp.
- D. Support flexible duct in accordance with the manufacturer's recommendations or SMACNA DCS, whichever is more stringent.
- 3.25 INSTALLING KITCHEN CANOPY EXHAUST DUCTWORK (NON-GREASE APPLICATIONS)
  - A. Kitchen canopy exhaust ducts shall be fabricated of stainless-steel, all welded construction, and seams ground smooth (where exposed).
  - B. Kitchen canopy exhaust duct shall extend to top of roof curb.
- 3.28 INSTALLING KILN EXHAUST DUCTWORK
  - A. Fabricate from stainless steel with continuously welded joints and seams ground smooth.
  - B. Minimum gage: 18, except where heavier gage is scheduled on drawings.

### 3.59 IDENTIFICATION

- A. Mark ductwork in accordance with requirements for identification specified in Section 23 05 00, Common Work Results for HVAC.
- 3.61 AIR DUCT LEAKAGE TESTS
  - A. Leakage test procedures shall be in accordance with SMACNA Leakage Test Manual.
  - B. After installation and prior to insulating, test the ductwork for air leakage. Ducts to be tested, test pressures, and leakage factors (maximum volume of leakage per 100 sq ft (9.3 sq m) of duct surface area) shall be as scheduled on the drawings.
  - C. Conduct tests before any equipment is connected that would be subject to damage from the test pressure. Provide temporary blank-offs or caps.
  - D. Notify parties whose presence is necessary for the test; and in all cases, the Architect and testing and balancing subcontractor at least two normal work days prior to the actual test.
  - E. While system is under test pressure, survey joints for audible leaks. Mark leakage points, shut down blower, and make repairs. Retest after duct sealant has dried or cured.
  - F. If test duct sections exceed the allotted leakage levels, locate sources of leakage, make repairs and repeat test procedures until acceptable leakage levels are demonstrated.
  - G. During the installation, continuously examine ductwork to ascertain that it is sealed properly.

# 3.75 CLEANING DUCT SURFACES

A. Where ducts will be exposed and therefore are required to be painted, remove labels used for construction and clean surfaces ready for painting.

## **END OF SECTION** Leakage test form follows Section

 PROJECT NAME
 PROJECT NO.

AIR SYSTEM \_\_\_\_\_

FAN CFM (Q) \_\_\_\_\_

AIR DUCT LEAKAGE TEST SUMMARY

LEAKAGE CLASS (GL)

SPECIFIED TEST PRESSURE (Pt)

DUCT CONSTRUCTION PRESSURE CLASS (P<sub>c</sub>)

DESIGN DATA FIELD TEST DATA RECORD DIAMETER PRESSURE "W.G. ALLOWABLE LEAKAGE SURFACE CFM **SUBJECT** AREA IN (TEST PERFORMED WITNESSED ACTUAL DUCT  $FT^2$ SECTION) DATE BY BY CFM \*\*\*\* TOTAL \*\*\*\* \*\*\* \*\* \*\*\*\*\* \*\*\*\* \*\*\*\* SYSTEM TEST SECTION(S)

PAGE \_\_\_\_\_ OF \_\_\_\_\_

### SECTION 23 33 00 - DUCT ACCESSORIES

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Products and devices installed in ducts.
- B. Flexible joint fabric.
- C. Bird screen.
- D. Volume extractors.
- E. Instrument test holes.
- F. Air turning vanes.
- G. Spin-in or dovetail fittings.
- H. Duct access doors.
- I. Dampers.
- J. Fire and smoke dampers.
- K. Duct clamps.
- 1.14 RELATED SECTIONS
  - A. Access doors: Section 23 05 03.
  - B. Louvers and Vents: Division 08.
  - C. Duct-mounted smoke detectors: Section 28 31 00.
  - D. Diffusers, registers, and grilles: Section 23 37 13.
  - E. Damper actuators: Automatic temperature control sections.

#### 1.20 REFERENCES

- A. AMCA 210: Laboratory Methods of Testing Fans for Rating.
- B. ASTM E 477: Test for Measurement of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
- C. NFPA 90A: Installation of Air Conditioning and Ventilating System.
- D. NFPA 90B: Installation of Warm Air Heating and Air-Conditioning Systems.

- E. SMACNA-05: Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
- F. SMACNA HVAC DCS: HVAC Duct Construction Standards, Metal and Flexible.
- G. UL 555: Fire Dampers.
- H. UL 555S: Smoke Dampers.

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Each type of duct accessory included in the project.
  - 1. Include manufacturer's written installation instructions for each type of fire damper.
- C. Shop drawings: Detail equipment assemblies and indicate dimensions, loadings, required clearances, method of field assembly, components, locations, and size of each field connection. Detail these accessories:
  - 1. Special fittings and manual and automatic volume damper installations.
  - 2. Fire and smoke damper installations, including sleeves and duct access doors and panels.
- D. Certifications: Certified test data for dynamic insertion loss; sound power levels; airflow performance data, and static-pressure loss.

# 1.40 QUALITY ASSURANCE

- A. Work of this section shall comply with NFPA 90A and 90B, and SMACNA HVAC DCS.
- 1.92 EXTRA MATERIALS
  - A. Provide one spare link for every four fire dampers installed in the project, with a minimum of two of each type.
  - B. Deliver and store spare links in the cabinet for spare automatic sprinklers, or as directed by the Owner.

# PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturers' names and specific products are described in the articles below to set a standard for materials, quality of construction, options and details, and performance. Provide named products, or equal products by other named manufacturers.

### 2.10 MATERIALS

A. Sheet metal: As specified in Section 23 31 13.
- B. Flexible joint fabric: Woven glass fabric with coating, complying with UL 214 for fire retardance and NFPA 90A for use in duct systems.
  - 1. For use indoors: Equal to Ventfabrics "Ventglas," coated with polychloroprene (DuPont "Neoprene"), 30 ounces per square yard (850 g per 0.8 square meter).
  - 2. For use outdoors: Equal to Ventfabrics "Ventlon," coated with DuPont weather-, sunlightand ozone-resistant "Hypalon," 26 ounces per square yard (732 g per 0.8 square meter).
- C. Bird screen: ASTM E 2016, general industrial-use wire cloth, Grade C, medium light or heavier, nominal 0.5-inch (13-mm) mesh and 0.063-inch (1.6-mm) wire diameter, aluminum or stainless steel.
  - 1. Frame: Removable, rewirable, of same material and finish as the duct or accessory to which it is installed.

# 2.20 MANUFACTURED UNITS

- A. Volume extractors: Equal to Hart & Cooley "Vectrol" Type AVLR, with the equal to Young Regulator Co. No. 429 FD end bearing and No. 443-B 3/8-inch operator; or Type VLK, with worm-driven mechanism accessible through face of diffuser or grille with an 18-inch-long removable key operator.
- B. Instrument test holes for ductwork balancing stations: Equal to Ventfabrics "Ventlock" No. 699 or 699-2 as required for insulation thickness, with gasket for base, and threaded cap.
- C. Air turning vanes: Double vane type, constructed in accordance with SMACNA HVAC DCS, from the same material as the duct.
- D. Spin-in or dovetail fittings in accordance with SMACNA HVAC DCS are acceptable for a round take-off connection from a rectangular duct, provided they meet the duct pressure classification.

# 2.21 DUCT ACCESS DOORS

- A. SMACNA standard construction, Air Balance, Inc., Model FSA-100-H or equal by Ruskin, Inc., Airstream Products Company, Inc., or Commercial Acoustics. Access doors to fire protection devices shall comply with NFPA 90A.
- B. Construction: Door and frame fabricated of 24 gage galvanized steel, minimum size 16 inches (406 mm) by 16 inches (406 mm), or 16 inches (406 mm) by maximum duct size.
- C. Door: Hinged with continuous piano hinge; number of cam latches to suit door size. Insulated doors shall be double pan construction, one inch (25 mm) thick with one inch (25 mm) thick minimum 3.5 pound (56 kg per cubic meter) density fiberglass insulation cut full to require forcing into the pan.
- D. Gaskets: Continuous around perimeter, sealing frame to duct and door to frame, neoprene or foam rubber.

E. As an option, provide round access doors equal to Ventfabrics "Ventlok Twist-In" doors, complete with safety holding cable, 12 inches (305 mm) diameter.

# 2.25 DAMPERS

- A. Where aluminum duct is required by the specifications, dampers shall be all aluminum construction.
- B. Manual volume dampers:
  - 1. 13 inches (330 mm) and larger in height: Balanced multi-louver, opposed-blade type with maximum blade width of 6 inches (155 mm), equal to Ruskin Model MD 35 with corrosion resistant, molded synthetic sleeve type bearing and 0.375-inch (9.5-mm) square control shaft; and with Young Regulator Co. Model No. 443B-3/8 damper regulators designed with 2-inch high base for mounting on externally insulated duct.
  - 12 inches (305 mm) or less in height: Fabricated from 16 gage metal with hemmed edges, 0.375-inch (9.5-mm) square rod, Young Regulator Co. Model No. 443B-3/8 regulator designed with 2-inch high base for mounting on externally insulated duct and Model No. 429 FD end bearing.
- C. Pressure relief or static pressure-control counterbalanced backdraft dampers: Equal to Ruskin Type CBS-4 fabricated with steel channel frame with 0.3125-inch (7.9-mm) mounting holes. Blades shall be 14 gage aluminum with polyurethane foam seals on edges, maximum width 10 inches, mounted on a steel shaft with "oilite" bearings. Individual blades shall be adjustable for final setting in the field. Frame shall have a rust-inhibitive coating applied at the factory.
- D. Counterbalanced backdraft dampers for use in fan discharge: Equal to Ruskin Type CBS-7 fabricated with galvanized steel channel frame with 0.3125-inch (7.9-mm) mounting holes. Blades shall be 16 gage galvanized steel, maximum width 10 inches (255 mm), mounted on a steel shaft with ball bearings. Individual blades shall be connected together to work in unison. Frame shall have a rust-inhibitive coating applied at the factory.

# 2.26 FIRE DAMPERS

- A. Fire dampers shall comply with NFPA 90A and applicable building and fire code requirements. Fire dampers shall be equal to the models specified below, and UL 555 labeled for use in static systems.
- B. Dampers connected to ducts: Size and configuration suitable to the connected duct.
- C. Material, blades and frame: Galvanized sheet steel, no less than 0.064 inch (1.62 mm) thick.
- D. Blades: Folding, with 100-percent interlocking joints to form a continuous steel curtain when closed.
  - 1. Joints: 180 degrees of free movement.
  - 2. Operator: Constant-force, stainless-steel spring for horizontal applications.
- E. Fusible links: Replaceable, 165 degrees F (74 degrees C) rated.

- F. Sleeves: Galvanized sheet steel no less than 0.052 inch (1.3 mm) thick; length to suit wall or floor application; sleeves, angles, and methods of fastening meeting requirements of manufacturer's UL-approved installation instructions.
- G. Ratings and frame types: Equal to Air Balance Inc. 119 Series for use in 1-1/2 -hour rated assemblies and 319 Series for use in 3-hour rated assemblies.
  - 1. Dampers in rated partitions between nonducted transfer grilles, or dampers terminating at a ducted wall grille or register: Type A frame, installed within or behind grille or register, access by removal of grille or register.
  - 2. Dampers connected to supply air ductwork: 100 percent free opening, Type C frame with welded-seam housing.
  - 3. Dampers connected to return air or exhaust air ducts: 90 percent free opening, Type B frame with welded-seam housing.

# 2.28 FIRE/SMOKE AND SMOKE DAMPERS

- A. Equal to Ruskin Model FSD-60, low-leakage type.
- B. Ratings:
  - 1. Combination Fire and Smoke Dampers:
    - a. Fire resistance in accordance with UL 555 no less than 1.5 hours.
    - b. Leakage in accordance with UL Standard 555S no higher than Leakage Class I (4 cfm per square foot at one inch wg).
    - c. Rated for use in static systems.
  - 2. Smoke Dampers: Same as combination dampers, except need not be rated for fire resistance.
- C. Double-skin airfoil-shaped blades, with a pressure loss of not more than 0.1 inch wg in full-open position at damper-face velocity of 2000 fpm (based on 36-inch by 36-inch damper).
- D. Sleeve: Furnish each damper complete with factory sleeve of length and gage required for satisfactory installation.
- E. Operator: Elevated temperature category B (250 degrees F (121 degrees C)) damper operator, electric or pneumatic as required by control system, factory-installed on exterior of sleeve and properly linked to damper operating shaft.
  - 1. Type: Spring-return fail-closed that will close damper upon power or pressure interruption.
  - 2. Ratings: Listed and labeled in accordance with UL 555 or 555S as fire or smoke damper operators as required by rating of damper.
  - 3. Coordinate damper operator sizing and voltage requirements with manufacturer.

# 2.70 ACCESSORIES

- A. Duct clamps for flexible duct and flexible fabric connections: Positive locking drawbands able to conform to any shape. Fabricate from a single piece of galvanized steel, with zinc-plated steel screw and buckle. Equal to "59 Series" manufactured by Ideal Division, Parker Hannifin Corporation.
- B. Nonmetallic duct clamps for flexible duct and flexible fabric connections: Heavy-duty adjustable type equal to products of Tyton Corporation, for 12-inch (305-mm) diameter and smaller flexible ductwork, complying with UL 181.
- C. Instrument test holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments, and length to suit duct insulation thickness.

# PART 3 - EXECUTION

#### 3.20 INSTALLATION, GENERAL

A. Duct accessories shall be mounted or installed properly in accordance with the manufacturer's instructions and as indicated on the drawings.

#### 3.21 INSTALLING CONNECTIONS AND SCREENS

- A. Flexible connections: Install where duct connects to motor-driven equipment, and in other locations shown on drawings. Securely clamp flexible connection to duct and collar with duct clamps, providing 1 inch (25 mm) slack. Stitch seams with fiberglass thread.
  - 1. Nonmetallic clamps: Install in accordance with manufacturer's recommendations, using manufacturer's special tools.
  - 2. Flexible connections are not required where duct connects to air-handling equipment with internally isolated fans.
- B. Install bird screen in outdoor air connections.

# 3.22 INSTALLING MANUFACTURED UNITS

- A. Provide necessary devices to balance the air flow to produce air quantities at outlets as indicated on the drawings.
- B. Provide balancing point stations where required for air balancing. Coordinate work with requirements of Section 23 05 93, Testing, Adjusting, and Balancing; final locations shall be as directed by the balancing and testing subcontractor. Stations shall consist of test holes spaced 6 inches (150 mm) on centers across bottom or side of duct. Install test holes before ducts are insulated.
- C. Provide turning vanes in 90-degree square elbows.
- D. Provide spin-in or dovetail fittings as indicated on the drawings.

- E. Installing duct access doors:
  - 1. Install duct access doors in ductwork for access to fire dampers, smoke dampers, ATC dampers, controls, vortex dampers, duct coils, control devices, and any other devices, equipment, or components requiring maintenance, service, or adjustment and located inside ducts or adjacent equipment.
  - 2. Provide OSHA-approved labels on doors enclosing fire protection devices. Labels shall have lettering at least 1/2 inch (13 mm) high describing the protection device enclosed.
- F. Installing air control devices:
  - 1. Install manual volume dampers, volume extractors, and other devices at locations indicated on drawings and where required to properly balance the systems and to deliver the air quantities indicated. Each damper and device shall have substantial operators of proper size with locking facilities. Volume dampers shall be equipped with locking type regulators.
  - 2. Install automatic control dampers.

# 3.23 INSTALLING FIRE AND SMOKE DAMPERS

- A. Fire and smoke dampers are an integral part of the rated partition or floor being penetrated. Install sleeves and dampers before beginning installation of the duct system being connected. Do not begin installing ducts until rated assembly, including installed dampers, has been completed.
- B. Install fire and smoke dampers where indicated and in accordance with the applicable requirements of the following:
  - 1. Details on drawings.
  - 2. NFPA requirements.
  - 3. Local building code.
  - 4. Manufacturer's UL-approved installation instructions.
  - 5. SMACNA-05.
- C. Install fire and smoke dampers in sleeves. Coordinate with other trades to properly frame openings so that damper and sleeve assembly can be secured in partition or floor.
  - 1. Do not use dampers and sleeves as a lintel for supporting the wall above the damper. Provide separate steel angles on both sides of wall or floor slab to hold damper and sleeve firmly in place.
  - 2. Sleeve thickness and retaining angle size are contingent on type of duct connection, duct size and damper manufacturer's requirements. See SMACNA recommendations and NFPA requirements.
- D. Coordinate voltages with manufacturer of motorized dampers.

E. After damper installation is complete and required ductwork connected, test operation of damper by releasing holding mechanism to see that damper operates freely and properly and closes tight. Make adjustments if required and reset holding mechanism.

# **END OF SECTION**

#### SECTION 23 34 00 - HVAC FANS

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Exhaust fan.
  - B. Accessories.

#### 1.14 RELATED SECTIONS

- A. Curbs: Section 23 05 06.
- B. Motors: Section 23 05 13.
- C. Roof-mounted gravity ventilators: Section 23 37 23.
- D. Variable frequency drives: Section 26 29 23.
- E. Controls: Sections 23 09 01 through 23 09 23.

# 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Reports of specified factory tests.
- C. Product data: Include rated capacities of each unit, weights (shipping, installed, and operating), furnished specialties, accessories, and the following:
  - 1. Certified fan performance curves with system operating conditions indicated. Include static pressure, brake horsepower, and static efficiency plotted against air volume.
  - 2. Certified fan sound power ratings.
  - 3. Motor ratings and electrical characteristics, and motor and electrical accessories.
  - 4. Material gages and finishes, including color charts.
  - 5. Dampers, including housings, linkages, and operators.
- D. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed and field-installed wiring.
- E. Maintenance data as required in Division 01 and Section 23 01 01.
- F. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

# 1.40 QUALITY ASSURANCE

- A. Fans shall be tested and rated in accordance with the applicable AMCA Standard Test Code and Certified Rating Program and bear AMCA Certified Air Rating Seal.
- B. Fan selections shall be made to the right of the peak static pressure point, but not on any "flat" portion of the fan curve. Generally, fan selection shall be in the 50 percent to 80 percent range of wide open volume.
- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
- D. UL label and local testing (if required): Section 23 05 00, Common Work Results for HVAC.

# 1.71 COORDINATION

A. Coordinate the installation of roof curbs, supports, and roof penetrations. Fan installation shall not reduce weathertightness of roof nor violate roof warranty.

# 1.91 EXTRA MATERIALS

A. Provide adjustments in drives and sheaves and belts as required at time of system balancing to obtain the airflow and static pressure indicated on drawings.

# PART 2 - PRODUCTS

# 2.30 FANS, GENERAL

- A. Fan size, capacity, class, arrangement, accessories and discharge shall be as scheduled on the drawings.
- B. Motors shall meet the requirements of Section 23 05 13, Common Motor Requirements for HVAC Equipment, including power factor and efficiency.
- C. The variable frequency controller shall be a variable frequency drive (VFD) as specified in Section 26 29 23, Variable Frequency Drives. Coordinate to ensure the fan wheel is balanced at all operating speeds. Ensure that unit is free of surge or vibrations due to harmonic frequencies.
- D. Belt drives and exposed rotating shafts shall be provided with guards meeting OSHA and MOSHA requirements.
- E. Fans shall have self-aligning, ball-type bearings designed for thrust load, and grease fittings shall be accessible for relubrication. Fans shall be statically and dynamically balanced.
- F. Motors for belt-driven units shall have adjustable variably pitched cast iron sheaves to allow a 10 percent increase or reduction in speed. Belts shall be sized for minimum 150 percent brake horsepower (bhp).
  - 1. Include one change in drive sheave for each unit if necessary to obtain correct air quantities at time of testing, adjusting, and balancing.

# 2.34 EXHAUST FANS

- A. Basis-of-design product: Subject to compliance with requirements, provide scheduled product, or comparable product by one of the following:
  - 1. Greenheck Fans.
  - 2. Jennco Fan.
  - 3. Loren Cook, Inc.
  - 4. Penn Barry.
  - 5 Twin City.
  - 6. ACME Engineering and Manufacturing.
  - 7. Aerovent, a Twin City Fan Company
- B. Roof centrifugal ventilator: Fan wheels shall be of the centrifugal backward curved nonoverloading airfoil design, direct or V-belt drive as scheduled. Fan wheel and fan housing shall be of all-aluminum construction, with motor and drive assembly located out of exhaust airstream in separate compartment that is forced-air-cooled with outdoor air. Exposed fasteners shall be stainless steel. Fan shaft and hub shall be zinc-phosphate coated.
- C. Roof upblast centrifugal ventilator: Fan wheels shall be of the centrifugal backward-inclined non-overloading airfoil design, direct or belt drive as scheduled. Fan wheel and fan housing shall be of all-aluminum upblast construction, with motor and drive assembly located out of exhaust airstream in separate compartment that is forced-air-cooled with outdoor air. Exposed fasteners shall be stainless steel. Fan shaft and hub shall be zinc-phosphate coated.

# 2.70 ACCESSORIES

- A. Bird screens: Specified in Section 23 33 00, Duct Accessories.
- B. A disconnecting switch without overload protection shall be included under the weather hood of roof-mounted units, completely factory-wired to motor. Motors for directly driven units shall be provided with solid-state variable speed control where scheduled on the drawings.
- C. Provide each unit with self-operating aluminum backdraft damper and frame unless indicated otherwise on the drawings. Damper blades shall operate in unison and shall be counterbalanced or otherwise provided with facilities to positively open under fan suction and to close tight when subject to backdraft.
- D. Identification: Each fan shall be identified with a fan number no less than 0.5 inch high, as shown in the fan schedule, on an aluminum strip riveted to hood of roof fans and on the motor side of frame for wall fans.
- E. Where called for on the drawings, provide explosion-proof motors with explosion-proof toggle disconnects.

# PART 3 - EXECUTION

# 3.20 INSTALLATION, EXHAUST FANS

- A. Fans shall be installed in compliance with the manufacturer's recommendations.
- B. Roof fans shall be attached to side of roof curbs using 3/16-inch (4.8-mm) cadmium-plated bolts and nuts or screws, as required, on a maximum of 8-inch (205-mm) centers and a minimum of 8 bolts or screws per fan unit. Use 1-inch minimum diameter aluminum washers with stainless-steel lockwashers under bolt or screw heads.
- C. Coordinate with air balancing and provide adjustments, sheaves, and belts as required in Part 1 above to obtain the airflow and static pressure indicated on the drawings.

#### 3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 23 05 00, provide operating instructions.
- B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

# END OF SECTION

# SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Ceiling- and wall-mounted diffusers, registers, and grilles.
- 1.14 RELATED SECTIONS
  - A. Louvers: Division 10.
  - B. Fire and smoke dampers: Section 23 33 00.
  - C. Automatic control dampers: Section 23 09 07.
  - D. Balancing: Section 23 05 93.

# 1.20 REFERENCES

A. NFPA 90A: Standard for the Installation of Air-Conditioning and Ventilating Systems.

# 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Each type of diffuser, register and damper, and grille, including frames and accessories, and performance data.
- C. Shop drawings:
  - 1. Schedule, including size, location, function, and finish of each diffuser, register, and grille.
  - 2. For each air control device, provide information required to balance the system. Include the factor for each size and type of device for converting velocity to volume.
    - a. Include this information in Operating and Maintenance Manuals.
- D. Samples: Manufacturer's complete line of color chips for anodized aluminum linear grilles and diffusers.

#### PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

- A. Grilles, registers and diffusers:
  - 1. Hart and Cooley Inc.
  - 2. Krueger.
  - 3. Metalaire.
  - 4. Nailor Industries, Inc.

- 5. Price Company.
- 6. Titus Products.
- B. Thermally powered variable air volume diffuser:
  - 1. Accutherm
  - 2. Rickard

# 2.21 DIFFUSERS, REGISTERS, AND GRILLES

- A. Devices of one of the named manufacturers, with performance data, characteristics, features, and accessories of the model or type specified or indicated on the drawings. Model numbers specified below are Krueger except as noted otherwise.
- B. See architectural drawings for type of walls and ceilings where diffusers, grilles, and registers are required. Coordinate margin and frame of each device with the substrate in which it will be installed. Where devices are installed in suspended ceilings, assure that they will fit correctly in the type of suspension supports shown or specified.
- C. Materials and finish:
  - 1. Construction:
    - a. Steel where mounted in ceilings.
    - b. Either aluminum or steel where mounted in walls near ceiling.
    - c. Heavy-duty steel where mounted in walls near floor.
    - d. Welded or mechanically fastened cores in diffusers located in gymnasium.
  - 2. Aluminum devices shall be all aluminum construction, including dampers, where specifications call for aluminum or stainless steel ductwork.
  - 3. Finish: Manufacturer's standard white enamel, suitable for final finish or for field painting, unless indicated otherwise.
- D. Provide stainless-steel safety cables to diffusers to prevent the face of each diffuser from falling during removal.

# 2.22 SUPPLY DIFFUSERS

- A. Throw length is based on performance data of the scheduled or specified manufacturer and model. Select units of other manufacturers whose performance data meet the required conditions. Throw direction of square and rectangular ceiling diffusers shall be four-way unless otherwise indicated on the drawings.
- B. Square and rectangular ceiling diffusers: Series SH with square, rectangular, or round neck and removable core. Each unit shall have a straightening grid. The grids and dampers shall be set at right angles to one another.
  - 1. Frame Style 23 (panel diffuser): Diffusers mounted in nominal 24 by 24-inch (600 by 600-mm) or 24 by 48-inch (600 by 1200-mm) flat steel panels as indicated on the drawings, to lay into suspended ceiling grid of acoustical ceilings.

- 2. Frame Style 22 (surface mount): Diffuser with flat frame to mount at underside of plaster or gypsum wallboard ceilings.
- C. Round, adjustable diffuser with round neck: RA2 series, surface-mounted frame, 360 degree discharge with infinitely field-adjustable vane settings for discharge pattern from vertical to horizontal, combination air extractor/damper and grid with concealed adjustment, duct-mounted straightening grid (shipped loose for field installation). Provide safety cables to inner cones to prevent from falling during removal.
- D. Linear slot diffusers: Series 1900 with size of slot and number of slots as indicated on drawings. Adjustable blades, for volume and air direction control, shall be furnished behind active supply sections in each slot opening. Blades and internal surfaces exposed to view shall be painted black. Provide surface mounting with positive holding concealed fasteners. Provide alignment tabs in frame where multiple units are joined, and mitered corners at 90 degree turns.
- E. Thermally powered variable air volume diffuser: Equal to Acutherm "ThermaFuser" model TF-HC, diffuser opened and closed by mechanical temperature-sensitive devices to increase or decrease the ducted air supply, for both cooling and heating.
  - 1. Thermal elements: Two room temperature sensing elements and one changeover element. Room temperature settings for both heating and cooling shall be separately field adjustable.
    - a. Element which responds to heating requirements shall be biased to offset stratification.
    - b. Changeover element shall be factory set to engage the heating mode at 81 degrees F and the cooling mode at 70 degrees F, and shall not extend above the neck of the diffuser.
  - 2. Each unit shall have 66 linear inches of discharge area around its perimeter.
  - 3. Factory test each unit.

# 2.23 SUPPLY GRILLES AND REGISTERS

- A. For registers, provide opposed-blade dampers with linkage and adjustment through grille face with a screwdriver or allen wrench. For plaster wall or ceiling construction, provide with plaster frames.
- B. Wall-mounted near ceiling: Grilles 880H (steel) 5880H (aluminum); registers 880H-OBD (steel) 5880H (aluminum); double deflection with horizontal face bars, minimum 1.25-inch (32-mm) overlap margin.
- C. Ceiling-mounted: Register 5180-OBD (aluminum) 180-OBD (steel), individually adjustable curved air deflection blades, 1-, 2-, 3-, or 4-way air pattern as indicated on the drawings, minimum 1.25-inch (32-mm) overlap margin.

# 2.24 RETURN AND EXHAUST GRILLES AND REGISTERS

- A. For registers, provide opposed-blade dampers with linkage and adjustment through grille face with a screwdriver or allen wrench. For plaster wall or ceiling construction, provide with plaster frames.
- B. Ceiling-mounted and wall-mounted near ceiling: Grille S-80H (steel) or S-580H (aluminum), Register S-80H-OBD (steel) or S-580H (aluminum). Fixed horizontal face bars set at 35 to 45 degrees deflection, minimum 1.25-inch (32-mm) margin.
- C. Wall-mounted near floor: Grille S-480-H, register S-480-H-OBD, heavy-duty steel construction, 14 gage fixed horizontal face bars set at 30 to 40 degrees deflection, spaced on 0.5 to 0.7-inch (13 to 18-mm) centers, and 14 gage vertical support bars on maximum 8-inch centers, minimum 1.25-inch (32-mm) margin.

# 2.25 TRANSFER GRILLES

- A. Ceiling-mounted and wall-mounted near ceiling: S80H (steel) or S-580H (aluminum), fixed horizontal face bars set at 35 to 45 degrees deflection, minimum 1.25-inch margin.
- B. Wall-mounted near floor: S-480-H (steel), heavy duty, 14 gage fixed horizontal bars set at 30 to 40 degrees deflection, spaced on 0.5- to 0.7-inch (13 to 18-mm) centers, and 14 gage vertical support bars on maximum 8-inch (205-mm) centers, minimum, (32-mm) margin.

# PART 3 - EXECUTION

# 3.21 INSTALLING GRILLES, REGISTERS AND DIFFUSERS

- A. Securely attach grilles, registers, and diffusers in place. Do not install the grilles and registers until duct interiors have been painted as specified in Section 23 05 00, Common Work Results for HVAC.
- B. Install all air control devices complete with the accessories specified, securely attached in position. Make operating devices accessible.
- C. Adjust diffuser straightening grids to provide uniform air distribution above diffuser face.
- D. Adjust supply register deflectors to provide uniform air distribution to the areas served.

# END OF SECTION

# SECTION 23 37 23 - ROOF-MOUNTED GRAVITY VENTILATORS

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Roof-mounted gravity ventilators, connected to HVAC system, for intake or relief.
- 1.14 RELATED SECTIONS
  - A. Curb: Section 23 05 06.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: For each type of ventilator included in the work. Include construction details, materials, dimensions and profiles, and finishes.
- C. Shop drawings: Show complete dimensions of complete assembled unit with accessories, including dimensions and configuration as required to coordinate with framing and bracing roof structure and deck.
- D. Samples: For color selection, submit chips showing manufacturer's complete line of colors. Color will be selected to match other roof-mounted equipment.

# PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

- A. Scheduled units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 23 01 01, and submit shop drawings as specified in article 1.30 above.
  - 1. Acme Engineering and Manufacturing Co.
  - 2. Greenheck Fan
  - 3. Jenn Fan Division, Breident
  - 4. Loren Cook Co.
  - 5. Penn Barry.

#### 2.30 VENTILATORS, GENERAL

- A. Material: All aluminum, with aluminum bird screen installed vertically over the opening.
- B. Construction: All welded, or riveted and welded.
- C. Free area: Such that air pressure drop will not exceed 0.05 inches at 500 fpm.
- D. Finish: Aluminum.

# 2.31 VENTILATOR TYPES

- A. Rectangular, low-silhouette, relief ventilators: Equal to Loren Cook VR, Acme EV, or Penn "Airette."
- B. Rectangular low-silhouette, intake ventilators: Equal to Loren Cook VI, Acme IV, or Penn "Airette."

## PART 3 - EXECUTION

#### 3.20 INSTALLATION

- A. General: Comply with manufacturer's written instructions. Coordinate installation of roof accessories with installation of roof deck, roof insulation, flashing, roofing membranes, penetrations, equipment, and other construction involving roof accessories to ensure that each element of the work performs properly and that combined elements are waterproof and weathertight. Anchor roof accessories securely to supporting structural substrates so they are capable of withstanding lateral and thermal stresses, and inward and outward loading pressures.
- B. Install roof accessory items according to construction details of NRCA's "Roofing and Waterproofing Manual," unless otherwise indicated.
- C. Separation: Separate metal from incompatible metal or corrosive substrates, including wood, by coating concealed surfaces, at locations of contact, with bituminous coating or providing other permanent separation.
- D. Securely install to the sides of roof curb using 0.1875 inch cadmium-plated bolts and nuts or screws, no more than 12 inches (305 mm) on centers, with a minimum of 8 bolts or screws per unit. Use aluminum washers with stainless-steel lockwashers under bolt or screw heads.
- E. Cap flashing: Where required as component of accessory, install cap flashing to provide waterproof overlap with roofing or roof flashing (as counterflashing). Seal overlap with thick bead of mastic sealant.
- F. Operational units: Test-operate units with operable components. Clean and lubricate joints and hardware. Adjust for proper operation.

# 3.75 CLEANING AND PROTECTION

A. Clean exposed surfaces according to manufacturer's written instructions. Touch up damaged metal coatings.

# **END OF SECTION**

# SECTION 23 41 00 - PARTICULATE AIR FILTRATION

#### PART 1 - GENERAL

## 1.10 SUMMARY

- A. Filters for temporary service during construction are required in the equipment sections, including changes required to meet the requirements of Indoor Air Quality Management in Division 01.
- B. Provide two sets of filters for every item of equipment requiring filters, as follows:
  - 1. Filters for regular service, installed before air balancing.
  - 2. Filters for regular service, provided as extra materials for future use.

#### 1.14 RELATED SECTIONS

- A. Heat pumps: Section 23 81 46.
- B. Ductless split-system units: Section 23 81 27.
- C. Unit heaters: Section 23 82 38.
- D. Energy recovery and dedicated outdoor air units: Section 23 72 00.
- E. Variable-refrigerant-volume multizone system: Section 23 81 28.
- F. Electric resistance terminal units: Section 23 82 38.
- 1.20 REFERENCES
  - A. ASHRAE 52.1: Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter.
  - B. ASHRAE 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
  - C. ARI 850: Commercial and Industrial Air Filter Equipment.
- 1.21 DEFINITIONS
  - A. MERV: Minimum Efficiency Reporting Value as determined by ASHRAE 52.2.
  - B. Temporary service: Operation of equipment during the construction period, before air balancing.
  - C. Regular Service: Operation of equipment during air balancing and in normal use during occupancy.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data:
  - 1. For filters, include filter ratings, rated flow capacity, and fire classification.
- C. Closeout submittals: As required for Operating and Maintenance Manuals in Division 01 and Section 15010, provide a schedule of locations of filters, identifying equipment and filter types and sizes, including prefilters and final filters.
- D. LEED Submittals:
  - 1. Product data for Credit IEQ 3 and IEQ 5: For filter media installed during construction and prior to occupancy, documentation indicating MERV rating.

# 1.40 QUALITY ASSURANCE

- A. Provide all filters for regular service from a single manufacturer.
- B. Test filters by methods described in ASHRAE 52.1 and ASHRAE 52.2.
- C. Comply with ARI 850.

# 1.92 EXTRA MATERIALS

- A. Disposable and throwaway filters: For each filter included for regular service, provide one extra filter. Identify each filter with its name and intended location and use.
- B. Provide filters and media in protective packaging, with identifying labels or markings.
- C. Except as otherwise required in Division 01, deliver to location designated by Owner, and shelve or stack as directed.

# PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design products: Subject to compliance with requirements, provide specified or scheduled products, or comparable product by one of the following:
  - 1. Filters:
    - 1. AAF International.
    - 2. Camfil Farr
    - 3. Continental Air Filter (Div. NiCon Filter Corp)
    - 4. Flanders Filters, Inc.

# 2.20 FILTERS, GENERAL

- A. Coordinate with approved manufacturers of the various approved air handling units and equipment for filter size and thickness required.
- B. Thickness: Generally, large air handling units shall have filters 2 inches and more thick. Smaller units such as fan-coil units may be limited to filters 2 inches thick.
- C. Filter face areas: As scheduled, or equivalent to one square foot for each 300 cfm.
- 2.21 THROWAWAY FILTERS
  - A. FS F-F-310, Type I throwaway frame and media, Grade B high dust holding capacity, of size and thickness to fit units.
- 2.22 DISPOSABLE FILTERS, MERV 8
  - A. Camfil Farr "Aeropleat IV", Class 2, thickness 1 and 2 inches, and size required for each location, disposable.
  - B. Rating in accordance with ASHRAE 52.1:
    - 1. Average efficiency: 25 to 30 percent.
    - 2. Average arrestance: 90 to 92 percent.
  - C. Rating in accordance with ASHRAE 52.2: MERV 8.
  - D. UL 900: Class 2.
  - E. Medium: Non-woven, reinforced cotton and synthetic fabric, pleated.
  - F. Medium support grid: Welded wire with an effective open area not less than 96 percent, bonded to medium.
    - 1. Performance: Medium shall not oscillate nor pull away from support grid.
    - 2. Design: Tapered radial pleats, supporting medium both vertically and horizontally.
  - G. Enclosing frame: High-wet-strength beverage board, with diagonal supports bonded to media pleats. Filter pack continuously bonded to inside of frame so that no air leaks around edges.
- 2.25 DISPOSABLE FILTERS , MERV 13
  - A. Camfil Farr "OPTI-PAC" high-performance, deep-pleated, 4-inch deep disposable type. Each filter assembly shall consist of a high-performance filter, medium retainer, holding frame, and sealer frame.
  - B. Medium: Microfine glass fiber reinforced with a laminated synthetic backing.
  - C. Rating in accordance with ASHRAE 52.1: Average efficiency 80-85 percent, and average arrestance not less than 98 percent.

- D. Rating in accordance with ASHRAE 52.2: MERV 13.
- E. The effective filter medium area shall not be less than 20 sq ft per 1000 cfm. Initial resistance at that rating shall not exceed 0.5 inch wg.
- F. UL 900: Class 2.

# PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Before startup of each item of equipment requiring a filter, install filters for temporary service.
    - 1. Generally, provide throwaway filters for temporary service.
    - 2. On equipment with prefilter and final filter, provide only the specified prefilter for temporary service.
  - B. Immediately prior to air balancing, remove temporary filters and install filters required for regular service.

# END OF SECTION

#### SECTION 23 72 00 - ENERGY RECOVERY AND DEDICATED OUTDOOR-AIR UNITS

### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Custom- and packaged-type outdoor-air-handling units with energy recovery, installed indoors and outdoors.
  - B. Custom -type units: DOAS-1, -2, and ERU-1, -2.
  - C. Packaged-type units: DOAS-3.
- 1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION
  - A. Disconnects for units: Division 26.

# 1.14 RELATED SECTIONS

- A. Divisions 01 and 23 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
- B. Refrigeration service: Section 23 01 00.
- C. Roof curbs: Section 23 05 06.
- D. Vibration isolation: Section 23 05 48.
- E. Efficiency and power factor of motors: Section 23 05 13.
- F. Filters: Section 23 41 00.
- G. Variable frequency drives: Section 26 29 23.
- H. Controls: Sections 23 09 01 through 23 09 23.
- I. Ground heat exchanger on piping system: Section 23 21 16.

# 1.20 REFERENCES

- A. ARI 410: Forced-circulation Air-cooling and Air-heating Coils.
- B. ARI 430: Central Station Air-Handling Units.
- C. ARI 1060: Rating Air-to-Air Energy Recovery Ventilation Equipment.

#### 1.21 DEFINITIONS

A. ATC: Automatic temperature controls (ATC), also referred to as "Energy Management Systems (EMS)."

- B. ATC contractor: Automatic temperature controls sub-contractor.
- C. DX: Direct expansion.
- D. DOAS: Dedicated outdoor-air unit.
- E. ERU: Energy recovery unit.
- 1.25 CONTROL SYSTEMS DESCRIPTION
  - A. Unit manufacturer shall provide packaged controls for unit operation, temperature control functions, and safety devices.
    - 1. Provide weatherproof enclosure on unit for the manufacturer's microprocessor based controller. Controller shall be complete with display and keypad. Minimum display size shall be 6-inch by 6-inch.

# 1.27 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under "Acceptable Manufacturers," below, ascertain that it will:
  - 1. Perform to the scheduled and specified capacities.
  - 2. Make no additional demands on other systems such as heat pump water, or electricity.
  - 3. Meet or exceed specified requirements.

# 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. LEED Criteria: Submit data verifying that the materials meet the LEED requirements. LEED information must be provided for materials to be reviewed and "Application for Payment" to be reviewed and certified.
- C. Unit manufacturer shall provide a detailed control sequence covering all modes of operation.
- D. Manufacturer's control coordination confirmation: Prior to submission of equipment shop drawings, manufacturer shall provide a letter of confirmation to verify that control requirements have been coordinated with the ATC contractor.
- E. ATC contractor submittals shall be prepared and submitted after all HVAC equipment submittals have been approved and shall incorporate the approved equipment submittals into the ATC contractor submittals.
- F. Shop drawings: Wiring diagrams prepared for this installation, including factory and field wiring of units, accessories, and equipment.

- 1. Indicate controls for all equipment, including those that are furnished by the manufacturer and clearly identify the furnished controls between manufacturer and ATC contractor, and wiring between factory and field installed.
- G. Product data: Each type of unit and each component, including manufacturer's installation instructions.
- H. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing laboratory.
- I. Certifications: Factory test reports, including test of casing insertion loss performance.
- J. Service agreement specified in "Maintenance Service" below, executed to the Owner and notarized.

# 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 23 01 01, Common Work Results for HVAC. Each unit shall be UL listed.
- B. Comply with requirements for LEED certifications specified in Division 01.
- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
- D. ATC contractor shall provide all necessary efforts to assure that equipment for the project are furnished with controls required for the sequences specified via combination of manufacturers' controls, ATC contractors' furnished controls and control devices, and hardwire interfaces.
- E. Make fan selections to the right of the peak static pressure point and not on any flat portion of the fan curve. Generally, fan selection shall be in the 50 to 80 percent range of wide open volume.
- F. Provide OSHA-approved fan drive guard where required.
- G. Unit operation:
  - 1. Refrigerant circuit shall operate at specified minimum ambient temperature, flow, and water temperature conditions.
  - 2. Unit shall start and operate within scheduled tolerance of nameplate voltage.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Follow manufacturer's instructions for protecting units during shipping, storage, and handling.
  - B. Protect coils and pipe connections with temporary covering until the unit is installed.

# 1.81 SPECIAL WARRANTY

A. In addition to general project warranty and correction period, provide manufacturer's special warranties.

- 1. Compressors shall be warranted for five years, as specified in Section 23 01 00.
- 2. Refrigeration circuits shall be warranted for 5 years to include the total cost of repairs on labor, parts, and refrigerant. Refer to warranty in Section 23 01 00.
- 3. Enthalpy type energy recovery wheels and heat exchangers shall be warranted for 5 years on all wheel, cartridge, and drive components. Warranty shall include total cost of repairs and/or replacement, including both labor and parts.

# 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Divisions 01 and 23 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

# 1.91 EXTRA MATERIALS

A. Filters: Refer to Section 23 41 00.

# PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

- A. Scheduled units are the basis for design of the project. The manufacturers listed also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 15010, and submit shop drawings and product data as specified in Part 1 above.
  - 1. Custom-type units:
    - a. Munters, Des Champs Technology
    - b. Engineered Air
    - c. Innovent
    - d. Xetex
    - e. Venmar
    - f. Annexair
  - 2. Packaged-type units (DOAS-3 only):
    - a. Aaon
    - b. Addison
    - c. Valent
- B. Comply with requirements of Article 1.27 above.

# 2.21 DEDICATED OUTDOOR-AIR AND ENERGY RECOVERY UNITS

A. Fans and coils shall be removable without dismantling the structural framing.

- B. Weatherproof construction for outdoor units:
  - 1. Roof sloped no less than 0.25 inch in one foot.
  - 2. Base adaptable for installation on roof curb where mounted outdoors and on concrete pad where mounted indoors.
- C. Base: Welded structural steel channel with integral steel lifting lugs, with manufacturer's standard primer and industrial enamel finish.
- D. Casing: Two-inch double walls, galvanized steel.
  - 1. Nonloadbearing panels: Exterior 18 gauge and interior 22 gauge.
  - 2. Loadbearing panels: Exterior 16 gauge and interior 18 gauge.
  - 3. Roof: Standing-seam construction.
  - 4. Insulation: Walls, floor, and roof, 2 inches thick, completely enclosed in panel construction, fiberglass no less than 1.5 lbs/cu ft density.
  - 5. Access doors: Same construction as walls, insulated, with stainless-steel piano hinges, at least two compression latches, and minimum 24 inches clear opening width.
    - a. Supply and exhaust air streams shall not be covered by a single door.
    - b. Provide access to filters, fans, heat exchangers, and other areas requiring access for maintenance.
  - 6. Finish: Interior and exterior galvanized G90. Exterior finished with 1.5-mil industrial enamel shown to withstand ASTM B 117 salt spray test for a minimum of 500 hours with no deterioration.
    - a. Provide unit in a factory custom painted finish with color to be selected by architect.
  - 7. Drain pans: Sealed, double wall, constructed of minimum 18-gage galvanized steel exterior and minimum 18-gage stainless steel interior. Fill space between exterior and interior walls with insulation.
    - a. Slope: Drain pans shall be sloped in 2 planes no less than 0.25 inch in one foot; cross break interior pans and pitch toward drain connections; ensure complete, positive condensate drainage.
    - b. Cooling coils and energy recovery coils shall have drain pans under the entire coil module.
    - c. Connections shall be to the side of the unit and shall enable proper trapping.
- E. Unit controller enclosure: Weatherproof enclosure mounted on the exterior of the unit casing to provide protection and access to all controllers and microprocessors with displays and keypads. All displays shall be a minimum of 6-inch by 6-inch.

# 2.22 NON-ENTHALPIC TYPE PLATE AND FRAME HEAT EXCHANGERS

A. Crossflow or counterflow type plate and frame heat exchangers with performance as scheduled on the drawings, rated in accordance with ARI 1060.

- B. Maximum operating differential pressure: No less than 10 inches wg at 70 degrees F across heat exchanger.
- C. Maximum operating temperature: No less than 400 degrees F.
- D. Construction:
  - 1. Aluminum frame and 99.5 percent pure aluminum plates no less than 0.008 inch thick.
  - 2. Entire heat exchanger surface shall be visible for inspection and cleaning without disassembling the heat exchanger.
  - 3. Drain pans: Under entire heat exchanger, terminated through the side of the unit and properly trapped, in accordance with the manufacturers recommendations.

# 2.23 ENTHALPIC TYPE PLATE AND FRAME HEAT EXCHANGER

- A. Product shall be equal to dPoint Technologies enthalpy type plate exchanger. Device shall be capable of transferring both sensible and latent energy between the outdoor and exhaust airflow streams.
- B. Heat exchanger shall be AHRI 1060 certified, flame proof, UL 723 compliant with a maximum flame spread index of 25 and a maximum smoke index of 50, and include the following:
  - 1. Cross-flow or counter cross-flow core orientation, with no moving parts.
  - 2. Water washable for removal of dust and contaminants.
  - 3. Aluminum frame, including both aluminum end plates and aluminum side rails.
- C. Device shall be suitable for operating temperatures ranging between minus 30 degrees C to plus 60 degrees C, without freezing or a decrease in thermal performance.

# 2.24 ENTHALPY TYPE ENERGY RECOVERY WHEEL (DOAS-3 ONLY)

- A. Certified thermal performance in accordance with ASHRAE Standard 84 and ARI 1060.
- B. Construction: Lightweight polymer substrate with permanently-bonded silica gel desiccant.
- C. Media: Full-removable, slide-out cassette oriented at a 90-degree angle to unit base. Cassette shall include all seals, drive motor, and drive belt. Individual pie-shaped wheel sections shall be removable from cassette.
- D. Wheel bearings: L-10 life in excess of 200,000 hours.
- E. Rim: Continuously rolled stainless steel and connected to the shaft through taper locks.
- F. Latent energy transfer: Entirely in vapor phase.
- G. Enthalpy wheel motor shall meet the requirements of Section 22 05 13 and suitable for use with variable frequency drive controllers.

#### 2.25 BLOWER AND MOTOR

- A. Unhoused plenum fans: Airfoil centrifugal type, designed for industrial duty and continuous operation, performance based on testing in accordance with AMCA 210, single-width, single-inlet, Arrangement 4-direct drive fans, sizes and capacities as scheduled on the drawings.
  - 1. Impeller diameters: Comply with the recommendations of AMCA 99.
  - 2. Blades: Hollow airfoil, double skin welded to the center and wheel-side plates.
  - 3. Hubs: Cast or welded, with straight bores and keyways, screwed to the shaft with no fewer than two set screws.
  - 4. Wheels: Statically and dynamically balanced.
  - 5. Shafts: Solid AISI 1040 or 1045 steel; straight; turned, ground and polished to minimum 16 micro-inch finish; sized to run at a minimum of 20 percent greater fan speed than the maximum in accordance with the AMCA Class.
  - 6. Bearings: Pillow block, self-aligning, ball or roller type, grease lubricated, minimum L-10 life of 40,000 hours. Both bearings shall be of the same bore, type, and manufacturer; one shall be fixed. Provide lubrication lines extended to the drive side of the fan.
  - 7. Inlet cones: Steel, formed by spinning; aerodynamically matched to the wheel side plate to provide streamlined air flow to the wheel and fully load the blades; securely attached to the wheel.
  - 8. Provide discharge safety cages and inlet screens.
- B. Motors: TEFC with NEMA frame and 1.15 service factor, suitable for use with variable frequency drives, complying with requirements of Section 23 05 13.
  - 1. Motor brake hp shall not exceed scheduled values.
  - 2. Fan brake hp shall not exceed 85 percent of motor brake hp.
- C. Drives: Provide a variable frequency drive (VFD) for each fan, complying with requirement of Section 26 29 23. Mount VFD's in a ventilated unit compartment accessible from the outside of the unit.
  - 1. All units shall be direct driven.
- D. Blower/motor assembly shall be mounted on a unitary base with spring isolators with two inch static deflection.

#### 2.26 DAMPERS

- A. Motorized low-leakage dampers with galvanized steel frame, formed galvanized steel blades, vinyl edge seals, metal jamb seals, and stainless-steel bearings.
  - 1. Outdoor air minimum damper: Airflow measuring, opposed-blade type, modulating actuator (energy recovery units only).
  - 2. Outdoor air maximum damper: Opposed-blade type, modulating actuator (energy recovery units only).
  - 3. Return air damper: Opposed-blade type, modulating actuator (energy recovery units only).
  - 4. Exhaust air minimum/maximum damper: Opposed-blade type, modulating actuator (energy recovery units only).
  - 5. Recirculation damper: Opposed-blade type, two position actuator.

- 6. Exhaust air damper: Opposed-blade type, two position actuator.
- 7. Outdoor air damper(s): Opposed-blade type, two position activator.

# 2.27 WATER-SOURCE HEAT PUMP

- A. Air/refrigerant (cooling) coil: Provide ARI rated coil with 0.02 inch thick seamless copper tubes and 0.0075 inch thick aluminum fins, pressure tested and guaranteed for 250 psi working pressure. Provide stainless steel IAQ drain pan under the coil extending past the coil to ensure condensate retention. Coil connection shall be complete with all required valves and devices installed by unit manufacturer.
- B. Integral water source heat pump system: Provide integral water source heat pump system factory piped, wired, charged, and tested. Entire heat pump section shall be assembled by the unit manufacturer.
  - 1. Integral water source heat pump system consisting of: Hermetic scroll compressors, air/refrigerant (cooling) coil, water-to-refrigerant heat exchangers, 4-way reversing valve, suction accumulator, line filter-driers, sump heaters. Furnish water flow valves, valve actuators, and interlocks with instructions for field installation.
  - 2. Minimum number of compressors per unit shall be as scheduled on the drawings. Provide an independent refrigerant, circuit for each compressor. Tandem compressors are not acceptable.
  - 3. Provide a factory insulated coaxial water to refrigerant heat exchanger for each compressor.
  - 4. Independent circuits shall be provided completely tested, dehydrated, and fully charged with refrigerant and oil. Provide refrigerant HFC-410A only.
  - 5. Provide minimum one digital scroll or variable speed compressor for each unit.
  - 6. Electric unit heater: Provide a 3 kW fan forced electric heater with thermostat to maintain the heat pump section above freezing during winter design conditions.
  - 7. Provide sound attenuation through the use of compressor blankets for each compressor.
- C. Head pressure control valves shall be 2-way configuration; fail safe, open to heat exchanger; factory installed and piped by manufacturer to a single-point connection at internal pipe chase. Factory piping shall include all required manufacturer accessories, in addition to those detailed on drawings.
- D. Microprocessor based refrigeration system control and safeties with display and keypad for alarm history, diagnostics, and other critical features; provided by the manufacturer. Locate microprocessor within control enclosure external to the unit or in compressor compartment.
  - 1. Controllers shall display and hold 25 or more alarms and display all details of alarms (times, date codes, etc.).

# 2.29 MODULATING HOT-GAS REHEAT COIL

- A. Reheat coil separated from evaporator coil by a minimum of 6 inches in the direction of airflow.
- B. Coil: ARI tested and certified for a 250 psi working pressure.
- C. Coil casing: 16 gage galvanized steel.

- D. Coil tubes: 0.375-inch diameter; 0.016-inch seamless copper tubes.
- E. Fins: Constructed of 0.0060-inch aluminum fins.
- F. Control: Factory-supplied modulating control valve.

# 2.30 FILTERS

- A. Provide temporary throwaway filters for use until disposable filters are installed for regular service.
- B. For regular service, provide filter banks for 2-inch-thick Merv 8 filters and 4-inch-thick Merv 13 filters at the outside air inlet of the heat exchanger, mounted in side-access slide racks.
- C. For regular service, provide filter bank for 2-inch-thick Merv 8 filters at the exhaust air inlet of the heat exchanger, mounted in a side-access slide rack.

# 2.31 ELECTRICAL SYSTEM

- A. Wiring: Meeting requirements of NFPA 70, unit factory-wired with a single-point power connection for normal operation. Unit wiring in liquidtight conduit. Entire unit shall be ETL listed, and each major component shall be UL listed.
  - 1. Provide programming to allow supply and exhaust fans, gas heating system, electric unit heater, and controls to operate on emergency power.
- B. Provide remote disconnect, fan motor starters and phase protectors, contactors, control transformer, control circuit fusing, service switch, and terminal block.
- C. Control panel: NEMA 250 Type 3R.
  - 1. Display panels shall be installed in main control panel.
  - 2. Display units: English with temperature display in Fahrenheit.
- D. Factory tests shall include test of wiring system.

# 2.32 SYSTEM CONTROLS

- A. System of factory-provided manufacturer's packaged direct digital temperature controls with electronic actuation, to perform as indicated on the automatic temperature control drawings. Manufacturer's controls shall be provided with BACnet protocol for interface with the DDC system.
- B. Unit manufacturer shall provide devices indicated on the drawings with at least the following features listed below. All devices shall meet the requirements of Sections 23 09 01 through 23 09 23.
  - 1. Supply fan with current sensing relay.
  - 2. Exhaust fan with current sensing relay.
  - 3. Damper actuators.

- 4. Temperature, humidity, and carbon dioxide sensors.
- 5. Economizer controls.
- 6. Modulating hot-gas reheat control.
- 7. Energy recovery wheel operation.
- 8. BACnet compatible microprocessor based controls complete with ATC terminal contacts for unit enable/disable, occupied/unoccupied, and general alarm.
- 9. Control power transformer.
- 10. Refrigeration cycle controls.
- 11. Refrigerant safety controls.
- 12. Head pressure control valves and associated control devices, factory-installed and piped to a single-point piping connection.
- C. EMS contractor shall provide:
  - 1. Field-wiring and -mounting of control instruments as required to accomplish manufacturers packaged sequence of operation.
  - 2. Mounting and wiring of factory-provided devices, including duct smoke detectors, and emergency fan disconnect switch.
  - 3. Signal indicating occupied, unoccupied, and safety/emergency controls.
- D. Manufacturers packaged controls:
  - 1. Manufacturer provided microprocessor based controller preprogrammed for unit operation, discharge temperature and humidity control, and unit safety control functions. Provide BACnet protocol for non-hard-wire interface (when permitted) with DDC system.
  - 2. Signal to enable/disable unit operation and place the unit into occupied/unoccupied modes of operation shall be provided through hardware interface with DDC system. Provide hardwire contacts for general alarm output to DDC system.

# 2.33 SEQUENCE OF OPERATION – DEDICATED OUTDOOR AIR SYSEMS (DOAS-1 THROUGH DOAS-3)

- A. General: Unit operation shall be enabled and disabled by respective zone DDC occupiedunoccupied schedule.
- B. Morning warm-up cycle:
  - a. Unit shall be deenergized throughout the morning warm-up cycle.
- C. Occupied cycle:
  - 1. Recirculation damper shall be proven closed throughout the occupied cycle.
  - 2. OA and EA dampers shall be proven open prior to energizing supply and exhaust fans.
  - 3. Unit supply and exhaust fans shall be energized and run continuously throughout the occupied cycle.
  - 4. Enthalpy wheel operation (DOAS-3 only):
    - a. Enthalpy wheel energized, then the EA damper shall modulate to maintain the unit discharge temperature setpoint, subject to an adjustable low limit enthalpy wheel EA discharge temperature setpoint (initial low limit temperature setpoint shall be 10

degrees F). OA bypass damper shall be closed. When the low limit temperature is reached, OA damper shall modulate under control of this low limit setpoint until this condition is eliminated.

- 5. DX coil control:
  - a. OA below 55 degrees F: Cooling operation shall be disabled. Reversing valves shall be positioned for heating and compressors shall be staged and cycle to maintain a unit discharge temperature of 72 degrees F. Compressors shall not be staged on until water flow is detected by the ATC flow switch. Manufacturer's head pressure control valve shall modulate to match compressor operation.
  - b. OA between 55 and 72 degrees F: Reversing valve shall be positioned to either heating or cooling and compressors shall be staged and cycle to maintain a unit discharge temperature of 72 degrees F, subject to a maximum entering coil dewpoint of 55 degrees F. On a rise in entering coil dewpoint above 55 degrees F, unit shall be placed into dehumidification mode. Compressors shall be staged and cycle to maintain a leaving coil temperature of 55 degrees F during dehumidification. For DOAS-3, hot gas reheat coil shall modulate under dehumidification mode to maintain the discharge air temperature setpoint. Compressors shall not be staged on until water flow is detected by the ATC flow switch. Manufacturer's head pressure control valve shall modulate to match compressor operation. Compressor operation shall be subject to a 50 degree F low-limit leaving coil temperature or a 60 degree F low-limit supply air temperature.
  - c. OA above 72 degrees F: Heating operation shall be disabled. Reversing valve shall be positioned for cooling and compressors shall be staged and cycle to maintain a unit discharge temperature of 72 degrees F, subject to a maximum entering coil dewpoint of 55 degrees F. On a rise in entering coil dewpoint above 55 degrees F, unit shall be placed into dehumidification mode. Compressors shall be staged and cycle to maintain a leaving coil temperature of 55 degrees F during dehumidification. For DOAS-3, hot gas reheat coil shall modulate under dehumidification mode to maintain the discharge air temperature setpoint. Compressors shall not be staged on until water flow is detected by the ATC flow switch. Manufacturer's head pressure control valve shall modulate to match compressor operation. Compressor operation shall be subject to a 50 degree F low-limit leaving coil temperature or a 60 degree F low-limit supply air temperature.
- 6. Hot gas reheat coil control (DOAS-3 only):
  - a. When system is operating in dehumidification mode: Hot gas reheat coil shall modulate under its packaged controls to maintain a unit discharge temperature of 72 degrees F.
  - b. When system is operating in heating or cooling modes: Hot gas reheat coil operation shall be disabled.
- D. Unoccupied cycle:
  - 1. Recirculation damper shall be open throughout the unoccupied cycle.
  - 2. OA and EA dampers shall be closed throughout the unoccupied cycle.
  - 3. Unit supply and exhaust fans shall be deenergized and unit shall be placed into the unoccupied mode of operation.

- 4. On a rise in space humidity above 60 percent RH, as sensed by the DDC room humidity sensor, unit shall be temporarily energized through a signal from the DDC system and operate in unoccupied dehumidification mode (with bypass damper open, exhaust fan deenergized, and EA/OA dampers closed) to maintain the unit manufacturer's exhaust air humidistat setpoint, located with the unit's exhaust air connection.
- 5. Once the space relative humidity falls below 55 percent RH, unit operation shall be deenergized through the DDC system.
- E. Compressor operation:
  - 1. Compressors shall be staged and cycled under the manufacturer's packaged controls to maintain controlling discharge air conditions with the appropriate deadbands and timing intervals to prevent short cycling.
  - 2. Manufacturer's safeties shall override DDC operations.
  - 3. Compressor operation shall be disabled when supply fan is off.
- F. Reversing valve operation:
  - 1. Compressor reversing valve shall be positioned appropriate to heating/cooling duty.
- G. Safety and emergency control:
  - 1. Whenever the emergency fan disconnect switch is thrown or limitations are exceeded by any air duct smoke detector, or static pressure sensor, the supply fan and exhaust fan shall be deenergized and OA and EA dampers shall close. An alarm indicating the specific condition shall be sent to the DDC system.

# 2.35 ENERGY RECOVERY UNIT SEQUENCE OF OPERATION (ERU-1 and ERU-2)

- A. General: Unit operation shall be enabled and disabled by respective zone DDC occupiedunoccupied schedule.
- B. Morning warm-up cycle:
  - 1. When indexed to "occupied" by the time schedule, the optimum start function of the DDC controller shall place the system in morning warm-up mode. The optimum start control function shall provide a space temperature within 1 degree of the occupied setpoint by the occupied time. If adequate space temperature is not achieved for all zones by the occupied time, an alarm shall be generated through the DDC system and the unit shall be indexed to the occupied cycle of operation described below.
  - 2. Under the warm-up cycle, the unit supply and return air fans shall be energized and run continuously. OA and EA (both min and max) dampers shall be closed and RA damper shall be open throughout.
  - 3. The reversing valve shall be positioned for heating and compressors shall be staged to maintain the room temperature sensors occupied heating setpoint.
  - 4. Once the occupied heating temperature setpoint is reached, the unit shall remain in the warm-up cycle (no ventilation) until indexed to the occupied cycle through the DDC system.
- C. Occupied cycle:

- 1. Supply and return fan operation:
  - a. When the unit is called to operation through the DDC system, the supply fan and return fan shall be energized through their corresponding VFDs and run continuously.
  - b. Supply fan operation (cooling): Modulate between minimum and maximum airflow setpoints to maintain cooling setpoint of the room temperature sensor. Minimum airflow setpoint shall be an adjustable setpoint (factory setpoint: 60-percent of maximum scheduled airflow).
  - c. Supply fan operation (heating): Operate at minimum airflow setpoint, subject to maximum discharge temperature of 85 degrees F. If maximum temperature is exceeded, increase towards maximum airflow setpoint.
  - d. Return fan operation: Modulate fan speed to maintain constant airflow differential with supply fan.
- 2. Minimum outdoor air control:
  - a. Minimum outdoor air operation shall be enabled when the return air enthalpy is below the outdoor air enthalpy, or the outdoor air temperature is below an adjustable low limit temperature setpoint (factory setpoint: 25 degrees F).
  - b. Minimum outdoor air damper shall open and maximum outdoor air damper shall be closed.
  - c. Return air damper and minimum exhaust air damper shall modulate in opposition to maintain the minimum outdoor air airflow measuring station setpoint. Maximum exhaust air damper shall be closed during minimum outdoor air control.
  - d. For ERU-1: Setpoint of minimum outdoor air airflow measuring station shall be incrementally reset between the minimum and maximum setpoints indicated on Energy Recovery Unit Schedule. All setpoints shall be adjustable.
- 3. Economizer operation:
  - a. Economizer operation shall be enabled when the return air enthalpy is above the outdoor air enthalpy and the outdoor air temperature is above an adjustable low limit temperature setpoint (factory setpoint: 25 degrees F).
  - b. When economizer operation is enabled, minimum outdoor air and exhaust air dampers shall remain open. Maximum outdoor air damper shall modulate to maintain the setpoint of the room temperature sensor, subject to a low-limit mixed air temperature of 50 degrees F.
  - c. Return air damper shall modulate in opposition with the maximum outdoor air damper.
  - d. Maximum exhaust air damper shall modulate in opposition with the return air damper.
- 4. Compressor and reversing valve operation:
  - a. Reversing valve shall be positioned to either heating or cooling duty and compressors shall be staged and cycled to maintain the room temperature sensor setpoint.
  - b. Include the appropriate deadbands and timing intervals to prevent short cycling.
  - c. Manufacturer's safeties shall override DDC operations.
  - d. Compressor operation shall be disabled when supply fan is off.
- 5. Dehumidification operation (hot gas reheat coil):

- a. On a rise in space humidity above the adjustable room humidity sensor setpoint, dehumidification operation shall be enabled. Factory setpoint for dehumidification operation shall be 50-percent RH.
- b. Reversing valve shall be positioned to cooling duty and compressors shall be staged and cycled to maintain the room humidity sensor setpoint, subject to a low-limit leaving coil temperature of 55 degrees F.
- c. Hot gas reheat coil shall modulate under its packaged controls to maintain the room temperature sensor setpoint.
- D. Unoccupied cycle.
  - 1. Unit shall be placed into the unoccupied mode of operation with the outdoor air (both min and max) and exhaust air (both min and max) dampers closed and the return air damper open throughout the unoccupied cycle.
  - 2. Unit supply and return air fans shall cycle and reversing valve and compressors shall be staged to maintain the unoccupied heating and cooling temperature setpoints of the room temperature sensor.
- E. Safety and emergency control:
  - 1. Whenever the emergency fan disconnect switch is thrown or limitations are exceeded by any air duct smoke detector or static pressure sensor, the supply fan and return fan shall be deenergized, the outdoor air (both min and max) and exhaust air dampers (both min and max) shall close, and the return air damper shall open. An alarm indicating the specific condition shall be sent to the DDC system.

# 2.36 ACCESSORIES

- A. Provide curbs for roof-mounted units as specified in Section 23 05 06, Curbs and Flashings.
  - 1. For DOAS-1 and DOAS-2, provide plenum type roof curb (minimum 30-inch plenum curb height).
- 2.90 SOURCE QUALITY CONTROL
  - A. Casing insertion loss: The insertion loss, per octave band, for the casing shall not be less than the following:

Frequency:	<u>63</u>	125	<u>250</u>	<u>500</u>	1000	<u>2000</u>	<u>4000</u>	<u>8000</u>
Insertion loss, dB:	24.8	24.1	22.3	24.7	26.1	29.0	31.2	33.1

Provide verifying test results from lab accredited by the U.S. Dept. Of Commerce and the National Institute of Standards and Technology (NIST). Insertion loss verification shall be in accordance with ISO 3746: 1975 Acoustics-survey (comparison) method.

# PART 3 - EXECUTION

# 3.05 PREPARATION

A. Coordinate installation with the automatic temperature controls subcontractor so that the system and each unit operate in accordance with schedules and sequence of operations.

# 3.20 INSTALLATION

- A. Install unit in accordance with the manufacturer's instructions and as indicated on drawings.
- B. Install units level and plumb, firmly anchored, in locations indicated and so as to maintain manufacturer's recommended clearances. Provide vibration isolation as specified in Part 2 above and in Section 23 05 48.
- C. Connections: Connect supply and return piping, drains, ducts, and electrical devices in accordance with drawings and manufacturer's instructions. Ground equipment.
- D. Test each drain pan and assure that installed slope is as specified and pan drains completely.
- E. Install filter provided with unit before energizing the unit supply fan. For units so designed, remove side panel of filter holder to permit access to filter.
- F. Prior to air balancing, remove filter and install new filter as specified in Section 23 41 00.
- G. Coordinate with air balancing and provide the proper drive for fan speed to obtain the airflow and static pressure indicated on the drawings.
- H. Generator power supply shall be available to the following:
  - 1. Electric heater within heat pump compressor section of custom type units.

#### 3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 23 05 00, provide operating instructions.
- B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

# END OF SECTION

# SECTION 23 81 27 - DUCTLESS SPLIT-SYSTEM UNITS

#### PART 1 - GENERAL

## 1.11 SECTION INCLUDES

- A. Ductless split system with interior and exterior units and refrigerant piping.
- B. Air-conditioning units.
- C. Heat pump units.

# 1.14 RELATED SECTIONS

- A. Motors: Section 23 05 13.
- B. Refrigerant piping: Section 23 23 00.
- C. Refrigeration service and compressor warranty: Section 23 01 00.
- D. Curbs: Section 23 05 06.
- E. Filters: Section 23 41 00.
- F. Controls: Sections 23 09 01 through 23 09 23.

# 1.20 REFERENCES

- A. ASHRAE 15: Safety Code for Mechanical Refrigeration.
- B. ASHRAE 90.1: Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.
- 1.27 PERFORMANCE REQUIREMENTS
  - A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article "Acceptable Manufacturers" below, ascertain that it will:
    - 1. Perform to the scheduled and specified capacities.
    - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
    - 3. Meet or exceed all specified requirements.
    - 4. Electrical power connections for the basis-of-design unit require the indoor unit to be wired through the outdoor unit. Other manufacturers may require separate power connections, which the contractor shall provide as required.

# 1.30 SUBMITTALS
- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Wiring diagrams: For power, signal, and control systems, differentiating between factoryand field-installed wiring.
- C. Product data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model.
  - 1. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
  - 2. Submit precharged tubing description.
- D. Samples: Color chips, showing manufacturer's complete line of finishes.

# 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.
- B. Fabricate and label refrigeration components to comply with ASHRAE 15.
- C. Energy efficiency ratio and coefficient of performance: Equal to or greater than prescribed by ASHRAE 90.1.
- 1.81 SPECIAL WARRANTY
  - A. Besides general project warranty, provide manufacturer's five-year extended warranty for replacing compressors, for each system, executed to the Owner.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled Mitsubishi Electric Corporation P Series unit, or comparable product by one of the following:
  - 1. Daikin AC
  - 2. Sanyo
  - 3. Mitsubishi Electric Corporation
  - 4. Panasonic Air Conditioning Group

# 2.11 MATERIALS

A. Refrigerant: HFC 410a.

B. Refrigerant pipe: Precharged Type L soft drawn, preinsulated seamless copper tubing, ASTM B 280. Length: As short as possible.

# 2.30 UNITS, GENERAL

- A. Each unit shall be provided with factory-installed means of disconnect in compliance with NEC (NFPA 70) and local codes. In the event a factory-installed disconnect is not available, provide an approved means of disconnect for field mounting.
- B. Heat pump units: Include changeover valves and defrost controls. When heat is called for, the changeover valve reverses the refrigerant flow, the interior coil operates as a condenser, heat is circulated into the room, and the outdoor coil operates as an evaporator.
- C. Air-conditioning units: Interior unit is an air conditioner and the outdoor coil is a condenser.

# 2.31 INTERIOR UNIT

- A. Frames: Steel angles or aluminum extrusions, welded construction.
- B. Panels:
  - 1. Insulated with 0.5-inch (13-mm) thick, 2 lbs per cubic foot (32 kg per cubic meter) density glass fiber insulation, with an R value no less than 15.
  - 2. Fasteners: Concealed, captive, easily operated for access without tools.
  - 3. Exterior finish: Manufacturer's standard baked enamel.
- C. Grilles: Each one-piece construction, aluminum, brushed finish, with foam gasket providing airtight seal between grille and cabinet. Supply grille adjustable in three directions. Return air grille hinged for access to filter.
- D. Drain pan: Insulated steel or plastic, with connections to exterior of cabinet.
  - 1. Slope to drain in two directions, minimum 0.25 inch in 1 foot, to 0.75-inch drain connection.
  - 2. Provide access for cleaning.
- E. Cooling coil: Aluminum fins extruded on to copper tubing with quick connections to precharged tubing. Pressure tested at 1.5 times working pressure. Provide expansion device.
- F. Fan: Centrifugal type with direct-connected controlled-speed motor mounted on vibration isolators.
- G. Filter: Throwaway type.

## 2.34 EXTERIOR UNIT

A. Unit shall be factory-assembled and -tested, of capacity and current characteristics indicated on the drawings. Unit shall be packaged type. Cabinet: weatherproof construction, steel, with baked enamel finish.

- B. Refrigeration circuit: Completely pre-piped, equipped with refrigerant; access valves in suction and liquid lines; filter dryer, sight glass, and pressure fittings for charging and evacuation.
- C. Compressors: Welded shell; reciprocating hermetic, rotary screw or scroll type; high efficiency.
- D. Condenser coil: Constructed of copper tube and aluminum fins, factory leak-tested at 1.5 times working pressure, dehydrated, and provided with full charge of refrigerant. Provide subcooler and accumulator.
  - 1. Low ambient control: Include head pressure control, designed to operate at temperatures down to 0 degrees F (minus 18 degrees C).
- E. Fans: Propeller, direct drive, dynamically balanced, speed-controlled motor.

# 2.35 CONTROLS

- A. Wall-mounted hard wired controllers shall incorporate the following features:
  - 1. Operation mode setting (Heat, Auto, Cool)
  - 2. Temperature setting: The LCD indicator displays the set temperature in units of 2 degrees F.
  - 3. Room temperature (intake air) display
  - 4. 24-hour on/off timer: Operation can be set to start or stop after a specified time in 1-hour increments from 1 to 24. The remaining time is indicated on the LCD display.
  - 5. Fan speed indicator: Displays the fan speed setting (high or low).
  - 6. Vane control: The angle of the air outlet vanes can be adjusted to one of four positions by pressing the air discharge Up/Down button.
  - 7. Auto air swing vanes: The air outlet vanes swing up and down for uniform air distribution.
  - 8. Self-diagnostic display: When unit stops, the display indicates where the trouble is located.
  - 9. Memory feature for storing instructions

## PART 3 - EXECUTION

# 3.20 INSTALLATION

- A. Assemble and set each unit in place in accordance with the manufacturer's instructions, plumb and level, firmly anchored, and maintaining manufacturer's recommended clearances.
- B. Connect piping as shown on the drawings and in accordance with manufacturer's instructions.
- C. In a finished space, all piping, wiring, and conduit shall be behind finished surfaces.
- D. Test each drain pan and ensure that installed slope is as specified and pan drains completely.
- E. Install filter provided with unit prior to energizing the unit supply fan.
- F. Prior to final acceptance, remove throwaway filter and install new filter as specified in Section 23 41 00.

# 3.81 OPERATING INSTRUCTIONS

A. As specified in Section 23 05 00, provide operating instructions.

# **END OF SECTION**

#### SECTION 23 81 28 - VARIABLE-REFRIGERANT-VOLUME MULTIZONE SYSTEM

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Heat recovery type variable-frequency-volume (VRV) system: Distributes refrigerant from the water-cooled condensing unit(s) to the indoor terminals to provide simultaneous heating and cooling.
  - 1. Condensing unit: Indoor water-cooled type unit.
  - 2. Indoor terminals: Ceiling cassette and horizontal ducted type units.

#### 1.14 RELATED SECTIONS

- A. Motors: Section 23 05 13.
- B. Piping: Section 23 23 00.
- C. Refrigeration service and compressor warranty: Section 23 01 00.
- D. Filters: Section 23 41 00.
- E. Controls: Sections 23 09 01 through 23 09 23.

#### 1.20 REFERENCES

- A. ASHRAE 15: Safety Code for Mechanical Refrigeration.
- B. ASHRAE 90.1: Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.
- 1.27 PERFORMANCE REQUIREMENTS
  - A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article "Acceptable Manufacturers" below, ascertain that it will:
    - 1. Perform to the scheduled and specified capacities.
    - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
    - 3. Meet or exceed all specified requirements.

# 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field

connection.

- 1. Wiring diagrams: For power, signal, and control systems, differentiating between factoryand field-installed wiring.
- C. Product data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model.
  - 1. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
  - 2. Submit precharged tubing description.
- D. Samples: Color chips, showing manufacturer's complete line of finishes.

#### 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.
- B. Fabricate and label refrigeration components to comply with ASHRAE 15.
- C. Energy efficiency ratio and coefficient of performance: Equal to or greater than prescribed by ASHRAE 90.1.

#### 1.81 SPECIAL WARRANTY

A. Besides general project warranty, provide manufacturer's five-year extended warranty for replacing compressors, for each system, executed to the Owner.

#### 1.92 EXTRA MATERIALS

A. Provide extra washable filter for each ceiling cassette type indoor terminal.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Scheduled units are the basis for design of the project. The manufacturers listed also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 1 and the article "Product Options" in Section 23 01 01, and submit shop drawings and product data as specified in Part 1 above.
  - 1. Daikin AC
  - 2. Trane
  - 3. Mitsubishi Electric Corporation

#### 2.11 MATERIALS

A. Refrigerant: HFC-410a.

B. Refrigerant pipe: Refer to Section 23 23 00, Refrigerant Piping.

## 2.20 UNITS, GENERAL

A. Each unit shall be provided with factory-installed means of disconnect in compliance with NEC (NFPA 70) and local codes. In the event a factory-installed disconnect is not available, provide an approved means of disconnect for field mounting.

## 2.21 INDOOR TERMINALS

- A. Ceiling-cassette or horizontal ducted type unit as scheduled with R-410A refrigerant; equipped with an electronic expansion valve; ceiling cavity type installation with an air panel grille; and capacity as scheduled.
  - 1. Factory assembled to include:
    - a. Expansion valve.
    - b. Control circuit board.
    - c. Fan motor thermal protector.
    - d. Condensate drain pan.
    - e. Condensate drain pump.
    - f. Auto-restart function.
    - g. Fused time delay.
    - h. Test run switch.
    - i. Return air thermistor.
  - 2. Cabinet: Constructed with sound absorbing foamed polystyrene and polyethylene insulation.
  - 3. Fan: Direct drive type with high and low fan speeds.
  - 4. Coil: Copper tubes expanded into aluminum fins to form a mechanical bond.
  - 5. Supply air: 4-way airflow with capability to change to 3-way and 2-way airflow to accommodate various field installations as described on the drawings.
  - 6. Return air: Flow through the concentric panel with manufacturer's standard washable filter.
  - 7. Shipping: Indoor unit and refrigerant pipes shall be charged with dehydrated air prior to shipment from the factory.
- B. Provide branch selector box at each variable-refrigerant terminal for independent heating and cooling operation at each indoor unit.

## 2.22 INDOOR CONDENSING UNIT

- A. Condensing unit: Water-cooled modular design to allow side-by-side installation with minimum spacing. Factory assembled and pre-wired with all the necessary electronic and refrigerant controls.
  - 1. Safety devices shall include:
    - a. High pressure switch.
    - b. Control circuit fuses.

- c. Crankcase heater.
- d. Fusible plug.
- e. Overload relay.
- f. Inverter overload protector.
- g. Thermal protector (overload) for compressor motor.
- h. Over current protection for the inverter.
- i. Anti-recycling timer.
- 2. Cabinet: Corrosion resistant, constructed from rust-proofed, mild steel panels coated with a baked enamel finish.
- 3. Compressor: Variable speed controlled scroll type compressor(s), capable of changing speeds with variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit.
- 4. Heat exchanger: Stainless-steel brazed plate type.
- 5. Features:
  - a. Automatic oil recovery cycle.
  - b. Automatically restart operation after a power failure without losing programmed settings.
  - c. Subcooling feature in circuit: Ensure the liquid refrigerant does not flash when it is being supplied to the various indoor units.

## 2.23 CONTROLS

- A. The entire system shall be provided with all required controls and shall be designed and installed by the equipment manufacturer. System shall be compatible with DDC system and provided with BACnet interface.
- B. Each indoor terminal shall be provided with a wall-mounted remote controller provided by the unit manufacturer. Controller shall be provided with an LCD display for local adjustment and hard-wired to the associated indoor unit. Controller shall support space temperature setpoint adjustment, provide fan on/off control, display alarm conditions, and permit automatic changeover of heating or cooling operation depending on room setpoint. Room temperature shall be sensed directly at the unit controller and not through the indoor unit's return air path.
- C. Provide a single, centralized system controller for operation of all indoor terminals and condensing units associated with the entire system. System controller shall be provided with an LCD display and located as indicated on the drawings. Controller shall be provided with an interface to the DDC system for enabling/disabling system operation and reporting general alarm conditions. Provide BACnet protocol for interface with the DDC system.

## 2.24 ACCESSORIES

- A. High efficiency air filters: 65 percent.
- B. Filter rack for high efficiency filters.

# PART 3 - EXECUTION

## 3.20 INSTALLATION

- A. Assemble and set each unit in place in accordance with the manufacturer's instructions, plumb and level, firmly anchored, and maintaining manufacturer's recommended clearances.
- B. Connect piping as shown on the drawings and in accordance with manufacturer's instructions. Piping between branch selector unit and indoor terminal shall be constructed of soft copper free of joints.
- C. Test each drain pan and ensure that installed slope is as specified and pan drains completely.
- D. Install filter provided with unit prior to energizing the unit supply fan.
- E. Prior to final acceptance, remove throwaway filter and install new filter as specified in Section 23 41 00.
- 3.81 OPERATING INSTRUCTIONS
  - A. As specified in Section 23 05 00, provide operating instructions.

# **END OF SECTION**

### SECTION 23 81 46 - WATER-SOURCE HEAT PUMP UNITS

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Packaged water-source heat pump units, designed for closed-loop ground-source system.
  - 1. Vertical heat pump units.
  - 2. Rooftop heat pump units.

#### 1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Disconnects for units not provided with factory-installed disconnects: Division 26.
- B. Wells for controls: Section 23 05 19.

# 1.14 RELATED SECTIONS

- A. Ground heat exchanger piping system: Section 23 21 16.
- B. Refrigeration service: Section 23 01 00.
- C. Efficiency and power factor of motors: Section 23 05 13.
- D. Filters: Section 23 41 00.
- E. Automatic temperature control system: Sections 23 09 01 through 23 09 23.
- F. Variable frequency drive: Section 23 29 23.
- G. Curbs: Section 23 05 06.
- H. Vibration control supports: Section 23 05 48.

#### 1.20 REFERENCES

- A. ARI/ISO/ASHRAE 13256-1: Water Source Heat Pumps.
- B. ARI Directory No. 2000: Directory of Certified Applied Air-Conditioning Products.

## 1.27 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under "Acceptable Manufacturers," below, ascertain that it will:
  - 1. Perform to the scheduled and specified capacities.
  - 2. Make no additional demands on other systems such as domestic or heat pump loop water, or electricity.

3. Meet or exceed specified requirements.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings: Wiring diagrams prepared for this installation, including factory and field wiring of units, accessories, and equipment.
- C. Product data: Each type of unit and each component, including manufacturer's installation instructions.
- D. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing laboratory.
- E. Certifications: Factory test reports.
- F. Submit product data for any digital controller that includes detailed controller information and available BACnet points.
- 1.40 QUALITY ASSURANCE
  - A. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC. Each unit shall be UL listed.
  - B. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Follow manufacturer's instructions for protecting units during shipping, storage, and handling.
  - B. Protect coils and pipe connections with temporary covering until the unit is installed.

#### 1.80 WARRANTY

- A. In addition to general project warranty and correction period, provide manufacturer's special warranties. Compressors shall be warranted for five years as specified in Section 23 01 00.
- B. Unit operation:
  - 1. Refrigerant circuit shall operate at specified minimum ambient temperature, flow, and water temperature conditions.
  - 2. Unit shall start and operate within scheduled tolerance of nameplate voltage.
- C. Compressors: As specified in Section 23 01 00, Operation and Maintenance of HVAC Systems.

#### 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Divisions 01 and 23 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

# PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Scheduled units are the basis for design of the project. The manufacturers listed also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 23 01 01, and submit shop drawings and product data as specified in Part 1 above.
  - 1. Vertical units:
    - a. Climate Master
    - b. Florida Heat Pump
    - c. Daikin
    - d. Trane
  - 2. Rooftop heat pump units:
    - a. Aaon
    - b. Valent
    - c. Addison
    - d. Trane
- B. Comply with requirements of Article 1.27 above.

## 2.20 HEAT PUMP UNITS, GENERAL

- A. Ground-coupled, closed-loop, premium-efficiency, extended-range units, factory-assembled.
  - 1. Refrigerant: HCF-410a.
- B. Designed, tested and rated in accordance with ARI/ISO 13256-1, and certified or listed in the ARI directory.
- C. Units include fans, refrigerant-to-air coils, filters, dampers, compressor, hose kits reversing valve, thermostatic expansion valve, refrigerant-to-water heat exchangers, and controls.
- D. Cabinet: Manufacturer's standard galvanized steel cabinet with epoxy or acrylic enamel finish (rooftop heat pump units only), compartmented, with access panels.
  - 1. Insulation: No less than 0.5-inch (12 mm)-thick multi-density fiberglass with cut edges sealed or protected with flanges.

- 2. Connections: Copper threaded fittings mechanically fastened to cabinet, including femalethreaded condensate drain connections, supply water connections, and return water connections. Water piping shall be insulated.
- 3. Locate compressor, reversing valve, and refrigerant-to-water heat exchanger out of the airstream. Insulate the divider between the condenser and fan sections.
- 4. Controls: In enclosure inside the unit.
- E. Fans: Centrifugal, direct- or belt-drive, with permanently lubricated motors. Motors shall be electronically commutated (ECM) type with thermal overload protections.
- F. Coil (evaporator coil; refrigerant-to-air heat exchanger): Rifled copper tubes with plate aluminum fins, designed for refrigerant working pressure of 450 psi (3102 kPa).
  - 1. Drain pan: Stainless steel or epoxy-coated, insulated, with overflow protection.
    - a. Slope to drain in two directions, minimum 0.25 inch (6 mm) in one foot (305 mm), to NPS 0.75 (DN 20) drain connection.
    - b. Provide access for cleaning.
- G. Filter section: Include filter frames and access panels or doors. Filter frames shall accommodate 2-inch-thick filters.
  - 1. Provide temporary throwaway filters for use until disposable filters are installed for regular service.
  - 2. Provide 2-inch-thick Merv 8 filters for regular service.
  - 3. Piping and electrical connections shall not interfere with arrangements for removing and replacing filters.
- H. Compressor: Two-stage, high-efficiency hermetically sealed on vertical units; single-stage hermetically sealed only where scheduled; serviceable hermetic type on rooftop units; installed on vibration isolators and enclosed in an acoustically treated enclosure.
  - 1. Controls: Include high and low pressure switches, low suction temperature cut-out, motor thermal overload protection, 5-minute anti-recycle timer, start capacitor kit, and stage 1/stage 2 compressor operation. Provide capability to reset compressor lockout circuit at the remote thermostat and at the disconnect.
  - 2. Sound attenuation: Provide with manufacturer's factory-installed sound attenuation package.
  - 3. Supply and return hose assemblies: Two 2-foot (0.6-m)-long metal braided hoses with swivel connectors on one end.
    - a. Hose fire rating: Meet requirements of UL 94.
    - b. Hose working pressure: Not less than 300 psi (2067 kPa).
- I. Reversing valve: Solenoid-activated refrigerant reversing valves energized only during the cooling mode and designed to fail in the heating position.
- J. Refrigerant-to-water heat exchangers (condenser coils): Coaxial, with inner cupronickel water tube and outer cupronickel or steel refrigerant tube, tested and rated for 450 psi (3102 kPa) refrigerant working pressure.

- 1. Thermal expansion valve assembly shall provide superheat over 30 to 110-degree F (1 to 43-degree C) liquid temperature range.
- K. Refrigerant safeties: Microprocessor based and provided by unit manufacturer.

# 2.21 VERTICAL HEAT PUMP UNITS

- A. Meeting the general requirements specified above, and the following additional requirements.
- B. Fans: Direct-drive centrifugal type, with adjustable fan speed selector switch, designed to produce specified air volume at specified external static pressure at the input voltage and phase scheduled. Unit shall be furnished for the voltage and phase shown on the drawings, and shall be warranted for operation at plus or minus 10 percent of the nameplate voltage.
- C. Operation: Unit shall start and operate at a minimum ambient temperature of 0 degrees F (-17.8 degrees C) with scheduled water flow and 35 degrees F (1.7 degrees C) entering water temperature.
- D. Cabinets:
  - 1. Base pan: 14 gage.
  - 2. Access panels: Provide access to electrical connections, blower, motor, and compressor.
  - 3. Internal parts exposed to moisture finished with plastic coating.
  - 4. Insulation: 0.5 inch thick with foil face or double wall.
- E. Fan motor speed shall not exceed 1200 rpm synchronous. Motor shall be ECM type and have a normal two-year lubrication schedule and shall be initially lubricated at the factory. Provide lubrication extension and include lubrication instructions in operating and maintenance manuals.
- F. Condensate hose: Clear preformed vinyl condensate hoses with nylon fittings, not less than NPS 0.75 (DN 20), 300 psig (2067 kPa) working pressure.
- G. Connections for supply and return: Copper fittings brazed to copper water tubes of refrigerantto-water heat exchanger.
- H. Refrigerant circuit (compressor, heat exchangers, reversing valve, and high-pressure and low-temperature safety controls):
  - 1. Sealed.
  - 2. Wired through a factory-installed lockout relay to remain deenergized until it is reset electrically at the circuit breaker panel. Manual reset at the unit not permitted.

# 2.22 CONTROLS FOR VERTICAL UNITS

- A. The ATC contractor shall provide for the following:
  - 1. Install wall-mounted space temperature sensor. Provide wiring and guard for manufacturer's wall-mounted temperature sensor.
  - 2. Furnish water control valves for field installation.

- 3. Building automation system connection and communication with manufacturer's heat pump controllers.
  - a. Refer to ATC drawings for manufacturer's packaged sequence of operation for both two-stage and single-stage heat pump units.
  - b. All heat pump unit controllers shall be provided with BACnet protocol for interface with the building automation system.
- 4. Provide switches at each control panel to serve as a panel disconnect. Each panel shall be fuse protected. Comply with Division 26, Low-Voltage Circuit Protective Devices.
- B. The equipment manufacturer shall provide for the following:
  - 1. Provide microprocessor based controller per unit operation, complete with BACnet protocol. Refer to ATC drawings for manufacturer's packaged sequence of operation for both two-stage and single-stage heat pump units.
  - 2. Dip switch type fan speed selector.
  - 3. Provide wall-mounted digital thermostat, complete with warmer/cooler setpoint adjustment dial and without display.
  - 4. Furnish and wire condensate overflow switch. Switches shall be equal to products specified in Section 23 09 13.

## 2.23 ROOFTOP HEAT PUMP UNITS

- A. Meeting the general requirements specified in this section, and the following additional requirements.
- B. Factory assembled, piped, internally wired, and tested.
  - 1. Factory piping, including all piping, fittings, and valves to a single point piping connection as detailed on the drawings.
- C. Cabinet, casing and frame construction.
  - 1. Construction: Zinc coated, heavy gauge, galvanized steel.
    - a. Exterior surfaces shall be cleaned phosphatized, and finished with a weather-resistant baked enamel finish, manufacturer's standard color.
  - 2. Cabinet design: Allow access for maintenance of unit(s) on one side. Service panels shall have lifting handles and be removed and installed by removing only a single fastener while providing a water and air tight seal.
    - a. Exposed vertical panels and top cover in the indoor air section shall be insulated with cleanable foil-faced, fire-retardant permanent, odorless glass fiber material.
    - b. Base shall be insulated with 0.5-inch, 1-pound density foil-faced, closed-cell material. Insulation edges shall be captured or sealed
- D. Filters: As described on the schedule and specified in Section 23 41 00.

- E. Compressors: Direct-drive, hermetic, scroll type compressors with centrifugal type oil pumps. Provide a minimum one digital scroll type compressor for each unit. Compressors shall include:
  - 1. Internal overloads.
  - 2. Internal spring isolation.
  - 3. Sound attenuation to minimize vibration transmission and noise.
  - 4. External high and low pressure switches.
- F. Refrigerant circuits shall include the following:
  - 1. Thermal expansion device.
  - 2. Service pressure ports.
  - 3. Refrigerant line filter-driers.
- G. Air-to-refrigerant coil: Internally finned, 0.375-inch copper tubes mechanically bonded to a configured aluminum plate fin. Factory-leak tested coils to 200 psig and pressure tested to 450 psig.
- H. Drain pan: Stainless-steel construction, reversible, removable, and double sloped.
- I. Supply and exhaust fans: Direct drive, backward curved plenum types with adjustable motor sheaves and idler arm assembly, and thermally protected motor(s).
  - 1. Direct drive axial fans may be used for return fan applications.
  - 2. Fan motors shall be suitable for use with variable frequency drive controllers.
- J. Water-to-refrigerant heat exchanger: Constructed of cupro-nickel with a working pressure of 400 psig on the refrigerant and water sides.
- K. Hot-gas reheat coil: Provide factory-installed, hot-gas reheat coil with modulating control for temperature control during dehumidification operation.
- L. Economizer: Factory installed, fully modulating, 0-100 percent motor and damper. Minimum position setting of the economizer shall be adjusted with a field-installed remote potentiometer.
  - 1. Provide factory-furnished, outdoor air airflow measuring station meeting the requirements of Section 23 09 13.
- M. Head pressure control valves shall be two-way configuration; fail safe, open to heat exchanger; factory installed and piped by manufacturer to a single-point connection at internal pipe chase. Factory piping shall include all required manufacturer accessories, in addition to those detailed on drawings.

## 2.24 CONTROLS FOR ROOFTOP HEAT PUMP UNITS

- A. The ATC contractor shall provide the following:
  - 1. Space temperature and humidity sensors.
  - 2. DDC controllers. DDC controller shall be mounted adjacent to unit manufacturer's controller.

- 3. Switches at each control panel to serve as a panel disconnect. Each panel shall be fuse protected. Comply with Division 26, Low-Voltage Circuit Protective Devices.
- B. The equipment manufacturer shall provide the following:
  - 1. Manufacturers microprocessor based control system, complete with BACnet protocol. System shall provide all temperature and humidity control functions, including damper, economizer, reversing valve, and compressor operations, in addition to refrigeration system control and safeties.
    - a. Provide room pressure exhaust fan control (RHPU-2 only).
    - b. Provide interface between unit controller and DDC controller for room temperature and humidity input control functions.
    - c. Head pressure control valves and associated control devices, factory-installed and piped to a single-point piping connection.
  - 2. Differential pressure switches: Factory-installed switches to indicate fan failure or a blocked filter.
  - 3. Humidistat: Duct-mounted and wired to manufacturers controller for hot-gas reheat coil control during dehumidification.
  - 4. Terminal strip for hardwire interface between manufacturers' controls and DDC system, including but not limited to, the following:
    - a. Unit On/Off (Enable/Disable) control functions.
    - b. Unit mode of operation (warm-up/occupied/unoccupied).
    - c. General alarm.
  - 1. Provide remote temperature and humidity setpoint adjustment through the DDC system.
- C. A factory certified technician must be present with DDC contractor and Commissioning Agent to successfully commission each unit through each sequence in every mode of operation.

# 2.25 SINGLE-ZONE VAV SEQUENCE OF OPERATION (RHPU-1 AND RHPU-2)

- A. General: Unit operation shall be enabled and disabled by respective zone DDC occupiedunoccupied schedule.
- B. Morning warm-up cycle:
  - 1. When indexed to "occupied" by the time schedule, the optimum start function of the DDC controller shall place the system in morning warm-up mode. The optimum start control function shall provide a space temperature within 1 degree of the occupied setpoint by the occupied time. If adequate space temperature is not achieved for all zones by the occupied times, an alarm shall be generated through the DDC system and the unit shall be indexed to the occupied cycle of operation described below.
  - 2. Under the warm-up cycle, the unit supply air fan shall be energized and run continuously as described below for the occupied cycle. OA and EA dampers shall be closed and RA damper shall be open throughout. Power exhaust fan shall be deenergized.
  - 3. The reversing valve shall be positioned for heating and compressors shall be staged to maintain the room temperature sensors occupied heating setpoint.

- 4. Once the occupied temperature setpoint is reached, the unit shall remain in the warm-up cycle (no ventilation) until indexed to the occupied cycle through the DDC system.
- C. Occupied cycle:
  - 1. Supply fan operation:
    - a. When the unit is called to operation through the DDC system, the supply fan shall be energized through its corresponding VFD and run continuously.
    - b. Supply fan operation (cooling): Modulate between minimum and maximum airflow setpoints to maintain cooling setpoint of the room temperature sensor. Minimum airflow setpoint shall be an adjustable setpoint (factory setpoint: 60-percent of maximum scheduled airflow).
    - c. Supply fan operation (heating): Operate at minimum airflow setpoint.
  - 2. Minimum outdoor air control:
    - a. Minimum outdoor air control shall occur at all times, except for economizer operation.
    - b. Outdoor air damper shall open to its minimum position.
    - c. Return air damper and exhaust air damper (for non-barometric damper units) shall modulate in opposition to maintain the minimum outdoor air airflow measuring station setpoint.
  - 3. Economizer operation:
    - a. Enable economizer operation when outdoor air dry bulb temperature falls below an adjustable temperature setpoint (factory setpoint: 60 degrees F).
    - b. Outdoor air damper shall modulate between to its minimum position and wide open to maintain the setpoint of the room temperature sensor, subject to a low-limit mixed air temperature of 40 degrees F.
    - c. Return air damper shall modulate in opposition with the outdoor air damper.
    - d. Exhaust air damper (for non-barometric damper units) shall modulate in opposition with the return air damper.
    - e. For RHPU-2: Power exhaust fan operation shall be enabled under economizer operation.
    - f. Power exhaust fan operation: Modulate to maintain the room pressurization setpoint with respect to the outdoors. Room pressurization setpoint shall be an adjustable setpoint (factory setpoint: +0.05 inch WG room pressurization).
  - 4. Compressor and reversing valve operation:
    - a. Reversing valve shall be positioned to either heating or cooling duty and compressors shall be staged and cycled to maintain the room temperature sensor setpoint.
    - b. Include the appropriate deadbands and timing intervals to prevent short cycling.
    - c. Manufacturer's safeties shall override DDC operations.
    - d. Compressor operation shall be disabled when supply fan is off.
  - 5. Dehumidification operation (hot gas reheat coil):

- a. On a rise in humidity above the adjustable high-limit return air humidistat setpoint, dehumidification operation shall be enabled. Factory setpoint for dehumidification operation shall be 50-percent RH.
- b. Reversing valve shall be positioned to cooling duty and compressors shall be staged and cycled to maintain the room humidity sensor setpoint, subject to a low-limit leaving coil temperature of 52 degrees F.
- c. Hot gas reheat coil shall modulate under its packaged controls to maintain the room temperature sensor setpoint.
- C. Unoccupied cycle:
  - 1. Outdoor air and exhaust air dampers shall be closed and the return air damper shall be open throughout the unoccupied cycle.
  - 2. Power exhaust fan shall be deenergized under the unoccupied cycle.
  - 3. Unit supply fan shall cycle and reversing valve and compressors shall be staged to maintain the unoccupied heating temperature setpoint of the room temperature sensor.
- D. Safety and emergency control:
  - 1. Whenever the emergency fan disconnect switch is thrown or limitations are exceeded by any air duct smoke detector or static pressure sensor, the supply fan shall be deenergized, the outdoor air and exhaust air dampers shall close, and the return air damper shall open. An alarm indicating the specific condition shall be sent to the DDC system.

## 2.90 SOURCE QUALITY CONTROL

A. Test operate each unit at the factory. Submit factory test report as required in "Submittals" in Part 1.

## PART 3 - EXECUTION

#### 3.05 PREPARATION

A. Coordinate installation with the controls subcontractor so that the system and each unit operate in accordance with schedules and sequence of operations.

## 3.20 INSTALLATION

- A. Install unit in accordance with the manufacturer's instructions and as indicated on drawings.
- B. Install units level and plumb, firmly anchored, in locations indicated and so as to maintain manufacturer's recommended clearances. Assure that access panels are accessible within closets. Provide vibration isolation as specified in Part 2 above and in Section 23 05 48.
- C. Connections: Connect supply and return piping, drains, ducts, and electrical devices in accordance with drawings and manufacturer's instructions. Ground equipment.
- D. Test each drain pan and assure that installed slope is as specified and pan drains completely.

- E. Install filter provided with unit before energizing the unit supply fan. For units so designed, remove side panel of filter holder to permit access to filter.
- F. Prior to air balancing, remove filter and install new filter as specified in Section 23 41 00.
- G. Coordinate with air balancing and control's contractor to provide the proper fan speed settings to obtain the airflow and static pressure indicated on the drawings.
- 3.81 OPERATING INSTRUCTIONS
  - A. As specified in Section 23 05 00, provide operating instructions.
  - B. Provide at least 4 hours of additional instruction time for the equipment specified in this section.

# **END OF SECTION**

## SECTION 23 82 38 - ELECTRIC RESISTANCE TERMINAL UNITS

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Electrical resistance heating equipment and devices.
- B. Unit heaters, cabinet and propeller unit types.
- C. Fan heaters.
- 1.14 RELATED SECTIONS
  - A. Filters: Section 23 41 00.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Product data: Each type and size of heater included in the project.
- C. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
- D. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, plan and sections, showing any changes in wiring, arrangement or access made necessary to accommodate the unit furnished.
- E. Shop drawings shall show dimensions of complete assembled unit with accessories.
- F. Samples: Manufacturer's complete line of colors and textures for cabinets and casings.

## 1.40 QUALITY ASSURANCE

- A. Each unit, and components as applicable, shall be UL listed and labeled.
  - 1. UL label and local testing (if required): As specified in Section 23 05 00, Common Work Results for HVAC.
- B. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

## PART 2 - PRODUCTS

# 2.30 ELECTRIC HEATING EQUIPMENT, GENERAL

A. Capacities and current characteristics of each unit are scheduled on the drawings.

- B. Heaters shall be suitable for voltage characteristics indicated on the drawings.
- C. Provide a factory-mounted electric disconnect switch mounted inside each heater.

# 2.36 PROPELLER UNIT HEATER

- A. Unit shall be for wall or ceiling suspension-type mounting and casing shall be constructed of 18 gage die-formed furniture grade steel. Provide individual adjustable louvers for the discharge grille. Metal surfaces of casing: Baked enamel.
  - 1. Basis-of-design product: Subject to compliance with requirements, provide QMark MUH, or comparable product by one of the following:
    - a. Berko Electric Heating
    - b. General Electric Co.
    - c. Vulcan Radiator Corp.
- B. Electric heating bank: Metal sheath finned-tube heating elements with automatic reset, thermal overheat protection, controlled by integral thermostat.
- C. Motor: Totally enclosed, continuous fan-duty, sleeve-bearing type with built-in thermal overload protection. Fan shall be aluminum construction, dynamically balanced and directly connected on motor shaft. Unit shall be provided with resiliently mounted fan/motor guard.
- D. Include mounting device.

# 2.37 ELECTRIC CABINET-TYPE UNIT HEATER

- A. Blow-through design with motor and fans in the air stream. Fan discharge shall be baffled to insure even air flow through entire area of heating bank. Unit shall have front supply and return grilles. Panels on the front, top, and bottom shall be internally insulated to provide quiet operation and low surface temperature. Front panel 14 gage steel.
  - 1. Basis-of-design product: Subject to compliance with requirements, provide QMark CU, or comparable product by one of the following:
    - a. Berko Electric Heating
    - b. General Electric Co.
    - c. Vulcan Radiator Corp.
- B. Cabinet finish: Baked enamel, with front access panel in color to be selected.
- C. Heating elements: Single terminal end, long life electric finned tubes with brazed helical coiled fins. Finned tubes shall be installed so that they can be removed individually, and center-anchored to insure noiseless expansion and contraction. Provide reset snap-action type thermal protection through holding coil circuit of the control system relays. Thermal protection shall be linear type to sense temperature the entire length of the heating element.

- D. Motor and fan assembly shall be directly driven. Motor shall be two-speed permanent split capacitor type with built-in automatic motor overload protection. Fan shall be forward-curved, double-inlet, centrifugal type, aluminum. Motor and fan shall be mounted on a galvanized steel mounting plate, formed for easy removal with motor leads of plug-in type. Provide combination two-speed, two-heat, tamperproof switch located within unit.
- E. Recessed unit shall have wall guard type recessed flanges. Recess depths shall be adjusted in field.
- F. Unit shall be factory-wired, including selector switch (except ceiling units), thermal fan switch, automatic reset overheat switch, power control relay, and circuit breaker disconnect. Provide an integral thermostat.

# 2.39 CEILING FAN HEATERS

- A. Unit shall be scheduled voltage, single-phase type.
  - 1. Basis-of-design product: Subject to compliance with requirements, provide QMark CWH, or comparable product by one of the following:
    - a. Berko Electric Heating
    - b. General Electric Co.
    - c. Markel Products, Inc.
    - d. Vulcan Radiator Corp.
- B. Unit shall be for recessed ceiling mounting with housing constructed of minimum 20 gauge steel. Grille shall be aluminum with louver designed for a downflow pattern.
- C. Electric heating element shall be nickel-chrome with automatically reset thermal overheat protection and controlled by integral snap-action thermostat. Provide hole plug for tamper-resistant thermostat installation.

# 2.40 WALL FAN HEATERS

- A. Unit shall be for recessed mounting and constructed of minimum 16 gage steel. Front plate shall be steel with supply and return louver.
  - 1. Basis-of-design product: Subject to compliance with requirements, provide QMark AWH, or comparable product by one of the following:
    - a. Berko Electric Heating
    - b. General Electric Co.
    - c. Markel Products, Inc.
    - d. Vulcan Radiator Co.
- B. Louver shall be designed for a downflow pattern.
- C. Electric heating element shall be shock resistant, steel sheath enclosed, fin tube type with automatic reset thermal overheat protection and controlled by integral thermostat to deenergized fan motor and heating element.

- D. Built-in fan delay switch energizes fan motor only after elements are heated, preventing discharge of unheated air. When heat shuts off, switch de-energizes fan motor after residual heat has been dissipated.
- E. Integral thermostat (range 40 to 90 degrees F.)
- F. Motor shall be of the totally enclosed, continuous fan-duty, sleeve-bearing type with built-in thermal overload protection. Fan shall be aluminum construction, dynamically balanced and direct connected on motor shaft. Unit shall be provided with resiliently-mounted fan/motor guard.

## PART 3 - EXECUTION

## 3.02 EXAMINATION

- A. Examine roughing-in for electric units to verify actual locations of electrical connections before beginning installation.
- 3.05 PREPARATION
  - A. Coordinate with other trades to ensure that recess or bracing in walls is constructed in locations and with dimensions required for installation of recessed or surface-mounted units.
- 3.20 INSTALLATION, GENERAL
  - A. Install level and plumb.
    - 1. Install manufacturer's access fitting for access to electrical connections, controls, and other fittings.
- 3.22 INSTALLATION, SUSPENDED UNITS
  - A. Suspend unit from construction above or from wall with manufacturer's hanger or 0.5-inch rods in accordance with manufacturer's instructions.
  - B. Prevent transmission of vibration to building.
- 3.23 INSTALLATION, WALL-MOUNTED UNITS
  - A. Install convectors located under windows with heating element and enclosure horizontally centered under windows.
  - B. Cabinet units: Install with electrical connections concealed.
    - 1. Recessed or semirecessed units:
      - a. In masonry walls: Bottom of unit shall be one masonry course above floor unless noted otherwise on the drawings.

- b. In exterior walls: Insulate back of unit with asphalt-impregnated fiberboard insulation.
- 2. Surface-mounted units:
  - a. Bottom of unit shall be at least 4 inches above floor. Provide subbase.
  - b. Install with a minimum of 4 bolts into the wall.

# 3.30 CONNECTIONS

- A. Ground equipment and connect wiring in accordance with requirements of Division 26.
- 3.60 FIELD QUALITY CONTROL
  - A. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - B. Test and adjust controls including safety controls. Replace damage or malfunctioning controls and equipment.

# END OF SECTION

## **SECTION 26 01 01 - ELECTRICAL GENERAL PROVISIONS**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. General provisions and requirements for electrical work.
- 1.14 RELATED SECTIONS
  - A. Requirements of this section generally supplement requirements of Division 01.
  - B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.

## 1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.
- 1.24 SYSTEM DESCRIPTION
  - A. The full set of Contract Documents applies to work of Division 26.
  - B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
  - C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
  - D. Except as required otherwise in Division 01, promptly obtain and pay for, all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
  - E. Electrical work of this project includes, as a brief general description, the following:
    - 1. Provide a complete electrical power distribution and lighting system for a new elementary school.
    - 2. Provide a complete fire detection and alarm system for a new elementary school building.
    - 3. The project includes commissioning under the direction of a Commissioning Agent (CxA).
    - 4. The project will be LEED certified.
  - F. See Division 01 for requirements related to LEED certification, commissioning, Owner's occupancy of the premises, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

## 1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 26 specifications.
- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in article "Substitutions" below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
  - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
  - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

## 1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 26 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
  - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
  - 2. Will provide the same warranty for the substitution as for the specified product.
  - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
  - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
  - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.

- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

# 1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project, and of representative manufacture. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
  - 1. Furnish: Supply item
  - 2. Install: Mount and connect item
  - 3. Provide: Furnish and install
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturer's instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent prior to initiating any work which may be affected by this decision.

## 1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with the project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate electrical work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.
- D. Coordinate location and elevation of all conduit, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractor's assistants shall include a competent electrical foreman, who shall be on the premises at all times to check, layout, coordinate and superintend the installation of work. The foreman shall establish all basic requirements relative to the work before starting, and be responsible for the accuracy thereof.

## 1.30 SUBMITTALS

- A. Manufacturers' and subcontractors' lists:
  - 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.
- B. Shop drawings and product data:
  - 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of Shop Drawings and Product Data for every item of equipment. Shop drawings or product data will not be considered until Manufacturers' Lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
  - 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.

- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electrical items furnished as items associated with mechanical items but not specifically described in the mechanical item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the mechanical item by identified specification paragraph.
- 5. Product data sheets shall be 8.5-inch by 11-inch cut sheets for operating and maintenance manual.
- C. Submit at least three copies of the results of every test required under any section in this division.
- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.
  - 1. Include project name, address, name and phone number of owner's representative, and project type and size.
- E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

# 1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

## 1.35 CONTRACT CLOSEOUT SUBMITTALS

- A. Project record documents:
  - 1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:
    - a. Contract Drawings.
    - b. Specifications.
    - c. Addenda.
    - d. Change Orders and other Modifications to the Contract.
    - e. Reviewed shop drawings, product data, and samples.

- 2. Maintain record documents separate from documents used for construction.
- 3. Record information concurrent with construction progress.
- 4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:
  - a. Manufacturer's name and product model and number.
  - b. Product options, substitutions, or alternates utilized.
  - c. Changes made by addenda and modifications.
- 5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:
  - a. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
  - b. Field changes of dimension and detail.
  - c. Details not on original Contract Drawings.
- 6. Submit documents as specified in Division 01.
- B. Operation and maintenance data:
  - 1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
  - 2. Binders: Three-ring binders with vinyl-covered hard covers. Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
  - 3. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", and title of project. Print on spine of binder "O & M INSTRUCTIONS". If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
  - 4. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
  - 5. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
  - 6. Part 1: Directory, listing names, addresses, and telephone numbers of electrical engineers; contractor; electrical subcontractors; and major electrical equipment suppliers.
  - 7. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
    - a. Significant design criteria.
    - b. List of equipment.
    - c. Parts list for each component, including recommended spare parts list.
    - d. Operating instructions.
    - e. Maintenance instructions for equipment and systems.
    - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

- 8. Part 3: Project documents and certificates, including the following:
  - a. Shop drawings and product data.
  - b. Photocopies of certificates.
  - c. Photocopies of warranties, guarantees, and bonds.
  - d. Test reports: Copies of the results of all tests required under all sections of specifications.
- 9. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
- 10. Submit final volumes revised, within ten days after final inspection.
- 11. Submit DVD optical disc storage media specified in Section 26 05 00.

# 1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
  - 1. The electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
  - 2. The National Electric Code, NFPA 70 (NEC).
  - 3. The National Fire Protection Association Code. (NFPA)
  - 4. International Building Code (IBC).
  - 5. International Energy Conservation, Fire, and Electrical Codes (ICC).

## 1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply.
  - 1. Factory Mutual (FM)
  - 2. American National Standards Institute (ANSI)
  - 3. American Society for Testing and Materials (ASTM)
  - 4. International Code Council (ICC)
  - 5. Institute of Electrical and Electronics Engineers (IEEE)
  - 6. National Electrical Code (NEC) (NFPA 70)
  - 7. National Electrical Manufacturer's Association (NEMA)
  - 8. National Fire Protection Association (NFPA)

- 9. The Occupational Safety and Health Act (OSHA)
- 10. Underwriters Laboratory Inc. (UL)
- 11. American Association of State Highway and Transportation Officials (AASHTO)
- 12. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
- 13. Maryland Occupational Safety and Health Act (MOSHA)
- 14. Illuminating Engineering Society of North America (IESNA)

## 1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.
- C. Store electrical construction materials such as wire, raceways and boxes, devices, and equipment in buildings, enclosed trailers, or portable enclosed warehouses.
  - 1. Materials and products subject to damage from moisture: Store in dry locations. If necessary, protect with protective wraps or covers.
  - 2. Plastics and other materials and products subject to damage from heat or cold: Store at manufacturer's recommended temperatures.
  - 3. Plastics and other materials and products subject to damage from sunlight: Protect from sunlight.
- D. Electrical equipment such as motor controllers, panelboards and circuit breakers stored before installation and installed during construction: Provide clean, dry locations at manufacturer's recommended temperatures, and cover or wrap if required to protect from incidental damage.

## 1.54 **PROTECTION**

- A. Control dust resulting from construction work to prevent its spread beyond the immediate work area, and to avoid creation of a nuisance.
  - 1. Do not use water to control dust. Use drop cloths or other suitable barriers.
  - 2. In areas where dirt or dust is produced as a result of the work, sweep daily, or more often as required.
  - 3. Provide walk-off mats at entries and replace them at regular intervals.
  - 4. Construct dust partitions, where indicated on the drawings or as required.
  - 5. Seal off all return air registers and other mechanical systems to prevent dust from entering.
- B. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
  - 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
  - 2. Protect finished work from damage, defacement, staining, or scratching.
  - 3. Protect finishes from cleaning agents, or grinding and finishing equipment.

- 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
- 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- C. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract sum.
- D. Protect work stored in place and supplies stored in the building.
  - 1. Store materials and products subject to damage from moisture in dry locations. If necessary, protect in wraps or covers.
  - 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- E. Protect electrical materials and products from weather events and accidents of construction.
- F. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

# 1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

## 1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
  - 1. Promptly notify the Owner and Architect in writing.
  - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

## 1.80 WARRANTY

A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties as specified in individual sections.

- B. During the correction period, the Contractor shall promptly correct any work found to be defective or otherwise not in accordance with the requirements of the Contract Documents, on receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
- C. When use of the permanent equipment has been permitted for temporary services during construction of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

# 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

## PART 2 - PRODUCTS

Not used.

# PART 3 - EXECUTION

## 3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of conduits. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.

- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.
- 3.14 TEMPORARY FACILITIES
  - A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.
- 3.40 PROGRESS MEETINGS
  - A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
  - B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

#### 3.82 COMMISSIONING

A. Comply with requirements of "Commissioning" in Part 1 above.

# **END OF SECTION**
## SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

## PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Requirements applicable to work of more than one section of Division 26.
- B. Testing wiring systems.
- 1.14 RELATED SECTIONS
  - A. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.
  - B. Operation and Maintenance Manuals: Division 01 and Section 26 01 01.
  - C. Painting: Division 09.

#### 1.21 DEFINITIONS

- A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.
- B. Qualified testing agency: A Nationally Recognized Testing Laboratory (NRTL), a National Voluntary Laboratory Accreditation Program (NVLAP), or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.

# 1.26 DESIGN REQUIREMENTS

- A. The drawings and system performances have been designed on the basis of using the particular manufacturers' products specified and scheduled on the drawings.
- B. Products of other manufacturers that are listed under the article "Acceptable Manufacturers," or permitted as "equal," are permitted provided:
  - 1. Product shall meet the specifications.
  - 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.
- C. Do not propose products with dimensions or other characteristics different from the design basis product that make their use impractical or cause functional fit, access, or connection problems.
- D. The contract drawings are generally diagrammatic, and do not indicate all fittings or offsets in conduit or all pull boxes, access panels, or other specialties required.

- 1. Install conduit exposed to view parallel with the lines of the building and as close to walls, columns, and ceilings as may be practical, maintaining adequate clearance for access at parts requiring servicing.
- 2. Install conduit a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.
- 3. No conduit shall be run below the head of a window or door.
- 4. Pull boxes and other appurtenances which require operation or maintenance shall be easily accessible. Do not cut or form handholes for operation or maintenance of appliances through walls or ceilings.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Test reports: Show that tests specified in Part 3 below demonstrate the specified results.
- C. LEED submittal:
  - 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For adhesives and sealants, include printed statement of VOC content.
  - 2. Product data for Indoor Environmental Quality (IEQ) Credit 4.4: For wood products such

as plywood equipment backboards, include printed statement of non urea-formaldehyde component present in material.

3. Product data for Credit IEQ4.2: For paints and coatings applied within the building water proofing envelope, documentation including printed statement of VOC content in g/L.

# 1.40 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the electrical, building, fire, and safety codes and regulations of the state, county, or city in which the work is performed.
- B. Electrical control panels, equipment, materials and devices provided or installed as work of Division 26 shall bear UL label, or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70. Provide testing, if required, without addition to the contract sum.
- C. Qualifications of DVD documentation technician: For video documentation specified in "Operating Instructions (Demonstration)," employ persons knowledgeable in DVD optical storage media for video and audio production and editing.
- D. The project shall be LEED certified. See requirements specified in Division 01 and individual sections for LEED requirements, waste and air quality control.
- E. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.
- F. Products shall contain no urea-formaldehyde content.

# PART 2 - PRODUCTS

## 2.10 MATERIALS

- A. Electrical equipment backing panels: Plywood, DOC PS 1, Exposure 1, C-D Plugged, fireretardant treated in accordance with AWPA C27, in thickness indicated, not less than 0.5 inch (13 mm) nominal.
  - 1. One side finished.
- B. Wood-preservative-treated lumber: Treated by pressure process, AWPA C2, with chemicals acceptable to authorities having jurisdiction, and marked with treatment quality mark of an inspection agency approved by the ALSC Board of Review.
  - 1. Application: Treat items indicated on the drawings, and the following:
    - a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
    - b. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
    - c. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
    - d. Wood framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.
    - e. Wood floor plates that are installed over concrete slabs-on-grade.
- C. Aircraft cable: 0.25-inch (6-mm) steel wire rope, galvanized, construction 7 by 19 strands, minimum 7000 lbs (31138 N) breaking strength.

# 2.21 DATE-SENSITIVE EQUIPMENT

- A. Date-sensitive equipment: Systems, equipment, or components which use or process date and time data in order to perform their functions.
- B. Each item of date-sensitive equipment used in the project shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

## PART 3 - EXECUTION

# 3.03 INSTALLATION OF PRODUCTS AND EQUIPMENT

- A. Manufacturer's instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturer's instructions and recommendations applicable to the project conditions.
  - 1. Immediately notify Architect if a difference or discrepancy is found between manufacturer's instructions and the drawings or specifications.

B. Install plywood backing panels with finished face exposed.

# 3.61 TESTS

- A. During the progress of the work and after completion, test the branch circuits and distribution system, and the low voltage alarm and signal systems.
- B. Results of the tests shall show that the wiring meets the requirements of this specification. Should any test indicate defect in materials or workmanship, immediately repair, or replace with new, the faulty installation, and retest the affected portions of the work.
- C. Furnish equipment and instruments necessary for testing.
- D. Tests shall demonstrate the following:
  - 1. Lighting, power, and control circuits are continuous and free from short circuits.
  - 2. Circuits are free from unspecified grounds.
  - 3. The resistance to ground of each non-grounded circuit is not less than one megohm.
  - 4. Circuits are properly connected in accordance with the applicable wiring diagrams.
  - 5. Circuits are operable. Demonstration shall include functioning of each control not less than ten times, and continuous operation of each lighting and power circuit for not less than 0.5 hour.
- E. Test circuit breakers larger than 100 amps at full voltage.
- F. Make voltage built-up tests with a voltage sufficient to determine that no short circuits exist.
- G. Immediately repair defects and retest until systems are operating correctly.
- H. Submit test reports.

## 3.81 OPERATING INSTRUCTIONS

- A. Furnish the necessary technicians, skilled workers, and helpers to operate the electrical systems and equipment of the entire project for one 8-hour days.
- B. Where specified in technical sections, provide longer periods required for specialized equipment.
- C. Instruct the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of systems and equipment.
- D. The Operating and Maintenance Manual shall be available at the time of the instructions for use by instructors and Owner personnel.
- E. Record each instruction session only in DVD media format (video and audio format), including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVDs with each Operating and Maintenance Manual.

F. Schedule the general and specialized instruction periods for a time agreed upon by the Owner and Architect.

## SECTION 26 05 01 - EXCAVATION AND FILL FOR ELECTRICAL WORK

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Trenching, backfilling, and compacting for electrical work underground inside the building and extending five feet beyond exterior building walls, and outside the building as shown on drawings.
  - B. Restoring and reseeding grassed areas.
- 1.14 RELATED SECTIONS
  - A. Cutting and patching: Division 01 and Section 26 01 01.
  - B. Underground electrical ductbanks: Section 26 05 44.
  - C. Conduit: Section 26 05 33.
  - D. Service entrance: Section 26 05 41.

#### 1.20 REFERENCES

A. ASTM D 1557: Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbs/cu ft (2700 kN-m/cu m).

#### 1.30 SUBMITTALS

- A. General: Submit in accordance with Division 01 and Section 26 01 01.
- B. Shop drawings: At the same scale as the contract drawings, showing field verified locations of utilities, and proposed detailed trenching plan.
- C. Product data:
  - 1. Warning tape
  - 2. Seed and mulch
- D. Certifications: Test reports showing that compaction meets specified requirements.

#### PART 2 - PRODUCTS

#### 2.10 MATERIALS

A. Backfill: Earth materials, free from perceptible amounts of wood, debris, or topsoil, free of frost at the time of placement, and not containing marl or other elements which tend to stay in a plastic state.

- B. Underground warning tape: Polyethylene 0.004 inch (0.102 mm) thick for metallic lines, and for non-metallic lines polyethylene both sides with metallic lining, six inches (152 mm) wide.
  - 1. Colors: In accordance with APWA and AASHTO standards.
  - 2. Markings: Repeated continuously along the entire length, legend appropriate for line being identified.
- C. Grass seed: Fresh new-crop seed, 90 percent pure and 85 percent germination. Mix: 70 percent Kentucky Bluegrass, 25 percent Red Fescue and 5 percent Red Top. Only strains of Kentucky Bluegrass found adaptable to Maryland shall be acceptable.
- D. Mulch: Free of sticks, weeds, or other foreign matter; either licorice root, tan root, or tan bark; fibrous by-product of extraction. Use only one type throughout the project.

# 2.12 EQUIPMENT

A. Mechanical tampers for compacting backfill: Capable of exerting a blow equal to 250 pounds per square foot (12 kPa) of area of the tamping face.

# PART 3 - EXECUTION

## 3.05 PREPARATION

- A. Contact local utility company underground information service (BGE Miss Utility) before beginning excavation outside buildings.
- B. The general locations of underground utilities are indicated on the drawings and are not to be assumed to be accurate or complete. Before beginning work, field check the area with the most accurate instruments available, such as Fisher Labs' Pipe and Cable Locators.

## 3.20 INSTALLATION

- A. Perform all excavating, trenching, sheeting, shoring, backfilling, and compacting required for the proper installation of the work.
- B. Where obstructions are encountered, obtain written approval and make necessary changes in line, grade or location.
- C. Protect existing utilities from damage during excavation and backfilling. Repair damaged new or existing work at no addition to the contract sum. Bracing, shoring and other protection of existing utilities is part of this work.
- D. Do not damage or remove existing shrubs or trees including their root systems, without prior notification to the Architect.
- E. Provide temporary roadways over trenches with railings and other safeguards, including amber blinker lamps or other warnings for night use.

F. Note the depths of footings. In cases where conduit is in close proximity to or below footings and where the natural earth under footings is disturbed, after the line is installed the voids shall be filled up to bottoms of such footings with solid concrete.

# 3.24 CUTTING

- A. Cut concrete and asphalt concrete with masonry saw prior to breaking it into smaller pieces for removal.
- B. Cut sidewalks perpendicular to the length at the closest existing joint that is a minimum of 24 inches back from either side of the top of the new trench.

## 3.25 TRENCHING

- A. Excavations inside the building shall be carefully planned. Stockpile excavated earth so as not to interfere with other construction. Dig trenches to the proper depths, providing extra depressions where required for hubs of pipes.
- B. Excavations outside the building shall generally follow the routes indicated on the drawings. Stockpile topsoil separately for later replacement. Excavations shall be of sufficient depths to provide, unless indicated otherwise on the drawings, a minimum cover as follows:
  - 1. Electrical conduit: Depth required by NFPA 70 (NEC).
- C. Trenches shall be of necessary depth and width for the proper laying of conduit with a minimum of 8 inches (205 mm) on each side of the joint.
  - 1. The sides shall be as nearly vertical as practicable. Unless local regulations are more strict, trenches 4 ft. (1220 mm) and deeper shall have shored sides as required by OSHA trenching regulations.
  - 2. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for each section of conduit on undisturbed soil at every point along its entire length, except for bell holes.
  - 3. No greater length of trench shall be left open, in advance of the completed structure placed in it, than can be completed in that day's operation.
  - 4. Except where rock is encountered, do not excavate below the depths required. Where rock excavation is required, excavate to a depth of at least 6 inches (150 mm) below the trench depth and fill the overdepth with compacted crusher run or bank run stone or sand. Unauthorized overdepths in excavation shall be backfilled with crushed stone, slag or gravel, thoroughly compacted.
  - 5. Whenever wet or otherwise unstable soil is encountered, it shall be removed to the depth and extent directed, and the trench backfilled to the proper grade with crushed stone, slag or gravel.
- D. Should springs be encountered within the work area, or soft soil conditions at the elevations required for load bearing, immediately notify the Architect and do not place any portion of the work on such surfaces until instructions are received.

- E. Furnish and maintain pumps, flumes, gutters, and appurtenances if required to keep the excavations free from water. Water shall be directed to a point remote from building operations, shown on the approved shop drawing.
- F. Excavation for manholes and similar structures shall be sufficient to leave a minimum of 12 inches (305 mm) and a maximum of 24 inches (610 mm) clearance on all sides. Fill over-depth excavation with concrete.

# 3.26 BACKFILL

- A. Place no backfill until the adjacent construction or the utility to be covered has been inspected, tested, and approved.
- B. Installing underground warning tape: Install in backfill above exterior buried lines not encased in concrete. Select legend and color appropriate for type of line. Install metallic lined tape for non-metallic lines. Install approximately 12 inches (305 mm) below grade.
- C. Electrical systems backfill:
  - 1. Backfill and compact in eight-inch (200-mm) layers, to level finished grade with the excavated materials approved for backfilling.
  - 2. Surplus earth shall be mounded up on excavation and left to settle. When directed by the Architect, surplus earth shall be removed and excavations leveled off to proper grade. Where direct burial cables are placed in trenches, first cover the cables with clean earth.
- D. Structure backfill:
  - 1. Do not backfill against structures with cement mortar joints until the mortar is at least twelve hours old.

## 3.27 COMPACTION

- A. Test in accordance with the requirements of ASTM D 1557.
- B. Compact under slabs, roads, and sidewalks to a 95 percent density.
- C. Compact unpaved areas to a 90 percent density.
- Backfill and compact trench in unpaved areas to within 4 inches (102 mm) of existing grade.
  Furnish and install compacted select topsoil for the final layer to finish even with existing grade.
  Remove surplus earth and rake unpaved areas for final planting.
- E. Take particular care in compaction of earth under joints of mechanical piping.

# 3.28 SEEDING

A. Seed disturbed grass areas at the rate of 5 pounds (2.27 kg) per 1000 sq. ft. (92.9 sq. m), with the seed mix specified.

- B. Uniformly distribute seed with an approved machine to ensure a covering of plus or minus 1/4 inch (6 mm). Sow half of the seed in one direction and the rest at right angles.
- C. Do not seed during windy weather or when ground is wet or otherwise untillable. Seed between the dates of March 1st to May 1st or August 15 to October 15 unless otherwise approved in writing.

# 3.29 MULCHING

- A. Mulch seeded areas immediately following seeding with fibrous mulch evenly applied at an average rate of 2 tons per acre (4483 kg per hectare) so as to provide a loose depth of not less than 2 inches (50 mm).
- B. Wet down mulch, unless a heavy rain wets it, to the Architect's satisfaction, immediately after application.

# SECTION 26 05 07 - FIRESTOPPING FOR ELECTRICAL WORK

## PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Through-penetration firestopping in fire-rated construction.
- B. Through-penetration smoke-stopping in smoke partitions.
- 1.14 RELATED SECTIONS
  - A. Sections specifying requirements for LEED rating are specified in Division 01.
  - B. Conduit: Section 26 05 33.
  - C. Cable tray: Section 26 05 36.

## 1.20 REFERENCES

- A. Underwriters Laboratories
  - 1. UL Fire Resistance Directory
  - 2. UL 1479: Through Penetration Firestops.
- B. American Society for Testing and Materials Standards:
  - 1. ASTM E 814: Standard Test Method for Fire Tests of Through-Penetration Firestops.

## 1.21 DEFINITIONS

- A. Assembly: Particular arrangement of materials specific to given type of construction described in referenced documents.
- B. Barriers: Time-rated fire walls, smoke barrier walls, time-rated ceiling/floor assemblies and structural floors.
- C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.
- D. Penetration: Opening or foreign materials passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.
- E. Sleeve: Metal fabrication or pipe section extending through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.
- F. System: Specific products and applications, classified and numbered by the rating agency to close specific barrier penetrations.

#### 1.25 SYSTEM DESCRIPTION

- A. Design requirements
  - 1. Fire-rated construction: Maintain barrier and structural floor fire resistant ratings including resistance to cold smoke at all penetrations.
  - 2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. LEED submittal:
  - 1. Product data for Indoor Environmental Quality (IEQ) Credit 4.1: For penetration firestopping, including printed statement of VOC content and chemical components.
- C. Product data: Manufacturer's specifications and technical data including the following:
  - 1. Detailed specification of construction and fabrication.
  - 2. Manufacturer's installation instructions.
- D. Quality control submittals: Statement of qualifications.
- E. Applicators' qualifications statement: List past projects indicating required experience.
- F. Certifications: Letters or forms showing acceptance by local authorities for systems without acceptance by a rating agency.
- 1.40 QUALITY ASSURANCE
  - A. Products and assemblies shall be tested and labeled by an independent, nationally recognized testing and labeling authority.
  - B. Comply with requirements for LEED certification specified in Division 01.
  - C. Installer's qualification: Firm experienced in installation or application of systems similar in complexity to those required for this project, plus the following:
    - 1. Acceptable to or licensed by manufacturer, state, or local authority where applicable.
    - 2. At least 2 years experience with systems.
    - 3. Successfully completed at least 5 projects of comparable scale, using these systems.
  - D. Local and state regulatory requirements: Obtain acceptance for proposed assemblies not conforming to specific rating agency classifications or rated assemblies.
  - E. Materials shall have been tested to provide fire rating at least equal to that of the construction in which they are to be installed.

F. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.

# 1.50 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
  - 1. Deliver products in original unopened packaging with legible manufacturer's identification.
  - 2. Coordinate delivery with scheduled installation date, allow minimum storage at site.
- B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

## 1.60 PROJECT CONDITIONS

- A. Existing conditions:
  - 1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
  - 2. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.
- B. Environmental requirements:
  - 1. Furnish adequate ventilation if using solvent.
  - 2. Furnish forced-air ventilation during installation if required by manufacturer.
  - 3. Keep flammable materials away from sparks or flame.
  - 4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
  - 5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

## 1.80 WARRANTY

A. General project warranty and correction period, as required in general conditions and Division 01, requires repair or replacement of materials or systems which fail in joint adhesion, co-adhesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, or general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated.

# PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers and products: Those listed in the UL Fire Resistance Directory for the UL System involved, or rated for the application by Warnock Hersey or by another acceptable rating agency.

# 2.20 THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

- A. Provide systems or devices listed and labeled by a rating agency, and conforming to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance. The system shall be symmetrical for wall applications. Systems or devices shall be asbestos-free.
  - 1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system, or by the use of a separate product included as a part of the rated system or device, and designed to perform this function.

#### 2.22 SMOKE-STOPPING AT SMOKE PARTITIONS

A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

#### 2.23 PENETRATIONS BY CABLE TRAYS

A. Where cable trays penetrate fire-rated construction, provide firestopping materials that may be easily removed to allow installation and removal of cables from the tray. Provide materials similar to fire blocks, fire-stopping pillows, or fire-stopping bags.

#### 2.70 ACCESSORIES

A. Fill, void or cavity materials and forming materials: Classified for firestopping use, or included in a rated firestopping assembly, by a rating agency.

## PART 3 - EXECUTION

#### 3.02 EXAMINATION

- A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
  - 1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.
  - 2. Do not proceed until unsatisfactory conditions have been corrected.

#### 3.05 PREPARATION

A. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

#### 3.20 INSTALLATION

A. Provide firestop devices or assemblies for every opening and penetration in floors or fire-rated construction.

- B. Install penetration seal materials in accordance with printed instructions of the rating agency and in accordance with manufacturer's instruction.
- C. Ensure an effective smoke barrier in each sealed penetration. Install smoke stopping as specified for firestopping.
- D. Protect materials from damage on surfaces subject to traffic.
- E. Where large openings are created in walls or floors to permit installation of conduits, cables, cable tray, or other items, close unused portions of opening with firestopping material tested for the application.
- 3.60 FIELD QUALITY CONTROL
  - A. Examine penetration seals to ensure proper installation before concealing or enclosing them.
  - B. Keep areas of work accessible until inspection and acceptance by applicable authorities.
  - C. Before substantial completion, patch and repair firestopping cut or penetrated by other construction work.
- 3.70 ADJUSTING AND CLEANING
  - A. Clean up spills of liquid components.
  - B. Neatly cut and trim materials as required.
  - C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

## SECTION 26 05 19 - WIRES AND CABLES

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Wire and cable rated 600 V and less.
- B. Type AC cable is not permitted.
- C. Type MC cable is not permitted.

## 1.14 RELATED SECTIONS

- A. Underground ducts and structures: Section 26 05 44.
- B. Conduits: Section 26 05 33.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data:
  - 1. Each type of wire and cable, including accessories.
  - 2. Include copies of UL certifications showing compliance with requirements in "Quality Assurance" below.

#### 1.40 QUALITY ASSURANCE

- A. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70 Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Products and installation shall comply with NFPA 70 and other applicable national, state, and local electrical codes.

# PART 2 - PRODUCTS

#### 2.20 LOW-VOLTAGE CONDUCTORS (600 V. MAX.)

- A. Conductors: Copper, 98 percent conductivity, rated for 75 degrees C, suitable for 600-volt duty, NEMA WC 70 Type THW, THWN, or THHN, solid for No. 10 and smaller and stranded for No. 8 and larger and when specifically noted.
- B. Conductor identification: Markings along outer braid denoting conductor size, type of insulation, and manufacturer's trade name, and color code. Identification shall extend to branch circuits and outlets. Use the color coding system tabulated below throughout the building's network of feeders and circuits, unless otherwise required by the authority having jurisdiction.

- 1. Colors on conductors No. 10 and smaller, or No. 6 and smaller for grounded and grounding conductors: Solid colored insulation.
- 2. Colors on conductors No. 8 and larger, or No. 4 and larger grounded and grounding conductors: Colored tape wrapped a minimum of 6 inches (150 mm) on either end of conductor.

COLOR CODE				
		PHASE		
VOLTAGE	NEUTRAL	А	В	С
120-V, 2 wire	White	Black, Red, or Blue, depending on phase		
208/120-V wye, 3-phase, 4-wire	White	Black	Red	Blue
480/277-V wye, 3-phase, 4-wire	Gray	Brown	Orange	Yellow

- C. Wire used solely for grounding purposes shall be green, if insulated.
- D. Control wiring shall be coded with colors different from those used to designate phase wires.

## 2.21 WIRING ACCESSORIES

- A. Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service where installed.
- B. Compression connectors: Color-keyed, Ideal Industries, Inc., wingnuts, 3M Company "Scotchlock", or equal by Thomas & Betts Corporation.
- C. Compression taps: Series CT-2 tap with CT-2C cover, or Series 54710 color-keyed compression taps, Burndy Corporation "Versitap" or equal by OZ/Gedney.
- D. Make splices in underground junction boxes, handholes, and manholes with waterproof splice kits.
- E. Power distribution blocks: Equal to FCI Burndy "U-Blok."

## PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Provide wiring indicated in accordance with national, state, and local electric codes.
  - B. Install wire and cable in raceways.
  - C. Wire and cable not installed in raceways:

- 1. Support from building structure; do not support from ceiling supports, ceilings, or other utilities.
- 2. Support no less than every 4 feet (1220 mm).

# 3.21 INSTALLING INTERIOR WIRING

- A. Sizes and locations: Minimum sizes unless otherwise indicated on the drawings.
  - 1. 120-V branch circuits, except as specified below:
    - a. Homerun from first outlet to panel: No. 12 when run is 50 feet (15000 mm) or less; No. 10 when run is more than 50 feet (15000 mm).
    - b. First outlet to other outlets: No. 12.
  - 2. Exit light and emergency lighting circuits: No. 10. Do not install in raceways, outlet boxes, or other locations with any other wiring system.
  - 3. Any system: Minimum No. 12 unless specified or shown on drawings to be smaller.
- B. Splicing shall be done in outlet boxes and junction boxes and not in conduit.
  - 1. Conductors No. 8 and larger: Terminated, spliced and taped, wherever practical, with compression connectors or solderless connectors. Use tools recommended by the manufacturer.
  - 2. Splices in conductors No. 10 and smaller, including lighting fixtures: Made with wire connectors.
  - 3. Taps in conductors No. 6 and larger: Made with compression taps or power distribution blocks.
- C. Wiring over boilers, in fluorescent fixture channels, in kitchen hoods, on rooftops and in other high ambient temperature areas shall be of types required by NFPA 70.
- D. Wires shall be neatly shaped in panels, troughs, boxes, and appurtenances.

## 3.22 COORDINATION WITH DEVICES AND EQUIPMENT

- A. Where conductor size or parallel conductors shown on drawings connect to terminals on devices or equipment which is not sized for the connection:
  - 1. Provide a junction box as near the equipment as possible but no more than 10 feet (3 m) away. Obtain approval of location before installing.
  - 2. Provide conductor(s) sized to the ampacity of the equipment, from equipment to junction box.
  - 3. In the junction box, splice the conductors from the equipment to the conductors of sizes, or parallel conductors, shown on the drawings.

## 3.23 INSTALLING EXTERIOR WIRING

A. Exterior lighting and 600-V circuits: Copper, No. 10 minimum, with an extra No. 10 (minimum) bare copper ground conductor.

#### 3.25 INSTALLING CABLE RATED BELOW 100 VOLTS

- A. Install in conduit in walls, in concrete floors, above inaccessible ceilings, where exposed, and wherever it may not be accessible or may be subject to physical damage. Otherwise, install above accessible suspended ceilings and attached to building structure with approved standoff insulated clamps.
- B. Cable routes shall avoid hot utilities which might adversely affect the system's performance or result in damage to the cable. If cable must be placed close to such utilities, keep it separate and protect with insulation.
- C. Do not run cable in hangers used for pipes, electric conduits, or ceiling hangers, nor support it in any way by attachments to pipes, conduits, or ceiling hangers.
- D. Provide separate conduit systems for each low-voltage system.
- E. Each cable run shall contain an S loop or other means to accommodate expansion or contraction.
- F. Cable bends shall have a radius not less than the value recommended by the cable manufacturer.
- G. Tag cables connected to electronic equipment, to show function and the location of other end. Securely fasten labels to the cable.
- H. Where ceiling plenums are used for passage of air by heating and air conditioning system, install low-voltage cables and wiring in conduit or use UL listed plenum cable.

#### **SECTION 26 05 21 - WIRING CONNECTIONS**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Power and control wiring for equipment.
- 1.14 RELATED SECTIONS
  - A. Equipment: Installed items requiring electricity, specified in other sections or shown on drawings.
  - B. Motors: Sections 22 05 13 and 23 05 13.
  - C. Control systems wiring: Section 23 09 02.

## PART 2 - PRODUCTS

#### 2.10 MATERIALS

A. Conduits, wires and cables, devices, and accessories as specified in other sections.

#### PART 3 - EXECUTION

#### 3.20 INSTALLATION

- A. Provide power wiring from motor starters to each motor and its manual controlling device. Interlock and control wiring related to the automatic temperature control system shall be provided under Section 23 09 02, Control Systems Wiring.
  - 1. Make flexible or liquid tight connections as specified in Section 26 05 33, Conduits.
- B. Except where provided with equipment, furnish and install manual pushbutton stations and pilot lights, with wiring. Where stations and pilot lights are grouped at central locations, mount them under a common faceplate.
- C. Rough in and connect to food service, equipment furnished under other sections and equipment furnished by Owner. Make connections as indicated on drawings with exact locations and details determined by approved shop drawings of the equipment.
  - 1. Under equipment sections, equipment will be set in position and the electrical devices and components furnished loose. Assemble, install, and wire under this section.
  - 2. Accomplish rough-in from walls with flush outlet boxes and from floors by means of conduit couplings finishing flush with finished floor.
- D. Certain equipment, as indicated, will be furnished with control panels and auxiliary control components. Mount the panels, furnish and install source wiring and disconnects, and completely connect controls and motors.

- E. Provide source wiring, connections, and disconnects for mechanical heating, ventilating, and air-conditioning (HVAC) equipment specified in Division 23. Refer to sections of Division 23 for equipment and controls.
  - 1. Provide weathertight enclosures for disconnects for outdoor equipment.
  - 2. Mount starters where required, and provide proper size overload protection.
  - 3. Where capacitors are required for power factor correction as specified in 23 05 13, Common Motor Requirements for HVAC Equipment, connect the capacitors.
- F. Roof exhaust fans will be equipped with factory-wired disconnects located adjacent to the motor under the ventilator hoods as specified in Section 23 34 00, HVAC Fans. Exhaust fans shall be controlled by various means as indicated on drawings.
  - 1. For fans shown to be manually controlled, furnish and install a manual motor starting switch with pilot light, located where indicated.
  - 2. Where necessary for larger and three-phase motors, provide magnetic starters.
  - 3. Where fans are provided with electrically operated dampers, provide wiring and relays for single-phase damper operators on three-phase motors.
- G. Cabinet unit heaters will be equipped with a manual motor starting switch with overload protection, located within the cabinet. Provide source wiring to line side of this switch. Automatic control of these units will be as described in Control Sequences.
- H. Where a Division 23 section requires installation of equipment under supervision of equipment manufacturer's representative, coordinate electrical installation to cooperate with representative's requirements.
- I. Provide power sources for Owner-furnished equipment.
- J. Provide power and control wiring for emergency generator, controllers, remote control panels and remote alarm bell. Mount remote bell and silence switch where indicated. Provide plastic nameplates under bell and switch.

## SECTION 26 05 26 - GROUNDING AND BONDING

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Grounding and bonding electrical systems and equipment.
  - B. Ground system test.
- 1.20 REFERENCES
  - A. ANSI/TIA/EIA J-STD-607
  - B. IEEE STD 142
  - C. NFPA 70
  - D. ASTM F467 and F468
  - E. UL 467
- 1.21 DEFINITIONS
  - A. Area served by a separately-derived system: The area within the building that contains any part of a circuit of the system.
  - B. IBGB: Intersystem Bonding Termination Grounding Busbar.
  - C. TMGB: Telecommunications Main Grounding Busbar.
  - D. TGB: Telecommunications Grounding Busbar.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 26 01 01.
  - B. Product data: Ground rods and connections
  - C. Certifications: System test.
- PART 2 PRODUCTS
- 2.20 MANUFACTURED UNITS
  - A. Ground conductor, unless specifically noted otherwise, shall be copper, 98 percent conductivity, solid for No. 10 AWG and smaller and stranded for No. 8 AWG and larger.

- B. Grounding busbar: Predrilled rectangular bars of electro-tin plated copper, 0.25 inches (6.3 mm) thick, 12 inch (300 mm) long, unless otherwise indicated on drawings, with 0.3125 inch or 0.4375 inch (7.9 mm or 11.1 mm) diameter holes horizontally spaced 1 to 1.125 inches (25.4 to 28.6 mm) apart.
  - 1. Intersystem bonding termination grounding busbar (IBGB) and telecommunications main grounding busbar (TMGB) shall be 4 inches (101.6 mm) wide, with four rows of holes. Telecommunications main grounding busbar shall comply with ANSI/TIA/EIE J-STD-607.
  - 2. Other grounding busbars shall be 2 inches (50.8 mm) wide with two rows of holes. Each telecommunications ground busbar (TGB) shall comply with ANSI/TIA/EIA J-STD-607.
  - 3. Stand-off insulators for busbar shall be flame-resistant fiberglass-reinforced thermoset polyester, UL recognized per UL Standard 891.
- C. Ground rods: Copper bonded steel, 0.75 inch diameter by 10 feet long, one end pointed and the other end tinned, equal to the product of Erico International Corporation.
- D. Mechanical type ground connectors:
  - 1. Connectors: IEEE 837 and UL 467 compliant, equal to FCI Burndy G Series, listed for use for specific types, sizes, and combinations of conductors and connected items.
  - 2. Nuts, bolts, and washers: Silicon bronze alloy type B per ASTM F467 and F468.
- E. Exothermic type ground connections: Exothermic welding systems shall be equal to "Cadweld," manufactured by Erico International Corporation.
- F. Lugs: Lugs shall be two- or four-hole, equal to Burndy Hylug series.

## PART 3 - EXECUTION

## 3.21 INSTALLATION, GENERAL

- A. Provide the complete grounding of conduit systems, electrical equipment, conductor and equipment enclosures, motors, transformers, and neutral conductors in accordance with applicable codes. Grounded phase and neutral conductors shall be continuously identified. Continuity of metal raceways shall be insured by double locknuts.
- B. Furnish and install main grounds for secondary electrical service to cold water main in accordance with NEC requirement. In addition to the cold water ground, provide ground rods as indicated or as required by NEC and applicable codes.
- C. Grounding busbar: Busbars shall stand off the wall a minimum of 2 inches (50.8 mm). Mount 6 inches (152.4 mm) above finished floor unless otherwise indicated. Insulate the busbar from its supports.
  - 1. Conductors connecting busbar to other busbars, and to the grounding electrode system shall be attached to busbar with exothermic welds.
  - 2. Connect other conductors to busbar using lugs.

- D. Install copper grounding jumpers of 3/0 copper cable around each main water valve in the building. Install copper grounding jumpers around conduit expansion fittings. Jumpers shall be of adequate current carrying capacity corresponding to size of conduit.
- E. Ground system connections which are beneath the floor and in a concealed or inaccessible location shall be brazed or welded. Brazing and welding shall be "CADWELD."
- F. Separately-derived 120/208-volt three phase wye electrical systems originating in transformers shall be grounded at the transformer neutral terminal:
  - 1. The grounding electrode for the system shall be whichever one of the following that is closest to the transformer:
    - a. Building's grounding electrode.
    - b. Steel structural member of the building conforming to NEC requirements for grounding electrodes.
    - c. First five feet of the water service piping to the building.
- G. Separately-derived three phase wye electrical systems originating in generators shall be grounded at the generator neutral terminal:
  - 1. The grounding electrode for the outdoor generator shall be a ground rod.
  - 2. The grounding electrode for the indoor generator shall be whichever one of the following that is closest to the generator:
    - a. Building's grounding electrode.
    - b. Steel structural member of the building conforming to NEC requirements for grounding electrodes.
    - c. First five feet of the water service piping to the building.
- H. Bonding separately-derived systems:
  - 1. Each metal water piping system, not used as the electrical system's grounding electrode, in the area served by the electrical system shall be bonded to the electrical system's neutral by a system bonding jumper.
  - 2. If exposed structural metal is not used as the grounding electrode for the system, bond exposed structural metal in the area served by the electrical system to the system's neutral by a system bonding jumper.
  - 3. If a metal water piping system in the area served by the electrical system is bonded to exposed structural metal by a NEC-compliant bonding jumper, then only one of the two (piping or structure metal) need to be bonded to the electrical system's neutral.
- I. Bonding straps and jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
  - 1. Bonding to structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  - 2. Bonding to equipment mounted on vibration isolation hangers and supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

- 3. Use exothermic-welded connections for outdoor locations; if a disconnect-type connection is required, use a bolted clamp secured with a minimum of two bolts and lock washers.
- J. Bonding interior metal ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

# 3.23 EQUIPMENT GROUNDING

- A. Provide insulated equipment grounding conductors to all feeders and branch circuits.
- B. Air-duct equipment circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water heater, heat tracing, and antifrost heating cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Signal and communication equipment: In addition to grounding and bonding required by NFPA 70, provide grounding systems complying with requirements in ANSI/TIA/EIA J-STD-607-C.
- E. Gas piping:
  - 1. Comply with NFPA 54.
  - 2. Provide bonding jumpers for each length of corrugated stainless-steel tubing (CSST).
    - a. Jumpers shall be No. 6 AWG or the same size as the equipment grounding conductor serving the equipment served by the CSST, whichever is larger.
    - b. Install in accordance with CSST manufacturers' instructions and NFPA 54.

## 3.30 APPLICATIONS

- A. Underground grounding conductors: Install bare copper conductor, No. 2/0 AWG minimum.
  - 1. Bury at least 24 inches (600 mm) below grade.
  - 2. Duct-bank grounding conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

# 3.59 IDENTIFICATION

- A. Comply with requirements in Section 26 05 00, Common Work Results for Electrical, for instruction signs. The label or its text shall be green.
- B. Install labels at the ends of telecommunications bonding conductors and the grounding electrode conductor where exposed.
  - 1. Label text: "If this connector or cable is loose or must be removed for any reason, please call the building telecommunications manager."

# 3.61 GROUNDING SYSTEM TEST

- A. Ensure that grounding system is continuous and that resistance to earth is not more than 5 ohms.
- B. Test each ground rod for resistance to earth before making connections to rod; tie grounding system together and test for resistance to earth.
- C. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall.
- D. Submit written results of each test including location of rods as well as resistance and soil conditions at time measurements were made.

## **SECTION 26 05 28 - EQUIPMENT FOUNDATIONS**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Equipment foundations (housekeeping pads).
- B. Outdoor equipment foundations.

#### 1.14 RELATED SECTIONS

- A. Service entrance: Section 26 05 41.
- B. Generators: Section 26 32 13.
- C. Transformers: Section 26 22 00.
- D. Switchboards: Section 26 24 13.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Concrete mix, grout, reinforcement, and accessories.
- C. Certifications: Test report showing strength of concrete.

## PART 2 - PRODUCTS

- 2.11 CONCRETE
  - A. Concrete: 3,000 psi (20.7 MPa) compressive strength at 28 days.

# 2.12 GROUT

- A. Non-shrink grout: Premixed, consisting of non-metallic aggregate, cement, water-reducing and plasticizing agents; capable of developing minimum compressive strength of 7,000 psi in 28 days.
  - 1. Five Star Products, Inc. "Five-Star Grout"
  - 2. L&M Construction Chemicals, Inc. "Crystex"
  - 3. Sonneborn "Sonogrout"

# 2.13 METAL REINFORCEMENT

A. Reinforcing bars: Deformed steel bars in accordance with ASTM A615, Grade 60, clean and free from loose rust, scale, or other coatings that will reduce bond.

- B. Welded wire fabric reinforcing: ASTM A 185 No. 6 steel wire spot-welded at intersections and of size 6 by 6 inch mesh.
- C. Metal accessories: Include spacers, chairs, bolsters, ties, and other devices necessary for properly placing, spacing, supporting and fastening reinforcement in place.

# PART 3 - EXECUTION

#### 3.21 INSTALLING EQUIPMENT FOUNDATIONS (HOUSEKEEPING PADS)

- A. Provide 4-inch-high concrete foundations (housekeeping pads) for floor-mounted equipment unless otherwise noted. Furnish foundations, bolts, sleeves, and appurtenances and install as recommended by equipment manufacturer. Anchor the concrete foundations by dowels inserted into the floor slab. Provide welded wire fabric reinforcement.
- B. Unless otherwise specified, install concrete work in accordance with the requirements of Division 03.
- C. Equipment shall be properly aligned. Level and grout equipment where necessary. Support conduit independently of equipment and so as not to cause a strain or thrust.
- D. Coordinate exact locations and configurations of equipment, foundations, and supports with the approved shop drawings of the equipment.

#### 3.22 INSTALLING OUTDOOR EQUIPMENT FOUNDATIONS

- A. Provide equipment foundations of size and thickness indicated.
- B. Place reinforcement accurately in position shown, securely fasten, and support to prevent displacement before or during pouring. Clean, bend, place, and splice reinforcement in accordance with approved shop drawings. Lap ends and sides of mesh reinforcement in slabs not less than one mesh.
  - 1. Coverage of main reinforcing shall be as follows: Slabs, 0.75 inch (19 mm); concrete poured against earth, 3 inches (75 mm); other locations, 2 inches (50 mm).
- C. Properly align, level, and grout equipment.

## SECTION 26 05 33 - CONDUITS

## PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Conduit and accessories, aboveground and below ground where not in duct banks.
- 1.14 RELATED SECTIONS
  - A. Exterior duct banks, manholes, and handholes: Section 26 05 44.
  - B. Firestopping: Section 26 05 07.
  - C. Boxes: Section 26 05 34.
  - D. Trenching: Section 26 05 01

#### 1.21 DEFINITIONS

- A. FMC: Flexible metal conduit.
- B. LFMC: Liquid-tight flexible metal conduit.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data:
  - 1. Each type of conduit included in the work, and related fittings.
  - 2. Accessory materials.
  - 3. Hangers and fasteners.

# PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
- B. Steel conduit and tubing:
  - 1. AFC Cable Systems, Inc. (FMC and LFMC)
  - 2. Allied Tube & Conduit; a Tyco International Ltd-Co.
  - 3. O-Z/Gedney, Unit of General Signal
  - 4. Wheatland Tube Co.
- C. Steel conduit fittings:
  - 1. Appleton Electric Co.

- 2. Cooper Crouse-Hinds.
- 3. Hubbell, Inc.; Killark Electric Manufacturing Co.
- 4. O-Z/Gedney; Unit of General Signal.
- 5. Spring City Electrical Manufacturing Co.
- 6. Thomas & Betts Corporation.
- D. Nonmetallic conduit, tubing and fittings:
  - 1. Allied Tube & Conduit; a Tyco International Ltd. Co.
  - 2. Arnco Corp.
  - 3. Beck Manufacturing
  - 4. CANTEX Inc.
  - 5. Certainteed Corp.; Pipe and Plastics Group
  - 6. Lamson & Sessions; Carlon Electrical Products
- E. Wiring troughs and fittings:
  - 1. Hoffman Engineering Co.
  - 2. Lamson & Sessions, Carlon Electrical Products
  - 3. Square D Schneider Electric
- F. Conduit hangers and supports:
  - 1. Thomas & Betts "Kindorf"
  - 2. Tyco Power-Strut
  - 3. Unistrut Diversified Products
- G. Fasteners:
  - 1. Caddy Fasteners by Erico Products Inc
  - 2. ITW Ramset "Red Head"
  - 3. Wej-It Fastening Systems

## 2.20 CONDUIT AND FITTINGS

- A. Galvanized steel conduit: Hot-dip galvanized with threads galvanized after cutting, one of the following:
  - 1. Rigid full weight, heavy-wall steel conduit (RGS) conforming to UL 6 and ANSI C80.1.
  - 2. Intermediate steel conduit (IMC) conforming to UL 1242 and ANSI C80.6.
- B. Steel conduit fittings: Cast malleable iron fittings with smooth finish and full threaded hubs. Include steel or malleable iron locknuts, bushings, and other fittings.
  - 1. Insulating bushings: Equal to Thomas and Betts Series 22.
  - 2. Hub fittings with recessed sealing ring and nylon insulated throat equal to Thomas and Betts Series 370.
  - 3. Fittings for exposed locations: Conduit outlet bodies, zinc or cadmium plated.

- C. Electrical metallic tubing (EMT): Hot-dip galvanized or sherardized thin-wall steel conduit conforming to UL 797 and ANSI C80.3.
- D. Connectors and couplings for EMT: Concrete- or rain-tight, compression or [set screw] type, made of zinc- or chromium-plated steel, equal to Thomas & Betts Series 5123. Connectors shall have nylon insulating throats.
- E. Flexible metal conduit (Type FMC): Made of sheet metal strip, interlocked construction, conforming to UL 1.
- F. Liquidtight flexible metal conduit (Type LFMC) shall conform to UL 360.
- G. Connectors for flexible metal conduit: Equal to angle wedge "Tite-Bite" with nylon insulated throat, Thomas & Betts Series 3110 and 3130.
- H. Liquidtight type connectors: UL 14814A. Fittings: With nylon insulated throat, equal to Thomas & Betts Series 5331.
- I. Plastic conduit: Polyvinyl chloride (PVC) Schedule 40, rated for use with 90-degree conductors, for exposed, underground, and encased applications, complying with NEMA Specification TC-2, UL 651, and ANSI C33.91.
- J. Plastic conduit fittings and cement:
  - 1. Fittings: Complying with NEMA TC 3, UL 514, and ANSI C33.91.
  - 2. Cement: Solvent cement made by the manufacturer of the conduit and fittings.
- K. Wiring troughs: Steel wiring trough with hinged cover, UL listed as wireways and auxiliary gutters, equal to Square D "Square-Duct."
  - 1. Cover: Opening complete width and length of trough;
  - 2. Finish: Baked enamel.
- L. Fittings for wiring troughs: Made with removable covers to permit installation of a complete system with access to wires throughout the system, UL listed with the troughs. Connections: Threaded screws at every connector.
- M. Weatherproof expansion fittings: With bonding jumpers, equal to O-Z/Gedney types AX and TX.

## 2.21 SLEEVES FOR RACEWAYS

- A. Steel pipe sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
  - 1. Sleeves for exterior walls: Anchor flange welded to perimeter.
- B. Sleeves for rectangular openings: Galvanized sheet steel of length to suit application. Minimum thickness:

- 1. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm): 0.052 inch (1.3 mm).
- 2. For sleeve cross-section rectangle perimeter equal to or more than 50 inches (1270 mm) and 1 or more sides equal to or more than 16 inches (400 mm): 0.138 inch (3.5 mm).
- C. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 05 07.

#### 2.22 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annual space between sleeve and conduit.
  - 1. Sealing elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - 2. Pressure plates: Stainless steel. Include two for each sealing element.
  - 3. Connecting bolts and nuts: Stainless-steel of length required to secure plates to sealing elements. Include one for each sealing element.

#### 2.23 ACCESSORY MATERIALS

- A. Pull rope: Polypropylene, thickness, tensile strength, and work load selected to meet project load requirements.
- B. Caps and plugs: Equal to Thomas & Betts Series 1470.
- C. Lubricant: Equal to Ideal Industries, Inc. "Yellow 77". UL approved.
- D. Bituminous protective coating: Coal tar based, self-priming on steel, applied in a wet film thickness at least 22.0 mils (559 microns) per coat.
- E. Rust inhibitive paint: Alkyd based, equal to Benjamin Moore Super Spec HP D.T.M Alkyd Low Lustre, white, black or bronzetone, applied in a wet film thickness of at least 2.9 mils.

## 2.24 CONDUIT HANGERS

- A. Adjustable hangers: Equal to Kindorf C-149 lay-in hanger or C-150 Clevis hanger.
- B. Trapeze hangers: Constructed of channels with Kindorf C-105 notched steel straps.
- C. Channels: Steel, 1.5 inches (38 mm) wide with 7/8-inch (22-mm) continuous slot, gages and weights equal to Kindorf 900 series.
- D. Beam clamps: Equal to Kindorf E-160 or E-230 adjustable type, for connecting hanger rod to steel beam.
- E. Hangers for conduit 1.0 inch (27 mm) and smaller, through or below bar joists: "Hang-on" hangers attached to joists with Minerallac scissor clips or two-piece stud clips.

F. Finish: All hangers, assemblies, plate washers, rods, locknuts, channels, bolts, and appurtenances shall be hot-dip galvanized.

# 2.25 FASTENERS

- A. General: Select fasteners such that load applied does not exceed one-fourth of manufacturer's load capacity in 3500 psi (24000 kPa) concrete.
- B. Fasteners to concrete: Self-drilling type expansion anchors, or machine bolt drop in anchors for drilled holes. Fasteners to concrete ceilings shall be vibration- and shock-resistant.
- C. Fasteners to drywall or cavity wall: Toggle bolts, hollow-wall drive anchors, or nylon anchors as required.

## PART 3 - EXECUTION

## 3.20 INSTALLATION, GENERAL

- A. Provide complete, separate and independent raceway system for each of the various wiring systems including, but not limited to, the following:
  - 1. Lighting
  - 2. Power
  - 3. Exit Lighting\*
  - 4. Emergency Lighting System\*
  - 5. Fire Alarm System
  - 6. Clock and Program
  - 7. Low Voltage Control System
  - 8. Control Wiring
  - 9. Voice and Data Systems
  - 10. Sound System
  - 11. Security Systems

\*These wiring systems may be installed in common raceways.

- B. Wire all raceway systems completely, except where otherwise indicated, as shown on drawings and as required for satisfactory operation of each system.
- C. Where wiring troughs are required or used to facilitate the installation, amply size them to accommodate conductors, in accordance with NFPA 70.
- D. Types and locations of conduits are scheduled at the end of the section.
- E. Do not install conductors or pull rope during installation of conduit.
- F. Where conduit is connected to a cabinet, junction box, pull box, or auxiliary gutter, protect the conductors with an insulating bushing. Provide locknuts both inside and outside the enclosure. Where conduit is stubbed up to above ceilings for future wiring, close ends with bushings.
- G. Bituminous protective coating:

- 1. Coat exposed threads on steel conduits in concrete slabs at couplings and fittings, after joints are made up.
- 2. Coat metallic conduits below grade not in concrete, and where emerging from below grade or slabs, four inches above and below grade or slab.
- H. Rust-inhibitive paint:
  - 1. Exposed threads of exterior conduit.
  - 2. All unfinished metal components.
- I. Make turns in conduit runs with manufactured elbows or using machines or tools designed to bend conduit. Turns shall be not less than the various radii permitted by NFPA 70.
- J. Sizes:
  - 1. Do not use conduit smaller than 0.75 inch (21 mm).
  - 2. Feeder conduits shall be as large as indicated, or as required by NFPA 70 (whichever is larger). Do not install more than one feeder in a single conduit.
  - 3. Conduit sizes shown on drawings are based on Type THHN/THWN wire.
- K. Make vertical runs plumb and horizontal runs level and parallel with building walls and partitions.
- L. Ground conduits as required by NFPA 70.
- M. Where conduits pass through building expansion joints, and wherever relative movement could occur between adjacent slabs, equip with weatherproof expansion fittings and bonding jumpers.
- N. Where conduits through roof cannot be installed inside equipment or pipe curbs, flash them in accordance with the SMACNA Architectural Manual.
  - 1. Coordinate flashing details and materials with manufacturer and installer of roofing system.
  - 2. Pitch pockets are not permitted.
- O. Run conduits concealed in new construction except where connecting to surface-mounted cabinets and equipment, and in electrical and mechanical equipment spaces. Install conduit above suspended ceilings and within walls and partitions.
- P. From each flush-mounted lighting or power panelboard, provide at least four 0.75-inch empty conduits, to terminate in furred ceiling space above. On floors above ground floor, provide two additional 0.75-inch conduits terminating in furred ceiling space below. Cap these conduits.
- Q. Immediately after each run of conduit is completed, test it for clearance, smooth the joints, and close at each end with caps or plugs to prevent entrance of moisture or debris.
- R. Conduit installed outdoors or at indoor locations exposed to continuous or intermittent moisture shall provide a liquidtight seal. Use steel or malleable iron hub fittings. Coat exposed threads with bituminous protective coating.

- S. Install no conduit in these locations:
  - 1. Setting beds for terrazzo or tile.
  - 2. Concrete toppings, unless specifically approved by Structural Engineer.

# 3.21 INSTALLING PULL BOXES, JUNCTION BOXES, OUTLET BOXES

- A. Install as specified in Section 26 05 34, Boxes.
- B. Install pull or junction boxes in long runs of conduits or where necessary to reduce the number of bends in a run.
  - 1. Select inconspicuous locations. Do not install until locations have been approved by the Architect.
  - 2. Install boxes flush with wall or ceiling surfaces, with flat covers. Where removable ceiling units are used, locate boxes above ceilings.
- C. Verify door swings with door frame installed before locating switch outlets.

# 3.22 INSTALLING FLEXIBLE CONDUIT

- A. Installation shall comply with NFPA 70.
  - 1. Minimum length: Two feet (610 mm).
  - 2. Maximum length: Six feet (1830 mm).
- B. Make immediate connections to recessed lighting fixtures, speakers, and other equipment in suspended ceilings with flexible metal conduit. Include sufficient slack to permit removal of fixture or equipment.
- C. Make immediate connections to motors and transformers with liquidtight flexible conduit. Include sufficient slack to reduce the effects of vibration.
- D. In wet locations, install liquidtight type, in such a manner that liquids tend to run off the surface and not drain toward the fittings.
- E. Where fittings are brought into an enclosure with a knockout, install a gasket assembly consisting of an O ring and retainer on the outside.

## 3.23 INSTALLING PULL ROPE AND CONDUCTORS

- A. After conduit is installed, fish pull rope. After completion of the work of this project, pull rope shall remain in conduits identified as to be left empty.
- B. Do not use a pull rope that has a tensile strength of more than one of the conductors of a twowire circuit, more than two of the conductors of a three-wire circuit, or more than three of the conductors of a four-wire circuit.

- C. Do not pull conductors into the conduits until the system is entirely completed and wet building materials are dry.
- D. Use only a lubricant approved for use with conductor materials and pull rope materials.

# 3.24 INSTALLING SLEEVES

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 05 07.
- B. Concrete slabs and walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Fire-rated assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- D. Cut sleeves to length for mounting flush with both surfaces of walls.
- E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- F. Size pipe sleeves to provide 0.25-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- H. Interior penetrations of non-fire-rated walls and floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint.
- I. Fire-rated-assembly penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Section 26 05 07.
- J. Exterior-wall penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

## 3.25 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
#### 3.26 INSTALLING CONDUIT HANGERS

- A. Single runs of overhead conduits 1.25-inch (35-mm) size and larger shall be supported by adjustable hangers, using 0.375-inch (10-mm) rods for conduits up to 2.0 inch (53-mm) size and 0.5-inch (13-mm) rods for conduits larger than 2.0 inches (53-mm).
- B. Support groups of conduits run in parallel on trapeze hangers suspended from 0.5-inch (13-mm) hanger rods.
- C. Space hangers not over 5 feet (1.5 m) apart for non-metallic conduits, and not over 10 feet (3 m) apart for metal conduits. Support conduits within 3 feet of each outlet, junction or pull box.
- D. Below bar joist construction, support hangers from a length of structural channel, welded to the top chords of at least two joists.
- E. Where large numbers of conduits are grouped together, stagger individual hangers so as not to concentrate the load on a few joists.
- F. Where hanger rods are attached to structural beams, use adjustable beam clamps.
- G. Attach hanger rods to concrete with expansion bolts and anchors.

## 3.29 INSTALLING UNDERGROUND CONDUIT, GENERAL

- A. Depth:
  - 1. Buried under building slabs: Top of conduit no less than 12 inches below the vapor barrier. Seal around conduits where they penetrate the vapor barrier.
  - 2. Outside building: Top of conduit no less than 24 inches below finish grade.
- B. Slope: At least 3 inches in 100 feet away from buildings and toward manholes or other drainage points.
- C. Cleaning: At the completion of each run, in each conduit, first run a testing mandrel not less than 12 inches (305 mm) long with diameter 0.25 inch (6.35 mm) less than the inside diameter of the conduit; then draw through a stiff-bristled brush until all particles are removed. Immediately install conduit plugs.
- D. Except at conduit risers, make changes in direction of runs, either vertical or horizontal, by long sweep bends. Bend may be made up of one or more curved or straight sections or combinations. Use manufactured bends with a minimum radius of 36 inches.
- E. Where underground nonmetallic conduit runs penetrate floor slabs, exterior walls, or bearing walls, penetrations shall be made with metallic elbows. Coat metallic elbows with bituminous protective coating.
- 3.30 INSTALLING UNDERGROUND CONDUIT WITHOUT CONCRETE ENCASEMENT
  - A. Run conduit in straight lines except as necessary.

- B. Trenches: At least three inches (80 mm) clearance on each side of the conduit.
- C. Warning tape: Install in backfill approximately 12 inches (300 mm) below grade.
- D. Under existing roads and paved areas not to be disturbed, jack rigid steel conduit into place.

# 3.90 SCHEDULE OF LOCATIONS

- A. RGS with screw joint couplings:
  - 1. Conduits in concrete slabs except where noted to be plastic.
  - 2. First five feet of conduit extending outside building.
  - 3. Under roads and paved areas where existing pavement is not to be disturbed, extending at least five feet beyond edges of pavement.
  - 4. Elbows penetrating floor slabs, exterior walls, or bearing walls.
- B. IMC with screw joint couplings:
  - 1. Conduits 2.0 inch (53-mm) size and larger except as noted above to be rigid steel.
  - 2. Wiring to exterior equipment.
  - 3. Conduits in boiler room, for fire alarm system, and for security systems.
- C. EMT:
  - 1. Sizes 1.5 inch (41 mm) and smaller except as noted above.
- D. Plastic with solvent cement joints:
  - 1. For exterior circuits, directly buried, except first five feet from building.
  - 2. Where noted under concrete slab, concrete encased.
  - 3. Where noted under concrete slab, direct buried.
  - 4. Where noted in concrete slabs.
  - 5. For concrete encased ductbanks.

# **END OF SECTION**

#### SECTION 26 05 34 - BOXES

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Boxes with covers.
- 1.14 RELATED SECTIONS
  - A. Conduits: Section 26 05 33.
  - B. Outlet boxes where required for special systems: Provided by the equipment manufacturers of the various systems.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Each type of box included in the project.

## PART 2 - PRODUCTS

- 2.01 ACCEPTABLE MANUFACTURERS
  - A. Subject to compliance with requirements, provide products by one of the following:
  - B. Boxes:
    - 1. Appleton/EGS Electrical Group
    - 2. RACO/Hubbell Electrical Products
    - 3. Steel City/Thomas & Betts
  - C. Floor boxes:
    - 1. Hubbell, Inc., Kellems
    - 2. Mono-systems, Inc.
    - 3. Steel City/Thomas & Betts
    - 4. Wiremold

#### 2.10 MATERIALS

- A. Outlet, switch, and junction boxes:
  - 1. Sheet metal: NEMA OS 1, sherardized or galvanized stamped.
  - 2. Cast-metal, where required for weather-exposed, or exposed locations: NEMA FB 1, aluminum, Type FD, with gasketed cover.

## 2.21 BOXES FOR WALLS AND PARTITIONS

- A. Outlet boxes in concrete construction: Octagonal, two-piece type, of sufficient depth to keep conduits not closer than 1 inch (25 mm) to surface.
- B. Switch and receptacle boxes in masonry partitions and walls: Square cornered tile wall boxes 3.5 inches (90 mm) deep, or four-inch (100-mm) square boxes with raised tile wall device covers. The device covers shall be of extra depths required to suit the block or brick construction in which they are placed.
- C. Switch and receptacle boxes in metal stud partitions: 4 inches (100 mm) square by 1.5 inches (38 mm) deep boxes with 0.75-inch (19-mm) raised tile wall device covers finishing flush with finished wall surface.
- D. Wall- and partition-mounted outlets for low-voltage systems: Same as specified above for switches and receptacles.
- 2.22 JUNCTION AND PULL BOXES
  - A. Junction and pull boxes in feeder conduit runs: Galvanized, of size required for conduit arrangement and not less than the size required by NFPA 70, and furnished with screwed covers.

## 2.23 FLOOR BOXES

A. Floor box for power and communications equal to Wiremold EFB Evolution Series, complete in-floor multi-service box consisting of floor box housing, removable cover, wiring devices, and device plates as detailed on drawings.

## PART 3 - EXECUTION

#### 3.20 INSTALLATION

- A. Provide box at each outlet, switch, and appurtenance. Each box shall be of a type suitable for the duty intended and shall be installed in accordance with the manufacturer's instructions.
  - 1. Where conduit is weather-exposed or exposed, provide cast-aluminum boxes.
- B. Coordinate locations of boxes with installation of conduit as specified in Section 26 05 33.
- C. Do not install boxes back-to-back (through the wall) in partitions.
- D. Firmly secure the boxes in place, plumb, level, and with front of device cover even with finished wall surface.
- E. Boxes in metal stud walls or partitions shall be securely supported by metal channels spanning between two studs and attached to same.
- F. Outlet boxes used for supporting lighting fixtures: Furnish with malleable iron fixture studs of "No-Bolt" type, secured by locknut. Provide structural channel supports for boxes occurring in

ceilings. Outlets in ceilings directly on bottom of joists shall be supported independent of ceiling construction. Outlets in suspended ceilings shall not be supported from ceiling construction. Special supports for boxes shall be as directed and approved by the Architect.

- G. Where service fittings will not permit ganging of boxes for floor outlets, outlets shall be as close as practicable.
- H. Provide a single cover plate where two or more devices are grouped together in one box.
- I. Verify door swings with door frame installed before locating switch outlets.
- J. Outlet boxes in fire-rated assembly:
  - 1. Clearance between boxes and wallboard shall not exceed 0.125 inch (3.2 mm).
  - 2. Surface area of individual outlet box does not exceed 16 square inches (103 sq cm).
  - 3. Entire surface area of boxes shall not exceed 100 square inches (645 sq cm) per 100 square feet (9.3 sq m) of wall surface.

## 3.59 IDENTIFICATION

- A. Identification on outside covers of pull and junction boxes in ceiling space or exposed on walls: Paint with colored enamel or mark with permanent waterproof black marker, or both, as specified.
  - 1. Fire alarm system: Red.
  - 2. Other special systems: Mark with system type, such as Data, Public Address, or Security.
  - 3. Power and lighting: Panelboard designation and circuit number(s).

# **END OF SECTION**

## SECTION 26 05 41 - LOW-VOLTAGE SERVICE ENTRANCE

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Service entrance for electric service, 480 V, 3 phase, 4 wires.
- B. Service entrance for communication services.

#### 1.14 RELATED SECTIONS

- A. Temporary power for construction: Division 01.
- B. Trenching: Section 26 05 01.
- C. Electrical manholes and underground ductbank: Section 26 05 44.
- D. Equipment foundations: Section 26 05 28.
- 1.18 PAYMENT PROCEDURES
  - A. New electric service will be installed by Baltimore Gas & Electric Co. (the Power Company).
  - B. Submit the bill on completion of this part of the work. Owner will directly pay the Power Company.

#### 1.30 SUBMITTALS

- A. General: Submit in accordance with Division 01 and Section 26 01 01.
- B. Product data: Each type of device or equipment required for the installation.
- C. Shop drawings: Submit shop drawings and other information as required to the Power Company.
- D. Certifications: Copy of certification for installation required by Power Company.

## 1.71 COORDINATION

- A. New electric service will be installed by Baltimore Gas & Electric Co. (the Power Company). Contact the designated power company service representative and verify the status of the project service application. If the current service application has expired, resubmit the service application using load data from the original application.
- B. New communications service(s) will be installed by Verizon and Comcast. Contact the service company representative(s) to coordinate installation of the new service(s).

- C. Arrange a project site meeting to verify that the proposed service entrance configuration is acceptable to the service company. Participants of the meeting shall include the service company representative, the Owner, the Contractor and the Architect/Engineer.
- D. Contact "Miss Utility" (1-800-257-7777) prior to any excavation or underground work. The location and depth for all utilities shall be verified.

# PART 2 - PRODUCTS

## 2.20 CONDUITS

- A. Power Company will provide primary and secondary cables, transformers, and meters, as described in the article "Installation by Power Company," below.
- B. Conduits: As specified and scheduled in Section 26 05 33, Conduits.
- C. Ductbanks: As specified in Section 26 05 44, Underground Ducts and Utility Structures, and in accordance with Power Company requirements.
- D. Fittings: As required by installation and by Power Company requirements, and as specified in Section 26 05 33, Conduits.

#### PART 3 - EXECUTION

#### 3.05 PREPARATION

- A. Coordinate installation with Power Company.
- B. Coordinate installation with communications service company.
- C. Coordinate installation with installation of gas lines and other underground utilities specified in Division 15.
- 3.20 INSTALLATION BY POWER COMPANY
  - A. Primary power from Power Company lines to a point underground at the property line.
  - B. Primary and secondary cables, transformer, and terminations to building main switchboard, including meters.

#### 3.21 INSTALLATION INCLUDED IN WORK OF THIS PROJECT

- A. Concrete encased ductbank from property line to power company transformer as indicated on the drawings, minimum 5 inches (127 mm), as specified in Section 26 05 44, Underground Ducts and Utility Structures, including markers or underground warning tape and in accordance with Power Company requirements.
- B. Concrete encased ductbank from transformer to C/T Cabinet location as indicated on the drawings, minimum 4-inches (102 mm), as specified in Section 26 05 44, Underground Ducts

and Utility Structures, including markers or underground warning tape, and in accordance with Power Company requirements.

- C. Where conduit enters a transformer or meter cabinet, provide bellmouth fittings on conduit ends 2 inches (51 mm) above the concrete slab.
- D. Concrete foundation for Power Company transformer: Specified in Section 26 05 28, Equipment Foundations.
- E. Manholes as shown on the drawings: Specified in Section 26 05 44, Underground Ducts and Utility Structures.

# 3.23 TELECOMMUNICATIONS SERVICES INSTALLATION

- A. Conduit for telecommunications services, including fiber optic cables, is indicated on the drawings.
- B. Provide conduits in ductbank for telecommunications services, as specified in Section 26 05 44. Spacing between conduits shall be no less than 3 inches.

# END OF SECTION

## SECTION 26 05 44 - UNDERGROUND DUCTS AND UTILITY STRUCTURES

#### PART 1 - GENERAL

#### 1.10 SUMMARY

- A. This section includes the following:
  - 1. Ducts in directly buried duct banks.
  - 2. Ducts in concrete-encased duct banks.
  - 3. Handholes and handhole accessories.

#### 1.20 REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO):
  - 1. AASHTO-HB 17: Standard Specifications for Highway Bridges. Includes the AASHTO categories for structural loads:
    - a. Heavy traffic: HS20.
    - b. Medium traffic: HS15.
    - c. Light traffic: H10.
- B. ASTM International (ASTM)
  - 1. ASTM C 478: Precast Reinforced Concrete Manhole Sections.
  - 2. ASTM C 857: Minimum Structural Design Loading for Underground Precast Concrete Utility Structures. Includes classes which correspond to AASHTO categories:
    - a. Heavy traffic: Class A-16.
    - b. Medium traffic: Class A-12.
    - c. Light traffic: Class A-8.
    - d. Walkway: Class A-0.3, 300 lb/sq ft (1465 kg/sq m).
  - 3. ASTM C 858: Specification for Underground Precast Concrete Utility Structures.
- C. Society of Cable Telecommunications Engineers (SCTE):
  - 1. SCTE 77: Specification for Underground Enclosure Integrity. Light duty and pedestrian traffic only. Includes Tiers for specific applications, and static vertical wheel load ratings:
    - a. Tier 5: Sidewalk applications with a safety factor for occasional nondeliberate vehicular traffic.
    - b. Tier 8: Sidewalk applications with a safety factor for nondeliberate vehicular traffic.
    - c. Tier 15: Driveway, parking lot, and off-roadway applications subject to occasional nondeliberate heavy vehicular traffic.

#### 1.30 SUBMITTALS

A. Product data: For the following:

- 1. Handhole hardware, cable racks, and stanchions.
- 2. Conduit and ducts, including elbows, bell ends, bends, fittings, and solvent cement.
- 3. Duct-bank materials, including spacers and miscellaneous components.
- 4. Warning tape.
- B. Shop drawings: Show fabrication and installation details for underground ducts and utility structures and include the following:
  - 1. For precast handholes, shop drawings shall be signed and sealed by a qualified professional engineer, and shall show the following:
    - a. Construction of individual segments.
    - b. Joint details.
    - c. Design calculations.
- C. Product certificates: For concrete and steel used in underground precast handholes, according to ASTM C 858.
- D. Product test reports: Indicate compliance of handholes with ASTM C 857 and ASTM C 858, based on factory inspection.
- 1.40 QUALITY ASSURANCE
  - A. Electrical components, devices, and accessories (including ducts for communications and telephone service): Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - B. Comply with ANSI C2.
  - C. Comply with NFPA 70.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Deliver ducts to project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
  - B. Store precast concrete units at project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
  - C. Lift and support precast concrete units only at designated lifting or supporting points.
- 1.60 PROJECT CONDITIONS
  - A. Existing utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated.
    - 1. Notify Architect at least two days in advance of proposed utility interruptions.
    - 2. Do not proceed with utility interruptions without Architect's written permission.

## 1.71 COORDINATION

- A. Coordinate layout and installation of ducts and handholes with final arrangement of other utilities and site grading, as determined in the field.
- B. Coordinate elevations of ducts and duct-bank entrances into handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations from those indicated as required to suit field conditions and to ensure duct runs drain to handholes, and as approved by Architect.

## PART 2 - PRODUCTS

## 2.01 PRODUCTS AND MANUFACTURERS

- A. Available manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
  - 1. Nonmetallic ducts and accessories:
    - a. ARNCO Corp.
    - b. Beck Manufacturing Inc.
    - c. Cantex, Inc.
    - d. CertainTeed Corp.; Pipe & Plastics Group.
    - e. ElecSys, Inc.
    - f. Electri-Flex Co.
    - g. IPEX, Inc.
    - h. Lamson & Sessions; Carlon Electrical Products.
    - i. Manhattan/CDT
    - j. Spiraduct/AFC Cable Systems, Inc.
  - 2. Underground precast concrete utility structures:
    - a. A.C. Miller Concrete Products, Inc.
    - b. Elmhurst-Chicago Stone Co.
    - c. Oldcastle Precast Group
    - d. Wausau Tile, Inc.
  - 3. Precast polymer concrete enclosures for underground construction:
    - a. Quazite/Strongwell (Hubbell Power Systems, Inc.).
    - b. Synertech (Division of Oldcastle Precast).
- 2.20 CONDUIT
  - A. Conduit and fittings are specified in Section 26 05 33.
- 2.21 DUCTS

- A. Rigid nonmetallic conduit: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by the same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.
- B. Rigid nonmetallic conduit: NEMA TC 2, Type EPC-80-PVC, UL 651, with matching fittings by the same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

## 2.22 HANDHOLES

- A. Cast-metal boxes: Cast aluminum, with outside flanges and recessed, gasketed cover for flush mounting and with nonskid finish and legend on cover. Unit, when buried, shall be designed to support AASHTO H10 loading.
- B. Precast handholes: Reinforced concrete, monolithically poured walls and bottom, with cast-aluminum frame and access door assembly forming the top of handhole. Duct entrances and windows shall be located near corners to facilitate racking. Pulling-in irons and other built-in items shall be installed before pouring concrete. Cover shall have nonskid finish and legend. Unit, when buried, shall be designed to support AASHTO H10 loading.
- C. Polymer concrete handholes: Molded of sand and aggregate bound with polymer resin, and reinforced with steel, with 6-inch (150-mm) square cable entrance at each side and weatherproof cover with nonskid finish and legend. Unit, when buried, shall be designed to support SCTE 77 Tier 15 loading.
- D. Cover legend: "ELECTRIC" or "COMMUNICATIONS".

## 2.25 ACCESSORIES

- A. Duct spacers: Rigid, nonmetallic, horizontally and vertically interlocking spacers, selected to provide minimum duct spacings and cover depths indicated while supporting ducts during concreting and backfilling.
- B. Pulling and lifting irons in floor: 0.875-inch-22-mm- diameter, hot-dip-galvanized, bent steel rod; stress relieved after forming; and fastened to reinforced rod. Exposed triangular opening.
  - 1. Ultimate yield strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
- C. Bolting inserts for cable stanchions: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 0.5-inch (13-mm) ID by 2.75 inches (69 mm) deep, flared to 1.25 inches (30 mm) minimum at base.
  - 1. Tested ultimate pullout strength: 12,000 lbf (53 kN) minimum.
- D. Expansion anchors for installation after concrete is cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 0.5-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.
- E. Cable stanchions: UL listed glass-reinforcement nylon; 4 inches (100-mm) wide by 36 inches (915 mm) long, prepunched for cable arm attachment.

- F. Cable arms: UL-listed glass-reinforced nylon; load capacity when assembled, 250 lbs at one inch from end of arm; 9 inches (230 mm) wide by 20 inches (510 mm) long and arranged for secure mounting in horizontal position at any location on cable stanchions.
- G. Grounding materials: Comply with Section 26 05 26.
- H. Duct-sealing compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and of adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- I. Warning tape: Underground-line warning tape specified in Section 26 05 01, Excavation and Fill for Electrical Work.
- 2.26 CONSTRUCTION MATERIALS
  - A. Waterproofing: Comply with Division 07 section specifying waterproofing.
  - B. Mortar: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
  - C. Concrete: Use 3000-psi- (20.7-MPa-) minimum, 28-day compressive strength and 0.375-inch (10-mm) maximum aggregate size. Concrete and reinforcement are specified in Division 03 Section "Cast-in-Place Concrete."

## PART 3 - EXECUTION

## 3.20 APPLICATIONS

- A. Underground ducts for electrical cables higher than 600 V: Type EPC-40-PVC concrete-encased duct bank.
- B. Underground ducts for electrical feeders 600 V and below: Type EPC-40-PVC, oncrete-encased duct bank.
- C. Underground ducts for electrical branch circuits 600 V and below: Type EPC-40-PVC, directly buried duct bank, except use Type EPC-40-PVC, concrete-encased duct bank, when crossing roads.
- D. Underground ducts for telephone utility service: Type EPC-40-PVC, directly buried duct bank, except use Type EPC-40-PVC, concrete-encased duct bank, when crossing roads.
- E. Underground ducts for communication circuits: Type EPC-40-PVC, directly buried duct bank.
- F. Handholes: Underground precast concrete utility structures or precast polymer concrete enclosures.
- 3.21 EARTHWORK

- A. Excavation and backfill: Comply with Section 26 05 01, Excavation and Fill for Electrical Work, but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore all areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching.

## 3.22 CONDUIT AND DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward handholes and away from buildings and equipment. Slope ducts from a high point in runs between two handholes to drain in both directions.
- B. Curves and bends: Use manufactured rigid steel elbows for stub-ups at equipment and at building entrances. Use manufactured long sweep bends with a minimum radius of 25 feet (7.5 m), both horizontally and vertically, at other locations.
- C. Use solvent-cement joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.
- D. Duct entrances to handholes: Space end bells approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts and vary proportionately for other duct sizes. Change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line. Grout end bells into handhole walls from both sides to provide watertight entrances.
- E. Building entrances: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall. Use fittings manufactured for this purpose. Follow the appropriate installation instructions below:
  - 1. Concrete-encased ducts: Install reinforcement in duct banks passing through disturbed earth near buildings and other excavations. Coordinate duct bank with structural design to support duct bank at wall without reducing structural or watertight integrity of building wall.
  - 2. Waterproofed wall and floor penetrations: Install a watertight entrance-sealing device with sealing gland assembly on the inside. Anchor device into masonry construction with one or more integral flanges. Secure membrane waterproofing to the device to make permanently watertight.
- F. Concrete-encased, nonmetallic ducts: Support ducts on duct spacers, spaced as recommended by manufacturer and coordinated with duct size, duct spacing, and outdoor temperature. Install as follows:
  - Separator installation: Space separators close enough to prevent sagging and deforming of ducts and secure separators to earth and to ducts to prevent floating during concreting. Stagger spacers approximately 6 inches (150 mm) between tiers. Tie entire assembly

together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

- 2. Concreting: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application. Pour each run of envelope between handholes or other terminations in one continuous operation. If more than one pour is necessary, terminate each pour in a vertical plane and install 0.75-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.
- 3. Reinforcement: Reinforce duct banks where they cross disturbed earth and where indicated.
- 4. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
- 5. Minimum clearances between ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and signal ducts.
- 6. Depth: Install top of duct bank at least 24 inches (600 mm) below finished grade in nontraffic areas and at least 30 inches (750 mm) below finished grade in vehicular traffic areas, unless otherwise indicated.
- G. Warning tape: Bury warning tape approximately 12 inches (300 mm) above all concrete-encased duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank.
- H. Stub-ups: Use rigid steel conduit for stub-ups to equipment. For equipment mounted on outdoor concrete bases, extend steel conduit a minimum of 5 feet (1.5 m) from edge of base. Install insulated grounding bushings on terminations. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches (75 mm) of concrete.
- I. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
- J. Pulling cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.

## 3.23 HANDHOLE INSTALLATION

- A. Elevation: Install handholes with depth as indicated. Where indicated, cast handhole cover frame directly into roof of handhole and set roof surface 1 inch (25 mm) above grade.
- B. Drainage: Install drains in bottom of units where indicated. Coordinate with drainage provisions indicated.
- C. Grounding: Install ground rod through floor in each structure with top protruding 4 inches (100 mm) above floor. Seal floor opening against water penetration with waterproof nonshrink grout. Ground exposed metal components and hardware with bare-copper ground conductors.

Train conductors neatly around corners. Use cable clamps secured with expansion anchors to attach ground conductors.

## 3.60 FIELD QUALITY CONTROL

- A. Testing: Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
- B. Grounding: Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26.
- C. Duct integrity: Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of the duct. If obstructions are indicated, remove obstructions and retest.
- D. Correct installations if possible and retest to demonstrate compliance. Remove and replace defective products and retest.

## 3.61 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

# **END OF SECTION**

## **SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS**

#### PART 1 - GENERAL

- 1.10 SUMMARY
  - A. This section includes electrical identification materials and devices required to comply with ANSI, NFPA, and OSHA standards.
  - B. This section addresses identification of electrical equipment, raceways, boxes, conductors, and other related electrical system components.
- 1.11 SECTION INCLUDES
  - A. Identification of power conductors and control cables.
  - B. Identification of equipment and instructions.
  - C. Miscellaneous identification products.
- 1.14 RELATED SECTIONS
  - A. Sections 26 05 19, Wires and Cables, and 26 05 33, Conduits.

#### 1.20 REFERENCES

- A. ANSI A13.1: Scheme for the Identification of Piping Systems.
- B. ANSI Z535.4: Standard for Product Safety Signs and Labels.
- C. ANSI/IEEE C2: National Electrical Safety Code.
- D. NFPA 70: National Electrical Code.
- E. NFPA 70E: Standard for Electrical Safety in the Workplace.
- F. OSHA 29 CFR 1910.144: Safety Color Code for Marking Physical Hazards.
- G. OSHA 29 CFR 1910.145: Specifications for Accident Prevention Signs and Tags.
- H. UL 969: Standard for Marking and Labeling Systems.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 26 01 01.
  - B. Product data: For each type of electrical identification product.
  - C. Identification schedule: An index of nomenclature for electrical equipment and system components used in identification signs and labels.

- D. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products. Non-rigid samples shall be mounted on 8.5-inch by 11-inch sheets with annotation explaining proposed use.
- 1.40 QUALITY ASSURANCE
  - A. Comply with ANSI A13.1 and IEEE C2.
  - B. Comply with NFPA 70.
  - C. Comply with OSHA standards.
  - D. Comply with ANSI Z535.4 for safety signs and labels.
  - E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

## 1.49 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other sections requiring identification applications, drawings, shop drawings, manufacturer's wiring diagrams, and the operation and maintenance manual; and with those required by codes, standards, and safety regulations. Use consistent designations throughout Project.
- B. Coordinate installation of identification materials and devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identification materials and devices with location of access panels and doors.
- D. Install identifying materials and devices before installing acoustical ceilings and similar concealment.

## PART 2 - PRODUCTS

## 2.01 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following manufacturers, or approved equal:
  - 1. Brady USA, Inc.
  - 2. Carlton Industries
  - 3. Ideal Industries, Inc.
  - 4. Panduit Corporation
  - 5. Presco
  - 6. Seton Identification Products
  - 7. Thomas and Betts Company
  - 8. Utility Safeguard

#### 2.10 GENERAL PRODUCT REQUIREMENTS

A. Except where otherwise indicated, provide manufacturer's standard identification products of category and type suitable for each application. Where more than one identification method is specified for an application, the Installer shall select and utilize each material in a consistent manner.

#### 2.11 CONDUCTOR AND CABLING IDENTIFICATION

- A. Adhesive labels: Preprinted, flexible, self-adhesive vinyl with legend overlaminated with a clear weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- B. Marker tapes: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

#### 2.12 EQUIPMENT IDENTIFICATION

- A. Engraved plastic nameplates: Laminated plastic, engraved, white letters on black background, except where other color schemes are noted or specified.
  - 1. Size: Minimum 0.75-inch (19 mm) by 2.5-inches (64mm).
  - 2. Letter size: Minimum height of 0.375-inch (10 mm).
  - 3. Mechanically fastened, except adhesive mounted where necessary due to substrate.
    - a. Mechanical fastener: Punched or drilled, with vandalproof stainless steel or brass screws or rivets.
- B. Baked-enamel signs: Preprinted, aluminum signs, punched or drilled for fasteners with corner grommets; with colors, legend, and size required for application.
- C. Exterior, metal-backed, signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate (CAB) signs with galvanized steel backing; punched or drilled for fasteners with corner grommets; with colors, legend, and size required for application.
- D. Adhesive film label: Machine-printed, black letters on white background, through thermal transfer or equivalent process, with clear weatherproof and UV-resistant covering. Minimum letter size height of 0.375-inch (10 mm).

## 2.13 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Underground warning tape: Permanent, bright-colored, continuous-printed, vinyl tape for use with underground cables, conduits, and ductbanks. Comply with ANSI Z535.
  - 1. Not less than 6-inches wide by 4 mils thick (152 mm wide by 0.102 mm thick).
  - 2. Tape Material:
    - a. Made of metal detectable polyester or vinyl.

- b. Compounded for permanent direct-burial service. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to destructive substances commonly found in soils.
- 3. Printed legend with black lettering, indicating type of underground line.
  - a. Provide inscriptions for power cabling with red-colored tape: Example "CAUTION BURIED ELECTRIC LINE BELOW".
  - b. Provide inscriptions for low-voltage system cabling with orange-colored tape: Example – "CAUTION – BURIED FIBER OPTIC LINE BELOW".
- B. Wiring device tape labels:
  - 1. Adhesive film label: Machine-printed, black letters on clear background, through thermal transfer or equivalent process. Minimum letter size height of 0.25-inch (6 mm).
    - a. Labeling for electrical devices and components such as receptacles, switches, control device stations, manual motor starters, network and phone jacks, junction and pull boxes, etc.
- C. Warning labels and signs:
  - 1. Self-adhesive warning labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configures for display on front cover, door, or other access to equipment unless otherwise noted.
  - 2. Baked-enamel warning signs: Preprinted, aluminum signs, punched or drilled for fasteners with corner grommets; with colors, legend, and size required for application.
  - 3. Fasteners: Self-tapping, stainless-steel screws or, stainless-steel machine screws with nuts, flat and lock washers.
- D. Tape markers: Vinyl, pressure-sensitive, with clear vinyl overlay.
  - 1. Working space, floor markers: Minimum 2-inch (50mm) wide, 5 mil (0.125 mm) thick, with black and white stripes.
- E. Cable ties: Fungus-inert, self-extinguishing, one-piece, self-locking, color-coded, nylon cable ties suitable for the application (general purpose, UV-stabilized outdoor, or plenum rated).
- F. Paint: Formulated for the type of surface, location, and intended use.
- G. Stenciling: Nonfading, waterproof, ink or paint. Black or color-coded.
- H. Adhesive: Heavy-duty, thermo-resistant, industrial grade adhesive, for adhesion to any surface without identification curling, peeling, or falling off.

## PART 3 - EXECUTION

## 3.20 INSTALLATION

A. Verify identity of each item before installing identification products.

- B. Location: Install identification products at locations for most convenient viewing without interference with operation and maintenance of equipment.
  - 1. For finished public spaces, coordinate identification product mounting locations with Architect
- C. Apply identification products to surfaces after equipment finish work has been completed.
- D. Clean surfaces before applying identification products, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. System identification labeling for raceways and cables: Each label shall be installed on sidewall of conduit and easily placed for proper identification. Locate labels at changes in direction, at penetrations of walls and floors, at 50-foot (15 m) maximum intervals in straight runs, and at 25-foot (7.6 m) maximum intervals in congested areas.
- G. Underground-line warning tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16-inches (400 mm) overall.

## 3.30 APPLICATION

- A. Miscellaneous:
  - 1. Access doors and panels: Apply engraved nameplate labels at access doors identifying concealed electrical item. Do not locate labels in finished, public spaces.
- B. Junction and pull boxes:
  - 1. Label each junction and pull box, identifying circuit designation or type of system.
    - a. Exposed boxes: Place label on coverplate, externally visible.
    - b. Concealed boxes: Place label or tag on inside cover of box.
    - c. Junction boxes concealed above suspended ceilings or exposed in non-occupied spaces may be marked with permanent ink marker in lieu of printed labels.
  - 2. Boxes with conductors greater than 600V: Apply labels identifying nominal system voltage on cover and minimum of one fixed side. One label shall be visible from the floor where boxes are installed exposed.
  - 3. Fire alarm system boxes shall have red finish. Boxes shall be prefinished prior to installation.
- C. Wiring and cabling identification:

- 1. Power circuit conductor identification, 600 V or less: Apply color-coded identification for cables, feeders, and power circuit conductors exposed in accessible vaults, junction and pull boxes, utility structures, and equipment enclosures. Apply color-coding scheme as indicated below throughout the building's network of feeders and circuits, unless otherwise required by the authority having jurisdiction.
  - a. Colors on conductors No. 10 and smaller, or No. 6 and smaller for grounded and grounding conductors: Solid colored insulation.
  - b. Colors on conductors No. 8 and larger, or No. 4 and larger for grounded and grounding conductors: Apply colored tape wrapped a minimum of 6 inches (150 mm) on either end of conductor and in boxes where splices or taps are made.
  - c. Conductors used solely for grounding purposes shall be green, if insulated.
  - d. Where multi-conductor cables are used, use same color coding system for identification of wiring.

COLOR CODE (600 V Max.)				
VOLTAGE	NEUTRAL	PHASE		
		А	В	С
120-V, 2-wire	White	Black, Red, or Blue depending on phase		
277-V, 2-wire	Gray	Brown, Orange, or Yellow depending on phase		
208/120-V wye, 3-phase, 4-wire	White	Black	Red	Blue
480/277V wye, 3-phase, 4-wire	Gray	Brown	Orange	Yellow

- 2. Power circuit conductor identification, greater than 600 V: Apply nonmetallic tags or aluminum, wraparound marker bands where cables, feeders, and power circuits are exposed in vaults, junction and pull boxes, and utility structures. Apply securely fastened legend identifying circuit or feeder designation.
- 3. Conductors for future use: Attach tags with circuit designation for conductors to be extended for future use.
- 4. Control and low-voltage system wiring shall be coded with colors and markings different from those used to designate phase wires.
- D. Wiring device labels: For wiring devices such as receptacles, devices installed in surface raceway assemblies, and other wiring devices operating at or greater than 120V.
  - 1. Apply adhesive film labels on inside of wiring device identifying circuit designation serving device.
- E. Equipment Identification: Install unique designation label consistent with contract documents and shop drawings.
  - 1. Labeling instructions:
    - a. Engraved plastic laminate nameplates, unless otherwise indicated.
    - b. Unless otherwise required, provide a single line of text with 0.5-inch (13mm) high lettering on 1.5-inch (38mm) high label. Where two or more lines are required, use single label with increased height.
    - c. For multi-section or multi-compartment equipment, apply labels identifying each compartment or section.
    - d. For fusible equipment, identify fuse type and size on the front cover.

- e. For enclosed circuit breaker equipment, identify device trip rating where rating is not visible.
- f. Where equipment has more than one source of power (i.e., transfer switch, separate control power source), the location and circuit designation of each power source shall be clearly identified at the equipment location.
- 2. Apply nameplates and labels to equipment according to the below identification schemes:
  - a. Identify equipment designation; voltage rating; phase and number of wires; and designation and location of load served. Apply products to the following equipment:
    - (1) Panelboards
    - (2) Switchboards
    - (3) Switchgear
    - (4) Substations
    - (5) Dimming system equipment
  - b. Identify equipment designation; primary and secondary voltage ratings; phase and number of wires; circuit designation and location of primary source; and designation and location of load served. Apply products to the following equipment:
    - (1) Disconnect switches
    - (2) Enclosed circuit breakers
    - (3) Contactors
    - (4) Motor starters and combination motor starter-disconnects
    - (5) Variable frequency drives
    - (6) Transformers
  - c. Identify equipment designation; voltage rating; phase and number of wires; and capacity rating. Apply products to the following equipment:
    - (1) Generator: Capacity rating in kilo-watts (kW).
    - (2) Transfer switches: Capacity rating in amperes; identify the location and circuit designation of each power source at the equipment location.
  - d. Identify equipment designation; and circuit designation and location of primary source. Apply products to the following equipment:
    - (1) Monitoring and control equipment
    - (2) Control stations
    - (3) Fire alarm control panels and auxiliary equipment
    - (4) Security panels and auxiliary equipment
- 3. Nameplates shall incorporate white lettering on colored backgrounds based on the following color-coding scheme:
  - a. Normal Power System: Black background.
  - b. Emergency Power System (Life-Safety Branch): Red background.
  - c. Emergency Power System (Equipment Branch): Blue background.

- F. Working space requirements: Identify required working clearances at electrical equipment. Working clearance dimensions shall be in compliance with NFPA 70 and OSHA regulations.
- G. Warning and caution labels and signs:
  - 1. Apply warning and caution labels on equipment in accordance with NFPA 70 and 70E, ANSI, and OSHA requirements including arc-flash hazard warning labels and special clearance requirements.
  - 2. Apply warning and caution labels and signs at locations where safe operation and maintenance of electrical system equipment is of concern.
  - 3. Apply warning signs on electrical room doors in accordance with NFPA 70 and 70E, ANSI, and OSHA requirements. Where doors are located in finished, public areas, located sign on the inside of the door. Coordinate mounting requirements with door type.
- H. Service-entrance equipment: Provide field marking of service entrance equipment maximum available fault current values in accordance with NFPA 70 requirements.
- I. Underground warning tape: Apply underground warning tape above underground ductbanks, conduit, or direct-buried cable.
- 3.60 FIELD QUALITY CONTROL
  - A. Coordinate names, abbreviations, colors, and other designations with construction documents, submittals, and applicable code and standards requirements. Utilize consistent designations and identification techniques throughout project.
  - B. Install identification products at locations that are clearly visible at normal viewing angles and without interference with operation and maintenance of the equipment.
  - C. Install identification products in a neat and clean, workmanship-like manner where products are securely attached and oriented parallel to equipment edges.

# END OF SECTION

## SECTION 26 08 00 - ELECTRICAL SYSTEM COMMISSIONING

## PART 1 GENERAL

- 1.1 WORK INCLUDED
  - A. Systems and equipment Start-Up and Functional Performance Testing.
  - B. Validation of proper and thorough installation of Division 26 systems and equipment.
  - C. Generic Start-Up Documentation for electrical systems and equipment.
  - D. Development of final Start-Up Documentation for electrical systems and equipment.
  - E. System Start-Up and Turn-Over procedures.
  - F. Coordination and execution of Training Events.
- 1.2 GENERAL DESCRIPTION
  - A. Commissioning (Cx) is the process of ensuring that (i) all building systems are installed and perform interactively according to the design intent; (ii) that systems are efficient and cost effective and meet the Owner's operational needs; (iii) that the installation is accurately documented; and (iv) that the Operators are adequately trained. Commissioning serves as a tool to minimize post-occupancy operational problems, and establishes testing and communication protocols to advance the building systems from installation to optimized, fully-dynamic operation.
  - B. Commissioning Authority (CxA) shall work with the Contractor and the design engineers to direct and oversee the Cx process and perform Functional Performance Testing.
  - C. The Commissioning Plan outlines the Cx process beyond the Construction Contract, including design phase activities and design team/owner responsibilities. The specification Sections dictate all requirements of the commissioning process relative to the construction contract. The Cx Plan is not part of the construction contract, although it is available for reference at the request of the Contractor.
  - D. This Section outlines the Cx procedures specific to the Division 26 Contractors. Requirements common to all Sections are specified in Sections 01 91 13 and 01 91 14 This Section and other sections of the specification details the Contractor's responsibilities relative to the Cx process.

# 1.3 SCOPE

- A. The following systems and equipment are included in the Scope of Commissioning for this project:
- B. Electrical Systems: All Division 26 (Electrical) equipment and systems are subject to commissioning, including but not limited to the systems listed below. All components and devices that make up these systems are included.
  - 1. Electrical connections for HVAC equipment
  - 2. Lighting Controls

## 1.4 RELATED WORK AND DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

- B. The Cx process references many related Sections, particularly Section 01 91 13 General Commissioning. It is important for all Contractors subject to the Cx process to be familiar with Section 01 91 13.
- C. Refer to Section 01 91 13 for a complete list of Sections on Related Work.
- 1.5 DEFINITIONS AND ABBREVIATIONS
  - A. Refer to Section 01 91 13 for a complete list of Definitions and Abbreviations.
- 1.6 REFERENCE STANDARDS
  - A. National Electric Code (NEC)
  - B. American Society for Testing and Materials (ASTM)
  - C. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA)
  - D. Illuminating Engineering Society (IES)
  - E. Institute of Electrical and Electronics Engineers (IEEE)
  - F. International Electrical Testing Association (NETA)
  - G. National Electrical Manufacturers Associates (NEMA)
  - H. National Fire Protection Association (NFPA)
  - I. Underwriters Laboratory, Inc. (UL)
  - J. Refer to Section 01 91 13 for additional Reference Standards.

# 1.7 DOCUMENTATION

- A. Documentation shall be as required in Section n 01 91 13. In addition, Contractor shall also provide to the CxA the following per the procedures specified herein, in the Cx Plan, and in other Sections of the specification:
  - 1. Factory Test Reports: Contractor shall provide any factory testing documentation or certified test reports required by the specifications. These shall be provided prior to Acceptance Phase. Factory Test Reports shall be provided in PDF electronic format.
  - 2. Field Testing Agency Reports: Provide all documentation of work of independent testing agencies required by the specification. These shall be provided prior to Acceptance Phase. Field Testing Agency Reports should be provided in PDF electronic format.

# 1.8 SEQUENCING AND SCHEDULING

A. Refer to Section 01 91 13.

# 1.9 COORDINATION MANAGEMENT PROTOCOLS

A. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 01 91 13 and the Cx Plan, but shall be refined and documented in the Construction Phase Cx Kick-Off Meeting. Contractor shall have input into the protocols to be used and all Parties will commit to scheduling obligations. The CxA will record and distribute.

# 1.10 CONTRACTOR RESPONSIBILITIES

A. Refer to Section 01 91 13: Detailed Contractor responsibilities common to all Divisions are specified in Section 01 91 13. The following are additional responsibilities or notable responsibilities specific to Division 26.

- B. Construction Phase
  - 1. Provide skilled technicians qualified to perform the work required.
  - 2. Provide factory-trained and authorized technicians where required by the Contract Documents.
  - 3. Prepare and submit required draft Start-Up Documentation and submit along with the manufacturer's application, installation and start-up information.
  - 4. Provide assistance to the CxA in preparation of the specific Functional Performance Test (FPT) procedures. Contractors, subcontractors and vendors shall review FPT procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests. Damage caused to equipment performed in accordance with the approved procedures will be the responsibility of the Contractor.
  - 5. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere this Section.
  - 6. Start-Up, Adjust, Test, and Turn-Over systems and equipment prior to functional performance testing by the CxA. Approved Start-Up Documentation shall be in accordance with Contract Documents, reference or industry standards, and specifically elsewhere in Part I of this Section.
  - 7. Record Start-Up on approved Start-Up Documentation forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above and in Section 01 91 13. Each task or item shall be indicated with the Party actually performing the task or procedure.
  - 8. Coordinate the work of the Electrical Testing Agency and the Cx requirements.
- C. Acceptance Phase
  - 1. Assist CxA in Functional Performance Testing. Assistance will typically include the following:
    - a. Manipulate systems and equipment to facilitate Functional Performance Testing (as specified in Section 01 91 13, Section 01 91 13, and the Cx Plan; in some cases this will entail only an initial sample);
    - b. Provide any specialized instrumentation necessary for Functional Performance Testing;

## 1.11 EQUIPMENT SUPPLIER RESPONSIBILITIES

- A. Refer to Section 01 91 13.
- 1.12 CONTRACTOR NOTIFICATION AND SCHEDULING
  - A. Refer to Section 01 91 13.
- 1.13 START-UP DOCUMENTATION
  - A. Refer to Section 01 91 13.
- 1.14 EQUIPMENT NAMEPLATE DATA
  - A. Refer to Section 01 91 13.
- 1.15 FUNCTIONAL PERFORMANCE TESTING
  - A. For applicable systems and equipment, Contractor shall participate in the initial samples of Functional Performance Testing as stipulated in Section 01 91 13 and Section 01 91 14.
- 1.16 FPT ACCEPTANCE CRITERIA

A. Acceptance criteria for tests are indicated in Section 01 91 14 and in the specification Sections applicable to the systems being tested. Unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device, which shall typically conform to NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-1991.

## 1.17 TRAINING

A. Contractors, subcontractor, vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of Section 01 91 13 and the individual Specifications.

## 1.18 O&M DOCUMENTATION CONTENT - PREPARATION AND LOGISTICS

A. Refer to Section 01 91 13 the individual Specifications

## PART 2 PRODUCTS

## 2.1 INSTRUMENTATION

- A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. Unless otherwise noted, all equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.
- B. Testing Instrumentation: Contractor shall provide all instrumentation necessary for tests for which they are responsible. CxA will provide standard instrumentation for measuring medium and low voltage electrical voltage, current, power factor, power, and total harmonic distortion (THD). CxA will provide receptacle testers for normal and GFI receptacle tests. Contractor shall provide all other instrumentation required to accomplish the specified testing.

# 2.2 WEB-BASED COMMISSIONING PORTAL

- A. All general and major subcontractors participating in the Cx process shall use the web-based Cx Portal ('Portal') to document the Cx procedures. The Portal is a Web-based Internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The Portal is hosted by the CxA and shall be accessible to all Parties participating in the Cx program. The Portal provides a common location to store Start-Up Documentation, Functional Performance Tests and results, project documents and deliverables. It also serves as a collaborative email hub to facilitate, automate, and track communications between Parties relating to the Cx process.
- B. Refer to Section 01 91 13 the individual Specifications for additional information and requirements for using the Portal.

# PART 3 EXECUTION

- 3.1 GENERIC START-UP DOCUMENTATION GENERAL
  - A. Part III of this Section outlines 'generic' or minimally acceptable Start-Up Documentation (which are defined to include both 'Start-Up Checks' and 'Start-Up Tests') and individual systems training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per normal quality control practices. These items shall provide a minimally acceptable

guideline for required Contractor development of Start-Up Documentation. Contractor shall synthesize these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized final Start-Up Documentation specific to the equipment and systems installed on this project.

B. Section 01 91 13 defines the systems and equipment Start-Up process in detail and provides definitions for Start-Up Documentation, including the generic Start-Up Documentation provided below.

## 3.2 START-UP CHECKS COMMON TO ALL SYSTEMS

- A. The following Start-Up verifications and procedures shall be considered common to all systems:
  - 1. Checkout shall proceed from lower level devices to larger components to the entire system operation.
  - 2. Verify labeling is affixed per specification and visible.
  - 3. Verify prerequisite procedures are done.
  - 4. Inspect for damage and ensure none is present.
  - 5. Verify system is installed per the manufacturer's recommendations.
  - 6. Verify system has undergone Start-Up per the manufacturer's recommendations.
  - 7. Verify that access is provided for inspection, operation and repair.
  - 8. Verify that access is provided for eventual replacement of the equipment.
  - 9. Verify that record drawings, submittal data and O&M documentation accurately reflect the installed systems.
  - 10. Verify all gauges and test ports are provided as required by contract documents and manufacturer's recommendations.
  - 11. Verify all recorded nameplate data is accurate.
  - 12. Verify that the installation ensures safe operation and maintenance.
  - 13. Verify specified replacement material/attic stock has been provided as required by the Contract Documents.
  - 14. Verify all rotating and moving parts are properly lubricated.
  - 15. Verify all monitoring and ensure all alarms are active and set per Owner's requirements.
  - 16. Complete all nameplate data and confirm that ratings conform to the design documents.

#### 3.3 MOTORS

- A. Startup and Checkout Follow the manufacturer's written procedures and the following as a minimum:
  - 1. Inspect terminations and grounding
  - 2. Ensure proper access to all electrical equipment
  - 3. Ensure proper labeling of all electrical equipment
  - 4. Compare wiring of poles to manufacturer's instructions
  - 5. Verify proper alignment, installation, and rotation
  - 6. Check voltage to disconnects with disconnect open and compare to rating data.
  - 7. In collaboration with the contractor who supplied the motor, bump it and ensure proper rotation.
  - 8. In collaboration with the contractor who supplied the motor, place the motor under load to the maximum feasible and measure
    - a. voltage and current at motor terminals on each phase and calculate balance
    - b. Power factor and phasing of each motor

- 9. Check the overloads in comparison to FLA measured and ensure adequacy of protection and reliability.
- 10. Observe several start to ensure the start is reliable.
- 11. Measure voltage available to all phases. After motor has been placed in operation under load measure amps and RPM
- 12. Record all motor nameplate data

# 3.4 INTEGRATED LIGHTING CONTROL SYSTEMS

- A. Include all applicable 'Start-Up Checks Common to All Systems". Additional Start-Up Checks and Tests are as follows.
- B. General: Provide the services of a factory-trained manufacturer's representative to assist the Contractor in the installation and start-up service of the lighting control system and train Owner's maintenance personnel as specified below. Representative will confirm the proper installation and operation of all system components. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.
- C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.
  - 1. Ensure all labeling is affixed and accurate.
  - 2. Ensure all terminations are tight.
  - 3. Check sensor placement is adequate for required duty.
  - 4. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it.
  - 5. Ensure all circuits for the loads are energized and ready for testing.
  - 6. Obtain all time schedules, individual device time-delay settings for all spaces, and on/off fade-rate settings from the Owner.
- D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.
  - 1. Test, calibrate, and set all digital and analog sensing, and actuating devices. Calibrate each instrumentation device by making a comparison between the graphic display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the Start-Up Report.
  - 2. Check each digital control point by making a comparison between the control command at the control panel and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device in the BAS Start-Up Report.
  - 3. Check full load current on all breakers serving controlled lighting to ensure that the breaker is properly sized.
  - 4. Check full load current on all control device contacts serving controlled lighting to ensure that the contact rating is properly sized.
  - 5. Enter all time schedules, override time-delays and on/off fade rates per Owner's direction.
  - 6. For Operator Interfaces:

- a. Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
- b. Output all specified reports for review and approval.
- c. Verify the alarm printing and logging is functional and per requirements.
- 7. Validate all interfaces with other systems on a point-by-point basis.
- E. Training: Train Owner's maintenance personnel on the operation and programming of the lighting control system.

# END OF SECTION

## SECTION 26 09 23 - STAND-ALONE LIGHTING CONTROL DEVICES

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Switches.
  - B. Occupancy sensors.
  - C. Lighting contactors.
  - D. Time-based control devices.
  - E. Photocells.
- 1.14 RELATED SECTIONS
  - A. Section specifying requirements for LEED rating is specified in Division 01.
  - B. Identification for electrical systems: Section 26 05 53.
  - C. Modular dimming controls: Section 26 09 36.
  - D. Interior lighting: Section 26 51 00.
  - E. Exterior lighting: Section 26 56 00.
  - F. Commissioning requirements: Divisions 01 and 23.
- 1.20 REFERENCES
  - A. IECC: International Energy Conservation Code.
  - B. NECA 1: Standard Practices for Good Workmanship in Electrical Construction.
  - C. NFPA 70: National Electrical Code.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Each type of device used in the project.
- C. Bill of materials: Provide detailed list of components and quantities.
- D. Shop drawings: Detail assemblies of standard and project specific components. Indicate dimensions and arrangement of components.

- 1. Floor plans: Identify locations of lighting control system components; interconnection of components. Utilize reflected ceiling plans to show location, orientation, and coverage area of sensors.
- 2. Wiring diagrams: Power, signal, and control wiring, differentiating between manufacturerinstalled and field-installed wiring, provided on a schematic diagram.
- 3. Include representative views of components, including button layouts, engraving, colors, and other physical characteristics pertinent to each device.
- E. Field quality control test reports.
- F. Qualifications of factory certified field service engineer.
- G. Operation and maintenance data: For lighting control system and associated components, provide product data, shop drawings, and test reports in operation and maintenance manual. In addition to items specified in Division 01, include list of replacement parts and assemblies.
- 1.40 QUALITY ASSURANCE
  - A. Comply with requirements for LEED certification specified in Division 01.
  - B. Devices shall be UL listed and labeled for their intended application.
  - C. Provide services from factory certified field service engineer to perform functional testing.
  - D. Qualifications for factory certified field service engineer:
    - 1. Minimum experience of 2 years training in the electrical/electronic field.
    - 2. Certified by the equipment manufacturer on the system installed.

## 1.50 DELIVERY, STORAGE, AND HANDLING

A. Store components indoors in a clean dry space with uniform temperature to prevent condensation. Protect switches from exposure to dirt, fumes, water, corrosive substances, and physical damage.

## 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

# PART 2 - PRODUCTS

## 2.20 SWITCHES

A. Manufacturers:

- 1. Pass & Seymour/Legrand (basis-of-design).
- 2. Leviton Manufacturing Co.
- 3. Hubbell/Bryant Electric.
- 4. Cooper Industries/Eaton Wiring Devices.
- B. Provide devices conforming to UL 20, equal to the following P&S catalog numbers:
  - 1. Switches: PS20AC1, PS20AC3 (3-way), PS20AC4 (4-way).
  - 2. Switches, weatherproof: PS20AC1, PS20AC3 (3-way), PS20AC4 (4-way), with CA1-GL cover.
- C. Device color: Brown.
- D. Device plates: Equal to Pass & Seymour, Type 302 stainless steel, SS Series.
- 2.21 OCCUPANCY SENSORS
  - A. Acceptable manufacturers
    - 1. Acuity Brands Lighting, Inc./Sensor Switch.
    - 2. Eaton/Cooper Controls/Novitas.
    - 3. Hubbell Inc.
    - 4. Lutron Electronics Co., Inc.
  - B. Wall switch occupancy sensors: Wired, dual-technology sensor, combination ultrasonic/passive infrared detector with override switch, capable of installation in a standard wall switch backbox.
    - 1. Line voltage: Rated at 120/277 dual-input voltage, 60 hertz.
    - 2. Device finish: White, with matching device plate.
      - a. Device plate shall be decorator style with mounting screws above and below device.
  - C. Ceiling-mounted occupancy sensors: Wired, dual-technology, combination ultrasonic/passive infrared detector, independently adjustable for installed conditions.
    - 1. Dual-technology detector: Includes both passive infrared and ultrasonic detectors:
      - a. Passive infrared: Utilize multiple segmented lens with internal grooves to eliminate dust and residue build-up, with field adjustable ambient light adjustment.
      - b. Ultrasonic: Utilize an operating frequency of 32 kHz or 40 kHz, controlled to operate within plus/minus 0.01 percent tolerance. Detector shall automatically adjust detection threshold to compensate for learned environmental behavior.
    - 2. Characteristics:
      - a. Indicator: LED positive detection.
      - b. Adjustable delayed off-time range: Between 30 seconds and 15 minutes.
      - c. Capable of installation in acoustical ceiling tile or gypsum ceiling. Detector shall have 360-degree coverage, minimum 900 square feet.
      - d. Fail on: Lights will stay on if sensor fails.

- e. Isolated relay: Provide an internal auxiliary set of contacts with Normally Open, Normally Closed, and Common outputs to allow other systems to monitor occupancy. For use with HVAC control system, or other control options where indicated.
- 3. Auxiliary components:
  - a. Power pack: Universal 120/277V switched input, controlled through a high-current 20A relay. Low voltage output, less than or equal to 24VDC, for powering low voltage occupancy sensors. Enclosure shall be plenum rated.
  - b. Override switch: Low-voltage switch shall operate on voltage less than or equal to 24VDC and shall have a momentary contact actuator to send a signal to the associated power pack to change the current lighting state. Color shall match switch device color specified above.
- D. Sensor finish color: White.

## 2.22 LIGHTING CONTACTORS

- A. Lighting contactors: Equal to Square D 8903, UL 508 listed, in NEMA 250 Type 1 enclosure, mechanically held, electrically operated, enclosed silver-alloy double-break contacts, coil-clearing contacts; withstand rating as indicated on the drawings; Hand/Off/Auto selector switch on cover.
  - 1. Provide contactor with two-wire control relay for two-wire control of mechanically held lighting contactor.

## 2.23 TIME-BASED CONTROL DEVICES

- A. Digital timeclock: Equal to TORK, EWZ Series, electronic 365-day microprocessor-based, solid-state, two-channel control, with 24-hour programming capability and feature to provide automatic tracking of sunrise and sunset times in order to automatically turn lights On at dusk and Off at dawn, selectable to channel.
  - 1. Provide one additional On and Off event per channel as well as selectable daylight savings time adjustment and automatic leap year correction.
  - 2. Include skip-a-day, Offset to sunrise and sunset, and manual override, independently programmable for each channel.
  - 3. Latitude: Adjustable from 10 to 60 degrees northern or southern hemisphere.
  - 4. Clock format: AM/PM.
  - 5. Unit shall be capable of operating during a power outage for 100 hours with a capacitor.
  - 6. Unit shall be DIN rail or surface-mounted in a NEMA 250 Type 1 enclosure.
- B. In-wall timer; Solid-state interval timer with manually operated toggle switch for installation in a 2.5-inch deep single-gang or multi-gang wall box, 120/277-volt input, 4-ampere rated contacts, flicker warning before timing out, complete with properly marked cover plate. Time cycle adjustable from 15 minutes to 12 hours and set at 6 hours.
  - 1. Single-pole type: Equal to TORK/NSi Industries, Model SS20F, with minimum 150-watt load at 277 volts.

2. Three-way type: Equal to TORK/NSi Industries, Model SS13F, with minimum 70-watt load at 277 volts.

# 2.26 PHOTOCELLS

- A. Open-loop exterior photocell: Equal to TORK, 2100 Series, 120/277 volt.
  - 1. Cell: Cadmium sulphide, epoxy coated, 1-inch diameter.
  - 2. Operation: Turn ON below 3 foot-candles; turn OFF within 3 to 12 foot candles; 2-minute time delay to prevent false switching.
  - 3. Temperature rating: Minus 40 degrees F (minus 40 degrees C) to plus 140 degrees F (60 degrees C).
  - 4. Contacts: Single-pole, single-throw, normally closed and fail in the ON position.
  - 5. Housing: Die-cast aluminum or zinc with weather protection gasket.
  - 6. Mounting: Fixed base with 0.5 inch (13-mm) threaded nipple.

## 2.30 CONDUCTORS AND CABLES

- A. Wiring to supply side of remote-control power sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19, Wires and Cables.
- B. Low-voltage control cable: Manufacturer's standard multi-conductor cable with stranded-copper conductors not smaller than No. 22 AWG, plenum rated.
  - 1. Class 2 Control Cables: Multi-conductor cable with copper conductors not smaller than No. 18 AWG.
  - 2. Class 1 Control Cables: Multi-conductor cable with copper conductors not smaller than No. 14 AWG.
- C. Digital UTP cabling: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5E for horizontal copper cable.

## 2.40 DEVICE PROGRAMMING REQUIREMENTS

A. Programming of lighting controls shall be performed by a factory certified field service engineer. Refer to lighting controls diagrams on the Drawings.

## PART 3 - EXECUTION

## 3.20 INSTALLATION, GENERAL

- A. Install devices in complete compliance with the manufacturer's recommendations.
- B. Provide a single cover plate where two or more devices are grouped together in one box.
- C. Verify door swings with door frame installed prior to rough-in for switches.
- D. Ground components according to Section 26 05 26, Grounding and Bonding.
- E. Fully document control device calibration settings after system programming with manufacturer's representative and submit this information as a part of the O&M manual.
- F. Devices shall be installed and programmed to meet the control intent.
- G. Manufacturer's factory certified field service engineer shall provide start-up service, including physical inspection of lighting control system and connected wiring and final adjustments to meet specified performance requirements.

## 3.21 INSTALLING OCCUPANCY SENSORS

- A. Install in accordance with manufacturer's written instructions.
- B. Provide line voltage type detectors when a single wall device controls lighting within a single space.
- C. Provide low voltage type detectors when ceiling detector(s) controls a single space.
- D. Coverage pattern: Verify coverage pattern of single detector or system of detectors to be capable of complete coverage of the space in which the lighting is intended to be controlled. Provide additional detectors as necessary to satisfy complete coverage.
- E. Programming requirements:
  - 1. Vacancy mode (manual on, automatic off).
  - 2. Occupancy mode (automatic on, automatic off).

## 3.59 IDENTIFICATION

- A. Materials: Refer to Section 26 05 53, "Identification for Electrical Systems." Identify devices and wiring.
- B. Lighting control stations:
  - 1. Custom engraving: Provide custom engraving on each button of each control station, defining button's function. Coordinate with owner for final approval of engraving.

## 3.60 FIELD QUALITY CONTROL

- A. Manufacturer's field service: Engage a factory certified field service engineer to test and inspect components, assemblies, and equipment installations, including connections.
- B. Functional testing. Perform tests and prepare test reports for the following:
  - 1. For occupancy sensors, confirm that the placement, sensitivity, and time-out settings are optimized to ensure lights turn off only after each space is vacated and do not turn on unless the space is occupied.

## **END OF SECTION**

## SECTION 26 09 33 - CENTRAL DIMMING CONTROLS

#### PART 1 – GENERAL

#### 1.11 SECTION INCLUDES

- A. This section includes a microprocessor-based central dimming control system including the following system components:
  - 1. Dimmer panels
  - 2. Wall station devices
  - 3. Miscellaneous system components

### 1.14 RELATED SECTIONS

- A. Interior lighting: Section 26 51 00.
- B. Lighting control devices: Section 26 09 23.
- C. Identification of electrical systems: Section 26 05 53.

#### 1.20 REFERENCES

- A. ASHRAE/IESNA 90.1: Energy Standard for Buildings except Low-Rise Residential Buildings.
- B. NECA 1: Standard Practices for Good Workmanship in Electrical Construction.
- C. NFPA 70: National Electrical Code.
- D. UL 489: Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.
- E. UL 508: Industrial Control Equipment.
- F. UL 916: Energy Management Equipment.
- G. UL 924: Emergency Lighting and Power Equipment.
- H. UL 1472: Solid-State Dimming Controls.

#### 1.21 DEFINITIONS

- A. Fade override: The ability to temporarily set fade times to zero for all lighting scenes.
- B. Fade rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
- C. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.
- D. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

E. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also as a "channel."

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Include assembly ratings and dimensioned plans, sections, and elevations showing minimum clearances, cable termination sizes, conductor entry, gutter space, installed features and devices, and material lists for each component. Include the following system components:
  - 1. Master control processor
  - 2. Dimmer panels
  - 3. Master control stations
  - 4. Wall station devices
  - 5. Sensors
  - 6. Cables
  - 7. Interface Devices
  - 8. Laptop computer and programming software
- C. Bill of materials: Provide detailed list of components.
- D. Shop drawings: Detail assemblies of standard and project specific components. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
  - 1. Include elevation, plan, and side views of components.
  - 2. Wiring riser diagrams: Power, signal, and control wiring, differentiating between manufacturer-installed and field-installed wiring, and including power and control wiring.
- E. Source quality-control reports.
- F. Field quality-control test reports.
- G. Operation and maintenance data: For lighting control system and associated components, provide product data, shop drawings, and test reports in operation and maintenance manual. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
  - 1. List of replacement parts and assemblies.

## 1.40 QUALITY ASSURANCE

- A. Lighting control system installation shall comply with NFPA 70.
- B. System components UL listed and labeled.
- C. Obtain central dimming components from a single source with total responsibility for compatibility of lighting control system components.

- D. Manufacturer shall have their quality system registered to the ISO 9001 Quality Standard, including in-house engineering for all product design activities.
- E. Lighting control system shall meet IEC801-2, tested to withstand a 15kV electrostatic discharge without damage or loss of memory.
- F. System shall be compatible with dimming ballasts connected to system.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Store switches indoors in clean dry space with uniform temperature to prevent condensation. Protect switches from exposure to dirt, fumes, water, corrosive substances, and physical damage.

## 1.80 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting control system and associated auxiliary components that fail in materials or workmanship within specified warranty period.
  - 1. Warranty period: Two years from date of substantial completion.
  - 2. Warranty shall include all parts and labor.
  - 3. Warranty shall begin at the date the equipment is accepted by the Owner.

## 1.90 SOFTWARE SERVICE AGREEMENT

- A. Technical support: Beginning with substantial completion, the manufacturer shall provide software support for a period of two years.
- B. Upgrade service: The manufacturer shall provide the latest version of product software at project completion. Software upgrades shall be installed and programmed when they become available for a period of two years. Upgrades shall include new operating systems and required licenses for use of software.

## PART 2 – PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide products manufactured by Lutron Electronics, Inc., or comparable product by one of the following:
  - 1. Lighting Control & Design, an Acuity Brand Company
  - 2. Lutron Electronics, Inc. (Project basis-of-design)
  - 3. Philips Lighting Controls

## 2.20 GENERAL SYSTEM REQUIREMENTS

- A. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.
- B. Dimmers and dimming modules: Comply with UL 508.

- 1. Line-voltage surge suppression: Factory installed as an integral part of solid-state dimmer and control panel.
- 2. Audible noise and radio-frequency interference suppression. Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
- C. Centralized Dimming System: Microprocessor-based, solid-state controls consisting of control stations and separately mounted dimmer panels.

## 2.22 DIMMER PANEL

- A. Factory pre-assembled, wired, and tested by manufacturer, convection cooled without fans, NEMA 250 Type 1 enclosure and suitable to control designated lighting equipment or accessory functions.
- B. Panel shall be capable of operation from a normal source feed, an emergency source feed, or a normal/emergency source feed.
- C. All input feed, load, and control terminals shall be front accessible without the need to remove dimmer assemblies or other components.
- D. Panel shall have minimum UL listed short circuit current rating as shown on drawings.
- E. Panel shall have main circuit breaker protection where indicated.
- F. Each dimmer should contain branch circuit protection:
  - 1. UL 489 listed, thermal-magnetic molded case circuit breaker for use on lighting circuits as specified in Section 26 24 16, Panelboards.
  - 2. Breakers shall contain a visual trip indicator and shall have a minimum UL listed short circuit current rating as shown on drawings.
  - 3. Breakers shall be replaceable without moving or replacing dimmer assemblies or other components.
  - 4. Breakers shall be switching duty (SWD) rated so that loads can be switched off via the breakers.
- G. Lighting dimmers: Solid-state dimmer modules.
  - 1. Each dimmer shall be rated for 16A continuous duty, 120V or 277V, 60Hz operation.
  - 2. Dimmer response to control signal shall follow the "Square Law Dimming Curve" specified in IESNA's "IESNA Lighting Handbook."
  - 3. Dimming range: 0 to 100 percent, full output voltage not less than 95 percent of line voltage.
  - 4. Each dimmer shall compensate for incoming line voltage variations such as changes in RMS voltage, frequency shifts, harmonics and line noise. Dimmer shall be capable of maintaining constant light level with no visible flicker due to minor power characteristic variations.
  - 5. Each dimmer shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/IEEE std. C62.41.

- 6. RFI suppression: Utilize high-grade choke.
- 7. Dimmer shall be capable of withstanding inrush current of 50 times operating current typically generated by a full circuit of switching electronic non-dim ballasts.
- 8. Dimmer controls shall be protected with an inline fuse and transient voltage surge suppression device.
- H. Non-dimmer modules shall include relays with contacts rated to switch 20A tungsten-filament load at 120V and 20A electronic ballast load at 277V.

## 2.32 WALL STATIONS

- A. Low-voltage, programmable wall station device with button configurations and functions as shown in details on the drawings.
- B. Device functionality: Wall station(s) shall provide an immediate local LED illumination response upon button activation to indicate that a system command has been requested. LED will remain lit contingent upon receiving system confirmation of the successful completion of the command.
  - 1. Each button shall be capable of performing an 'On' or 'Off' operation of the programmed zone.
  - 2. Buttons shall be capable of modifying the state of multiple zones to create a scene.
- C. Wall stations shall be engraved with appropriate zone and scene descriptions, furnished to the manufacturer prior to fabrication. Size and style of engraving type shall be determined by the Architect during submittal stage. Any silk-screened borders, logos, graduations, etc. shall use a graphic process that chemically bonds the graphics to the metal faceplate, resisting removal by scratching, cleaning, etc. Use zone designations indicated on drawings.
- D. Finish: White.
  - 1. Faceplate shall match wiring device finish.

## 2.45 MISCELLANEOUS SYSTEM COMPONENTS

- A. Conductors and cables
  - 1. Wiring to supply side of remote-control power sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19, Wires and Cables.
  - 2. Low voltage control cable: Manufacturer's standard multi-conductor cable with stranded-copper conductors not smaller than No. 22 AWG, non-plenum rated.

## 2.90 SOURCE QUALITY CONTROL

A. Perform full-function testing on 100 percent of all system components and panel assemblies at the factory.

## PART 3 – EXECUTION

### 3.20 INSTALLATION

- A. Comply with NECA 1.
- B. Wiring method:
  - 1. Comply with requirements in Section 26 05 19, Wires and Cables.
  - 2. Install wiring and cabling for control and signal transmission conductors in conduit between devices and system components.
  - 3. Minimum conduit size shall be 0.75 inch (21mm).
- C. Wiring within enclosures: Bundle, lace, and train conductors to terminal points. Separate powerlimited and non-power-limited conductors according to conductor manufacturer's written instructions.
- D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise noted.
- E. Splices, taps, and terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- F. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- G. Install in accordance with national, state, and local codes, and manufacturer's instructions.
- H. Include items not specifically mentioned but necessary for proper operation.
- I. Connect wiring as indicated on the drawings and in accordance with manufacturer's recommendations.
- J. Identify components.

## 3.25 SYSTEM INTEGRATION AND PROGRAMMING

- A. Coordinate at least one meeting between the Facility Representative, Lighting Control System Manufacturer, and other related equipment manufacturers to discuss equipment integration procedures and programming requirements. The results of the meeting(s) shall be documented and included in the O&M manual.
- 3.30 CONNECTIONS
  - A. Ground equipment according to Section 26 05 26, Grounding and Bonding.
- 3.59 IDENTIFICATION
  - A. Materials: Refer to Section 26 05 53, Identification for Electrical Systems. Identify panels, devices, relays, controls, and wiring. Identify equipment ratings.

- B. Nameplates: Refer to Section 26 05 53, Identification for Electrical Systems. Provide nameplate for each panel, located on front of assembly.
  - 1. In addition to nameplate, furnish master label, stamped metal, listing standard manufacturer information including voltage, ampere, frequency, and short-circuit ratings; manufacturer's model and project designations.
- C. Control components mounted within the assembly, such as relays, pushbuttons, switches, etc., shall be identified corresponding to designations on manufacturer's drawings using tags and other identification materials.
- D. Label each dimmer module with a unique designation.
- E. Custom engraving: Provide custom engraving on each button of each wall station, defining button's function. Coordinate with owner for final approval of engraving.

## 3.60 FIELD QUALITY CONTROL

- A. Manufacturer's field service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Tests and inspections:
  - 1. Continuity test of circuits.
  - 2. Operational test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operation functions.
    - a. Include testing of dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
  - 3. Emergency power transfer: Test system functions as part of a simulated power outage.
- C. Remove and replace malfunctioning dimming control components and retest as specified above.
- D. Reports: Written reports of tests and observations. Record defective materials and workmanship and report unsatisfactory test results. Record repairs and adjustments.

## 3.75 CLEANING

- A. Inspect and clean surfaces and repair damaged finishes to match original finish.
- B. Clean interior of equipment according to manufacturer's instructions.

## 3.81 OPERATING INSTRUCTIONS

A. As specified in Section 26 01 01, provide operating instructions.

## **END OF SECTION**

## SECTION 26 09 36 - MODULAR DIMMING CONTROLS

### PART 1 - GENERAL

### 1.11 SECTION INCLUDES

- A. Lighting relay room controllers (0-10V dimming relay network capable controllers).
- B. Lighting control stations (low-voltage digital wall stations).
- C. Sensor devices (occupancy sensors and daylight sensors).
- D. Auxiliary devices (interfaces and power supplies).
- E. Conductors and cables.
- F. Cost of system startup and testing shall be included in contract sum.

## 1.14 RELATED SECTIONS

- A. Section specifying requirements for LEED rating is specified in Division 01.
- B. Commissioning requirements: Divisions 01 and 23.
- C. Electrical identification: Section 26 05 53.
- D. Stand-alone lighting control devices: 26 09 23.
- E. Interior lighting: Section 26 51 00.
- F. Mechanical system controls: Division 23.
- 1.20 REFERENCES
  - A. IECC: International Energy Conservation Code.
  - B. NECA 1: Standard Practices for Good Workmanship in Electrical Construction.
  - C. NFPA 70: National Electrical Code.
  - D. UL 924: Emergency Lighting and Power Equipment.
- 1.21 DEFINITIONS
  - A. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
  - B. Zone: A fixture or group of fixtures controlled simultaneously by a single dimmer/relay.
- 1.26 DESIGN REQUIREMENTS

A. Lighting controls shall meet the mandatory control requirements as defined in IECC 2015 energy code. Select control strategies implemented by the lighting systems may go beyond these requirements to support LEED certification.

## 1.27 PERFORMANCE REQUIREMENTS

- A. Provide a complete, digital, network capable, lighting control system. Lighting control system shall include equipment necessary for the proper operation and program of the lighting control system including 0-10V dimming relay controllers, control stations, sensors, and other interfaces, with communications interface provisions to a future network-based lighting controls system server.
- B. System shall be able to meet the functionality and sequence of operation(s) as listed on the Drawings.
- C. Each 0-10V dimming relay shall be individually controllable and shall include on-off, dimming, scene settings, and other control functions to meet designated sequence of operation(s).

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Manufacturer's technical product datasheet for each system component including assembly ratings and dimensioned plans, sections, and elevations showing minimum clearances, cable termination sizes, conductor entry, gutter space, and installed features, where applicable.
- C. Bill of materials: Detailed list of components and quantities.
- D. Shop drawings: Detail assemblies of standard and project specific components. Indicate dimensions and arrangement of components.
  - 1. Floor plans: Identify locations of lighting control system components; interconnection of components. Utilize reflected ceiling plans to show the following:
    - a. Location, orientation, and coverage area of sensors.
    - b. Locations of lighting relay room controllers and lighting control stations.
  - 2. Summary list of control devices, sensors, other loads, and interface devices.
  - 3. Wiring diagrams: Power, signal, and control wiring, differentiating between manufacturerinstalled and field-installed wiring, indicated on a schematic diagram.
  - 4. Include representative views of components, including button layouts, engraving, colors, and other physical characteristics pertinent to each device.
  - 5. Load schedules: Indicate connected load, load type, and voltage per circuit, circuits and their respective control zones, circuits that are on emergency, and capacity, phase, and corresponding circuit numbers.
- E. Source quality-control test reports.
- F. Field quality-control test reports.

- G. Qualifications of factory certified field service engineer.
- H. Operation and maintenance data: For lighting control system and associated components, include product data, shop drawings, and test reports in operation and maintenance manual. In addition to items specified in Division 01, include the following:
  - 1. List of replacement parts and assemblies.
- 1.40 QUALITY ASSURANCE
  - A. Comply with requirements for LEED certification specified in Division 01.
  - B. System components shall be UL listed and labeled for their intended application.
  - C. Qualifications for factory certified field service engineer to perform functional testing:
    - 1. Minimum experience of 2 years training in the electrical/electronic field.
    - 2. Certified by the equipment manufacturer on the system installed.
  - D. Obtain lighting controls system components from a single source with total responsibility for compatibility of lighting control system components and lighting fixtures.
  - E. Lighting control system installation shall comply with NFPA 70, as well as applicable ANSI and IEC standards, and FCC regulations.
  - F. Lighting control system shall meet IEC801-2, tested to withstand a 15kV electrostatic discharge without damage or loss of memory.
  - G. Technical support:
    - 1. Onsite support: Manufacturer's authorized service and maintenance representative characteristics shall include the following:
      - a. Located in the Baltimore/Washington, DC metropolitan area.
      - b. Staff is factory employed and trained.
      - c. Service available 24 hours a day, seven days a week, 365 days a year.
      - d. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
      - e. Service and maintenance contracts available.
    - 2. Phone support: Toll free technical support shall be available.

#### 1.50 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver or install equipment until spaces are enclosed and weather-tight, wet work in spaces is complete and dry, work above equipment is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

B. Store components indoors in a clean dry space with uniform temperature to prevent condensation. Protect switches from exposure to dirt, fumes, water, corrosive substances, and physical damage.

## 1.60 PROJECT CONDITIONS

- A. Environmental conditions: Lighting control system components shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient temperature: 0 to 40 degrees C.
  - 2. Relative humidity: 5 to 90 percent, non-condensing.

## 1.80 WARRANTY

- A. Special warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting control system and associated auxiliary components that fail in materials or workmanship within specified warranty period.
  - 1. Warranty period: Two years from date of substantial completion.
  - 2. Warranty shall include all parts and labor with no deductible.
  - 3. Warranty shall begin at the date the equipment is accepted by the Owner.
- B. Warranty service: Qualified personnel shall be available to repair or replace components of lighting control system and associated auxiliary components that fail in materials or workmanship. Furnish Owner with a telephone number where service representative can be reached at all times. Service personnel shall be at the site within 48 hours after receiving a request for service, and shall restore the lighting control system to proper operating condition within 72 hours.

## 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

## 1.91 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged in protective box or covering for storage and identified with labels describing contents.
  - 1. Lighting relay room controllers: A minimum of two (2).
  - 2. Occupancy sensors: A minimum of ten (10).
  - 3. Daylight sensors: A minimum of five (5).
  - 4. Lighting control stations (low-voltage digital wall switches): Five (5) of each type.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide products manufactured by Lutron Electronics Co., Inc., Energi Savr Node series, or comparable product by one of the following:
  - 1. Acuity Brands Lighting, Inc., Blue Box series / MicroPanel series.
  - 2. Eaton/Cooper Controls, Greengate series.
  - 3. Lutron Electronics Co., Inc., Energi Savr Node series (basis-of-design).

### 2.09 SYSTEM REQUIREMENTS

- A. General system operation:
  - 1. System shall be capable of receiving input signals from lighting control system sensors, lighting control stations (low-voltage digital wall switches), 0-10V control relays, and fire alarm control modules; and sending signals to lighting relay room controllers.
  - 2. Each input and controlled device shall be connected to associated lighting relay room controller via a low-voltage signal loop.
- B. System shall comply with UL standards including UL 916 and UL 924.
- C. System requirements:
  - 1. Emergency mode: Lighting relay room controllers and associated lighting fixture LED drivers shall comply with UL 924 requirements and operate under the following conditions:
    - a. Loss of power: Upon loss of power to a lighting relay room controller, lighting relays shall operate in the closed ('on') position and associated LED drivers shall operate in a full light output state. Once normal or backup power is restored, lighting relays shall remain in the closed ('on') position and LED drivers shall remain in a full light output state until a new command is initiated.
    - b. The default settings for emergency-designated fixtures shall not be capable of being modified.
    - c. Fire alarm system input: Upon alarm signal from the fire alarm system, lighting relays shall operate in the closed ('on') position and associated LED drivers shall operate in a full light output state. Upon alarm silencing, lighting relays shall remain in the closed ('on') position and LED drivers shall remain in a full light output state until a new command is initiated.
  - 2. Occupancy detection: The system shall reduce the power consumption in vacant areas by reading the status of low voltage occupancy sensors.
    - a. Occupancy sensor wiring: Occupancy sensors shall be wired directly to the associated lighting control system room controller for power and communications. Where the number devices/sensors exceed the amount allowed for a room controller, provide necessary interface devices and power packs to meet controllability intent of the contract documents.

- b. Occupancy sensor groupings: The set of light fixtures that are controlled by a given occupancy sensor shall be configurable through system software and shall not require any manual wiring to modify.
- c. Occupancy sensor modes: Each occupancy sensor shall have the following programmable lighting modes:
  - 1) Occupied mode: The occupied mode represents the lighting mode when occupancy is detected. Light levels will remain at the occupied level until occupancy is no longer detected.
  - 2) Setback or transition mode: Transition or setback modes provide a gradual change in light levels when occupancy is no longer detected.
  - Vacancy mode: The vacancy mode represents the lighting mode when occupancy is no longer being detected and setback and transition levels have expired.
- 3. Daylight harvesting: The lighting system shall adjust light levels (100-percent light level to 10-percent light level) in response to varying ambient light levels in a continuous and imperceptible manner in order to maintain a constant light level at desk height. Ambient light levels shall be determined from daylight sensors.
  - a. Daylight sensor wiring: Daylight sensors shall be wired directly to the associated lighting relay room controller for power and communications. Where the number devices/sensors exceed the amount allowed for a room controller, provide necessary interface devices and power packs to meet controllability intent of the contract documents.
  - b. Daylight sensor groupings: The set of zones that are controlled by a given daylight sensor shall be configurable through system software and shall not require manual wiring to modify.
  - c. Daylight sensor settings: Settings associated with a given daylight sensor shall be adjustable through system software and shall not require any physical adjustment to the sensor itself.
- 4. Future remote access: Operating parameters of the lighting control system shall have the capability to be configurable from any internet enabled computer through a web-browser and a network connection to a future lighting controls system server.

## 2.21 LIGHTING RELAY ROOM CONTROLLERS

- A. Product: Equal to Lutron, Model QSN-4T16-S (0-10V control), custom programmed, network capable.
- B. Characteristics:
  - 1. Enclosure: NEMA 250 Type 1, steel.
  - 2. Delivered and installed as a UL listed factory assembly.
  - 3. Input power: Dual-rated 120/277-volt, 60 hertz, phase to neutral.
  - 4. Feed-through type.
  - 5. Relays:
    - a. 20-ampere, 120/277-volt rated.

- b. Independently addressable.
- c. Minimum of 500,000 switching cycles at full load.
- 6. Capable of switching the following load types:
  - a. Light emitting diode (LED) lighting fixtures/luminaires.
  - b. 20-ampere rated receptacle or plug loads.
- C. Functionality: Functions of associated lighting control stations shall be set up at the lighting relay room controllers' electronic controls that include indicated number and arrangement of scene presets, channels, and operational times.

## 2.22 LIGHTING CONTROL STATIONS (LOW-VOLTAGE DIGITAL WALL STATIONS)

- A. Description: Low-voltage, field-programmable digital wall station device with button configurations and functions as shown in the lighting controls diagrams on the Drawings.
- B. Functionality: Lighting control station(s) shall provide an immediate local LED illumination response upon button activation to indicate that a system command has been requested. LED will remain lit contingent upon receiving system confirmation of the successful completion of the command.
  - 1. Each button shall be capable of performing an 'On' or 'Off' operation of the programmed zone.
  - 2. Buttons shall be capable of modifying the state of multiple zones to create a scene.
  - 3. Lighting control station(s) with raise/lower buttons shall have capability of raising or lowering light levels.
- C. Lighting control stations shall have control over programmed scenes.
- D. Lighting control stations shall be engraved with appropriate zone and scene descriptions, furnished to the manufacturer prior to fabrication. Size and style of engraving type shall be determined by the Architect during submittal stage. Any silk-screened borders, logos, graduations, etc. shall use a graphic process that chemically bonds the graphics to the faceplate, resisting removal by scratching, cleaning, etc. Coordinate exact engraving text with Owner prior to order. If Owner does not have a preference, use zone designations indicated on the Drawings.
- E. Lighting control station(s) functions shall be configurable from associated lighting relay room controller.
- F. Configurations: Button-based style with each button fully customizable to perform defined function. Button shall have toggle capability.
  - 1. Provide multi-button configurations as detailed on the Drawings.
- G. Device finish: White, with matching device plate.
  - 1. Device plate shall be decorator style with mounting screws above and below device.
- 2.23 SENSOR DEVICES

- A. Ceiling-mounted occupancy sensors: Wired, dual-technology, combination ultrasonic/passive infrared detector, independently adjustable for installed conditions.
  - 1. Dual-technology detector: Includes both passive infrared and ultrasonic detectors:
    - a. Passive infrared: Utilize multiple segmented lens with internal grooves to eliminate dust and residue build-up, with field adjustable ambient light adjustment.
    - b. Ultrasonic: Utilize an operating frequency of 32 kHz or 40 kHz, controlled to operate within plus/minus 0.01 percent tolerance. Detector shall automatically adjust detection threshold to compensate for learned environmental behavior.
  - 2. Characteristics:
    - a. Indicator: LED positive detection.
    - b. Adjustable delayed off-time range: Between 30 seconds and 15 minutes.
    - c. Capable of installation in acoustic ceiling tile or gypsum ceiling. Detector shall have 360-degree coverage, minimum 900 square feet in rooms and minimum 2000 square feet in corridors.
    - d. Isolated relay: Provide an internal auxiliary set of contacts with Normally Open, Normally Closed, and Common outputs to allow other systems to monitor occupancy. For use with HVAC control system, or other control options where indicated.
- B. High-bay ceiling occupancy sensor: Wired, passive infrared detection capable of installation in high ceiling space and suitable for high-bay installations.
  - 1. Passive infrared detector: Utilize multiple segmented lens with internal grooves to eliminate dust and residue build-up, with field adjustable ambient light adjustment.
  - 2. Selectable delayed off-time settings.
  - 3. Detector shall have 360-degree coverage.
  - 4. Isolated relay: Provide an auxiliary set of contacts with Normally Open, Normally Closed, and Common outputs to allow other systems to monitor occupancy. For use with HVAC control system, or other control options where indicated.
- C. Daylight sensors: Wired, ceiling or fixture mounted open-loop interior photocell.
  - 1. Open-loop basis for daylight sensor control scheme. Continual monitoring of daylight entering building windows to enable daylight harvesting control of room lighting.
  - 2. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
  - 3. Provide linear response from 0 to at least 500 footcandles.
  - 4. Performance requirements: The lighting control system manufacturer or authorized representative shall provide daylight sensor layout that provides adequate coverage for performance requirements of each space.
    - a. Provide design layout of daylight sensor devices.
    - b. The lighting control system manufacturer shall arrange an onsite pre-installation meeting and system startup meeting. The lighting control manufacturer shall provide

direction regarding sensor location and relocation should conditions require a deviation from indicated design locations.

- c. Provide at no additional cost any additional daylight sensors or hardware required to meet sequence of operations.
- d. Lighting control system manufacturer shall program or offer guidance to program areas utilizing daylight sensors to ensure conformance with contract document requirements.
- D. Sensor finish color: White.
- E. Sensor power packs: Provide when quantity of sensors exceeds the maximum allowable per control circuit. Provide sensor power packs where required for power connection to sensors. Plenum-rated, Class 2 control wiring between sensors and control units.

## 2.26 AUXILIARY DEVICES

- A. Emergency lighting interface:
  - 1. UL 924 listed when used with lighting relay room controller.
  - 2. Senses one phase or all three phases of building power.
  - 3. Signal to lighting relay room controller on emergency lighting to turn lights controlled by room controller to full-light output circuit if power on any phase fails.
  - 4. Accepts a contact closure input from fire alarm system.
- B. Power supplies: Provide power supplies as indicated or as required to power system devices and accessories; junction box-mounted power supply.
- C. Electronic low-voltage interface: Operates electronic low-voltage lighting with a smooth continuous Square Law dimming curve.
- D. Time clock: Astronomic, 7-day programmable, capable of communicating directly with lighting relay room controller.

## 2.30 CONDUCTORS AND CABLES

- A. Wiring to supply side of remote-control power sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19, Wires and Cables.
- B. Low-voltage control cable: Manufacturer's standard multi-conductor cable with stranded-copper conductors not smaller than No. 22 AWG, plenum rated.
  - 1. Class 2 control cables: Multi-conductor cable with copper conductors not smaller than No. 18 AWG.
  - 2. Class 1 control cables: Multi-conductor cable with copper conductors not smaller than No. 14 AWG.
- C. Digital UTP cabling: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5E or Category 6 for horizontal copper cable.

### 2.40 DEVICE PROGRAMMING REQUIREMENTS

- A. Programming of lighting controls shall be performed by a factory certified field service engineer. Refer to lighting controls diagrams on the Drawings.
- 2.90 SOURCE QUALITY CONTROL
  - A. Perform full-function testing on 100 percent of system components and panel assemblies at the factory.

## PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Install devices in complete compliance with the manufacturer's recommendations.
  - B. Ground components according to Section 26 05 26, Grounding and Bonding.
  - C. Fully document control device calibration settings after system programming with manufacturer's representative and submit this information as a part of the O&M manual.
  - D. Devices shall be installed and programmed to meet the control intent.
  - E. Manufacturer's factory certified field service engineer shall perform start-up service, including physical inspection of lighting control system and connected wiring and final adjustments to meet specified performance requirements.

#### 3.21 INSTALLING LIGHTING RELAY ROOM CONTROLLERS

- A. Room controllers shall be surface mounted in accessible ceiling space above entry door.
- B. Provide identification of ceiling grid below room controllers to locate device.
- 3.22 INSTALLING LIGHTING CONTROL STATIONS (LOW-VOLTAGE DIGITAL WALL SWITCHES)
  - A. Provide a single cover plate where two or more devices are grouped together in one box.
  - B. Verify door swings with door frame installed prior to rough-in for switches.
- 3.23 INSTALLING SENSOR DEVICES
  - A. Install in accordance with manufacturer's written instructions.
  - B. Occupancy sensors:
    - 1. Provide low-voltage type detectors.
    - 2. Coverage pattern: Verify coverage pattern of single detector or system of detectors to be capable of complete coverage of the space in which the lighting is intended to be controlled. Provide additional detectors as necessary to satisfy complete coverage.

- 3. Install at least three feet away from HVAC diffusers, or as indicated in manufacturer's written instructions.
- 4. Programming requirements:
  - a. Vacancy mode (manual on, automatic off).
  - b. Occupancy mode (automatic on, automatic off).
- C. Daylight sensors: Location of interior daylight sensors shall be determined by manufacturer's certified field service engineer, based on optimization calculations for greatest energy savings.
- D. Accessory interface devices: Where additional devices are required and need power connection, provide the following:
  - 1. 277-volt circuit: Connect to room/space unswitched normal lighting circuit using 2 #12 + #12 ground in 3/4-inch conduit.
  - 2. 120-volt circuit: Connect to nearest unswitched receptacle circuit using 2 #12 + #12 ground in 3/4 inch conduit.

## 3.59 IDENTIFICATION

- A. Materials: Refer to Section 26 05 53, "Identification for Electrical Systems." Identify devices, wiring, and ceiling grid below locations of lighting relay room controllers.
- B. Lighting control stations: Provide custom engraving on each button of each control station, defining button's function. Coordinate with Owner for final approval of engraving prior to ordering.

## 3.60 FIELD QUALITY CONTROL

- A. Manufacturer's field service: Engage a factory certified field service engineer to test and inspect components, assemblies, and equipment installations, including connections.
- B. Engage a factory certified field service engineer to make site visits indicated to ensure proper system installation and operation. Visit duration shall be suitable to accomplish required tasks.
- C. First visit (Pre-installation): Make first visit prior to installation of wiring for lighting control system.
  - 1. Review:
    - a. Low-voltage wiring requirements.
    - b. Separation of power and low-voltage/data wiring.
    - c. Wire labeling.
    - d. Lighting relay room controller locations.
    - e. Lighting control station locations.
    - f. Load circuit wiring.
    - g. Connections to other equipment.
    - h. Installer responsibilities.
    - i. Power panel locations.
    - j. Additional manufacturer installation requirements.

- 2. Define scope of second visit (typical classroom review): Coordinate with factory certified field service engineer for the area to serve as a mockup of the lighting control system in a typical classroom. Define installation requirements to be completed by second visit.
- D. Second visit (Typical classroom review):
  - 1. Provide mockup of the lighting control system in a typical classroom where directed by the Owner and Architect to demonstrate operability and set quality standards for materials and installation. Mockup installation shall be complete including room controller, control stations, devices, and wiring. Owner and Architect shall review mockup prior to installation of lighting control system in other classrooms.
    - a. Approval of mockup does not constitute approval of deviations from the contract documents contained in mockup unless Architect specifically approves such deviations in writing.
    - b. Subject to compliance with requirements, approved mockup may become part of the completed work if undisturbed at time of substantial completion.
  - 2. Wiring and hardware review: Wiring connections and electrical equipment included in the scope of the lighting control system shall be assessed.
  - 3. Field testing: Sensor connections and lighting control station connections shall be verified.
  - 4. Additional requirements: Coordinate with factory certified field service engineer for additional installation requirements for the completion of the lighting control system.
  - 5. Submit test report.
- E. Completion of installation and programming: Make visits upon completion of installation of the lighting control system. Perform the following tests and inspections:
  - 1. Wiring and hardware review: Wiring connections and electrical equipment included in the scope of the lighting control system shall be assessed.
  - 2. Field testing:
    - a. Verify connection to sensors and lighting control stations.
    - b. Ensure that control hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the contract documents and manufacturer's installation instructions.
    - c. For occupancy sensors, confirm that the placement, sensitivity, and time-out settings are optimized to ensure lights turn off only after each space is vacated and do not turn on unless the space is occupied.
    - d. For daylight sensors, confirm daylight sensor location is optimized to achieve maximum energy savings while maintaining the desired set point and that the light levels in the space are reduced relative to the amount of usable daylight in the space.
  - 3. Tuning: Coordinate with factory certified field service engineer an on-site meeting with the Owner and Engineer to make required adjustments to the lighting control system for conformance with the original design intent.
  - 4. Operational test: After installing room controllers, control stations, and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.

- 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- 6. Submit test report.
- F. On-site training: Make two visits for on-site training as described under Article 3.81, Operating Instructions.
- G. Lighting control components shall be considered defective if they do not pass tests and inspections.
- H. Prepare test reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

## 3.80 SYSTEM STARTUP

- A. Upon completion of project, engage a manufacturer's certified field service engineer to perform startup service.
  - 1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
  - 2. Complete installation and startup checks according to manufacturer's written instructions.

## 3.81 OPERATING INSTRUCTIONS

- A. As specified in Section 26 05 00, "Common Work Results for Electrical", provide operating instructions.
- B. Engage a factory certified field service engineer to train Owner's maintenance personnel to adjust, operate, and maintain lighting control equipment and devices.
- C. On-site training:
  - 1. Schedule at least two sessions of eight consecutive training hours of instruction time.
  - 2. Train Owner's facility management and maintenance personnel, and selected Owner representatives.
  - 3. Training shall include, but not be limited to, overview, adjustment, operation, use, maintenance, and demonstration of the lighting control system.
  - 4. The first training session shall occur within one month of substantial completion. The second training session shall be scheduled between 6 months and 9 months of substantial completion.
  - 5. Each training session shall include on-site demonstration of lighting control system functionality with the Owner.

# **END OF SECTION**

### SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Transformers for electric power 600 V and below.
- B. General-purpose transformer.
- C. K-rated transformer.
- 1.14 RELATED SECTIONS
  - A. Equipment foundations: Section 26 05 28.
- 1.20 REFERENCES
  - A. NEMA ST 20: Dry-Type Transformers for General Applications.
  - B. DOE 2016: Department of Energy federal law 10 CFR Part 431 "Energy Efficient Program for Certain Commercial and Industrial Equipment."

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Each transformer, includes the following:
  - 1. Outline dimensions and weights.
  - 2. kVA rating.
  - 3. Primary and secondary voltage.
  - 4. Taps.
  - 5. Impedance.
  - 6. Insulation class and temperature rise.
  - 7. Sound level.
- C. Shop drawings: Provide shop drawings, sealed by a professional engineer, for each field-fabricated trapeze type support used for mounting transformers.
- D. Certifications:
  - 1. Specified sound levels.
  - 2. Compliance with DOE 2016 for energy efficiency.
- E. Test reports: Factory and field test reports specified in Parts 2 and 3 below.

- F. Unit shown on drawings is based on the characteristics of the design basis unit specified in Part 2. If another acceptable manufacturer's unit should be proposed, ascertain that it will meet the required standards and performance. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, showing any changes in wiring, arrangement or access made necessary to accommodate the unit proposed.
- G. Operation and Maintenance Data: For transformer to include in operation and maintenance manuals: In addition to items specified in Division 01 and Section 26 01 01, include the following:
  - 1. Final settings for transformer taps and measured voltage.

## 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 26 05 00, Common Work Results for Electrical.
- B. UL Energy Verification Mark to confirm compliance with DOE 2016.

## PART 2 - PRODUCTS

- 2.01 ACCEPTABLE MANUFACTURERS
  - A. Square D Company units are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 26 01 01, and submit shop drawings as specified in the article "Submittals" above.
    - 1. Eaton Corp; Cutler-Hammer Products
    - 3. General Electric Company
    - 4. Siemens Energy & Automation, Inc.
    - 5. Square D Company (Schneider Electric)

## 2.30 TRANSFORMERS, GENERAL

- A. Factory-assembled and -tested, air-cooled units of types specified, of size, phase, and voltage ratings indicated on the drawings, designed for 60-Hz service.
- B. Cores: Grain-oriented, nonaging silicon steel.
- C. Coils: Continuous copper windings without splices except for taps.
- D. Enclosure: Heavy-gage steel enclosure and base, arranged for conduit entrance on the primary and secondary sides and provided with adequate louvered openings to allow suitable ventilation and cooling. NEMA 250 Type 1.
- E. Enclosure Finish: Degreased, cleaned, phosphatized, primed and finished with baked enamel paint. Comply with NEMA 250; color manufacturer's standard gray.

- F. Taps: Four, 2.5 percent rated kVA taps, two below and two above rated primary voltages, except transformers rated 15 kVA and smaller may have two 5-percent-rated kVA taps, one above and one below rated primary voltage.
- G. Sound levels based on NEMA ST 20 test procedure:
  - 1. Transformer 50 kVA and smaller: Not more than 45 dB.
  - 2. Transformers 51 to 150 kVA: Not more than 50 dB.
  - 3. Transformers 151 to 300 kVA: Not more than 55 dB.

## 2.31 GENERAL-PURPOSE TRANSFORMERS

- A. Self-cooled, dry type of size, phase, and voltage rating indicated on the drawings, designed in accordance with NEMA ST-20. Dry-type, general-purpose transformers shall be Energy Efficient type in compliance with DOE 2016.
- B. Insulation: The maximum hot spot temperature can be 30 degrees C higher than the specified average below.
  - 1. Transformers below 15 kVA: Class 150 degrees C having a maximum temperature rise under full load conditions not exceeding 115 degrees C when the transformer is operating in 40 degrees C ambient temperature.
  - 2. Transformers 15 kVA and higher: Class 220 degrees C having a maximum temperature rise under full load conditions not exceeding 115 degrees C when the transformer is operating in 40 degrees C ambient temperature.

## 2.40 K-RATED TRANSFORMERS

- A. Transformers evaluated by the UL K-Factor evaluation, UL listed and labeled for K-13, defined as the sum of fundamental and harmonic  $1_h(pu)^2h^2$  in accordance with UL 1561.
- B. Temperature:
  - 1. Neither the primary nor secondary temperature shall exceed 220 degrees C at any point in the coils while they carry their full rating of non-sinusoidal load (i.e., insulation shall be UL-recognized 220-degree-C system).
  - 2. Transformers shall be listed for no more than 115 degrees C average temperature rise.
- C. Transformers shall not have excessive neutral current when supplying loads with large amounts of third harmonic. Neutral bus shall be configured to carry 200 percent of rated current.

## PART 3 - EXECUTION

## 3.20 INSTALLATION, GENERAL

A. Mount on wall, ceiling, or floor as shown on the drawings. Transformers shall not be mounted in corrosive areas.

- 1. Wall mount: Use manufacturer's wall-mounted bracket in accordance with manufacturers' instructions.
- 2. Ceiling mount: Use one of the following two methods:
  - a. Use manufacturer's ceiling-mounted bracket in accordance with manufacturers' instructions.
  - b. Field-fabricated trapeze mount: Trapeze mounting made from galvanized-steel strut or channel. Suspend trapeze from galvanized-steel rods, anchor to ceiling or structure above. If trapeze is adjacent to wall, additionally fasten to wall. Provide vibration isolation between transformer and trapeze or between trapeze and its supports.
- 3. Floor mount: On equipment foundation (housekeeping pad).
- B. Mount exterior equipment on equipment foundation as shown on drawings.
- C. Ground neutrals of dry type transformers as specified in Section 26 05 26, Grounding and Bonding, and as required by NEC (NFPA 70).
- 3.21 INSTALLING TRANSFORMER
  - A. Protect against overload on the primary side by circuit breakers in the panelboards as indicated.
  - B. Install transformers on Isomode vibration isolator pads.
  - C. Make immediate connections to and from transformers through flexible metal conduit.

## 3.59 IDENTIFICATION

- A. Materials: Refer to Division 26 Section "Identification for Electrical Systems."
- B. Nameplates: Refer to Division 26 Section "Identification for Electrical Systems" for additional requirements. Provide identification nameplate for each transformer located on front of assembly.
- 3.60 FIELD QUALITY CONTROL
  - A. Perform tests and inspections and prepare test reports.
    - 1. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  - B. Tests and inspections:
    - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

## 3.70 ADJUSTING AND CLEANING

- A. Refinish painted surfaces damaged during construction to match the rest of the equipment.
- B. Measure voltage on the secondary side of transformer during a typical occupancy period and adjust taps to achieve nominal voltage output. Nominal voltage shall be plus three percent or minus two percent of nameplate secondary voltage.
- C. Record final tap settings and measured voltage and include in Operation and Maintenance manuals.

## 3.85 **PROTECTION**

A. Apply temporary heat within indoor transformer enclosures, in accordance with manufacturer's recommendations, until the space temperature and humidity are under normal control.

## **END OF SECTION**

### SECTION 26 24 13 - SWITCHBOARDS

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Service and distribution switchboards rated 600 V and less, for interior installation, including:
  - 1. Utility metering section
  - 2. Main switch section, circuit breaker type.
  - 3. Ground fault protection system.
  - 4. Distribution sections, circuit breaker type.
  - 5. Surge protective devices.

#### 1.14 RELATED SECTIONS

- A. Fuses: Section 26 28 13.
- B. Equipment foundations: Section 26 05 28
- C. Surge protective devices: Section 26 43 13.

#### 1.20 REFERENCES

- A. NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
- B. NEMA AB 1, Molded Case Circuit Breakers and Molded Case Switches.
- C. NEMA PB 2, Deadfront Distribution Switchboards.
- D. NEMA PB 2.1, Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less.
- E. UL 891, Dead-Front Switchboards.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: For each type of switchboard including overcurrent protective devices, groundfault protective devices, transient voltage suppression, and accessories. Include weights, dimensions, minimum clearances; and manufacturer's technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- C. Shop drawings: For each switchboard, include the following:
  - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly, location, and size of each field connection.

- 2. Single-line diagram representation of switchboard, bus configuration, current, and voltage ratings.
- 3. Short-circuit current rating of switchboard assembly and overcurrent protective devices.
- 4. Utility company metering provisions with indication of approval by utility company.
- 5. Scheduled of features, characteristics, ratings, and factory settings of individual protection devices.
- 6. Wiring diagrams for power and control, differentiating between manufacturer-installed and field-installed wiring.
- 7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
- D. For service entrance switchboards, submit to utility company, BGE for approval.
- E. Coordination Drawings: Floor plans, drawn to 1/4"=1'-0" scale, on which the following items are shown and coordinated with each other based on input from installers of the items involved:
  - 1. Dimensioned concrete base; outline of equipment; and required clearances; relationship between components and adjacent architectural, structural, and mechanical elements.
  - 2. Underground conduit stub-up locations, where applicable.
  - 3. Overhead conduit riser locations.
  - 4. Grounding cable locations and terminations.
  - 5. Identify equipment sections including front and rear orientation.
- F. Operation and maintenance data: For switchboards to include in the maintenance manuals specified in Division 01. Include manufacturer's detailed written instructions on adjusting overcurrent protective devices.

## 1.40 QUALITY ASSURANCE

- A. Source limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency accepted by the authority having jurisdiction, and marked for intended location and application; listed as a complete assembly.
  - 1. UL label and local testing (where required): As specified in 26 05 00, Common Work Results for Electrical.
- C. Product selection for restricted space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

## 1.49 COORDINATION

- A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.
- B. Coordinate size and location of concrete bases.

C. Coordination location of underslab conduit.

### 1.50 DELIVERY, STORAGE, AND HANDLING

- A. Delivery in sections of lengths that can be moved past obstructions in delivery path.
- B. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

#### PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Switchboards manufactured by Square D are the basis for design of the project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 26 01 01, and submit shop drawings as specified in the article "Submittals" above.
  - 1. Eaton Corp; Cutler Hammer Products
  - 2. General Electric Company
  - 3. Siemens Energy & Automation, Inc.
  - 4. Square D Company (Schneider Electric)

#### 2.31 MAIN SWITCHBOARD

- A. Service entrance and distribution switchboard, NEMA PB 2, UL listed, in a NEMA 250 Type 1 enclosure except as indicated otherwise.
- B. Construction: Deadfront with front access.
  - 1. Formed code-gage steel, welded and bolted together to support cover plates, bussing, and component devices during shipment and installation.
  - 2. Finish: Gray enamel over a rust-inhibiting phosphate primer.
  - 3. Furnish each unit with a master nameplate, listing standard manufacturer information including voltage, ampacity, frequency, and short-circuit ratings; manufacturer's model and project designations.
- C. Sections: Each shall have an open bottom and individual removable top plate for installation and termination of conduit.
  - 1. Wireway front covers: Hinged to permit access to the branch breaker load side terminals without removing the covers.
- D. Bussing: Plated copper and of sufficient cross-sectional area to meet UL 891 for temperature rise.

- 1. Through bus: Ampacity, and braced to have a short-circuit current rating of RMS symmetrical amperes, as shown on the drawings. The through bus shall have provisions for the addition of future sections. Bolt supports, connections and joints with grade 5 hex head bolts and belleville washers.
- E. Utility metering compartment: Fabricated compartment and section meeting utility company's requirements. If separate vertical section is required for utility metering, match and align with basic switchboard.
- F. Owner's metering:
  - 1. Meters: Multifunction digital meter mounted in a door, minimum 25 percent accuracy, and supplied with potential and current transformers. Meters shall have the ability to be read remotely over a RS-485 communications port.
    - a. Phase- (and neutral, where applicable) selectable meter functions shall include instantaneous current, instantaneous voltage, instantaneous real power, instantaneous reactive power, instantaneous complex power, power factor, and total harmonic distortion. Readings shall be true root-mean-square where applicable.
    - b. Meter shall also record peak demand per phase for real, reactive, and complex power, with date/time stamping.
    - c. Meter shall also record kilowatt-hours, kilovar-hours, and kilovoltamp-hours consumed.
    - d. Meter shall have a data log and an event log with a minimum memory of 100 kilobytes. Meter shall capture waveforms when triggered by disturbances (as defined in programming) in voltage or current.
  - 3. Potential and Current Transformers: ANSI C57.13.
- G. Main circuit breaker section: Enclosed, molded-case type circuit breaker, totally front-accessible and front-connectable. Line side circuit-breaker connections shall be jaw type plug-on.
  - 1. Circuit breaker: NEMA AB 1, handle lockable; frame size, trip rating, number of poles, and auxiliary devices as indicated; interrupting capacity rating to meet available fault current.
    - a. 200 A and larger: Trip units interchangeable within frame size.
    - b. 400 A and larger: Field-adjustable short-time and continuous current settings.
    - c. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.
- H. Ground fault protection system for main section:
  - 1. Current sensor and relaying equipment: Split-core type current sensor shall enclose all phase conductors, and neutral conductors, if present, of the circuit to be monitored.
  - 2. Monitor panel: Include a push-to-test button for the test circuit and a red, ground fault indicator light which indicates the circuit interrupter has opened due to a ground fault condition.

- 3. Test winding: Shall simulate the flow of ground fault current through the current sensor, in order to test the complete system, including sensor pickup, relaying equipment, and electric trip mechanism of the switch.
  - a. Ground fault relay: Solid-state construction, with adjustable pickup for ground fault currents from 200 amperes to 1200 amperes. Settings for individual relays shall be as shown on the drawings. Time delay provided by the field-adjustable ground fault relay circuitry shall have continuous settings from 0.03 to 0.6 seconds.
- I. Circuit breakers:
  - 1. Circuit breakers shall be suitable for mounting in the switchboard sections for which they are scheduled: Either group- or individually-mounted distributed sections.
    - a. Group-mounted circuit breakers through 1200 A:
      - 1) Circuit breaker(s) shall be grouped-mounted plug-on with mechanical restraint on a common pan or rail assembly.
      - 2) The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
      - 3) Circuit breaker(s) equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker(s) shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breaker(s) of different frame sizes shall be capable of being mounted across from each other.
      - 4) Line-side circuit breaker connections shall be jaw type.
      - 5) Unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including appropriate connectors and mounting hardware.
  - 2. Electronic trip molded case circuit breakers:
    - a. Circuit breakers shall be rated for 100 percent of nominal current.
    - b. Circuit breakers shall have the following time/current response adjustments: Long time pickup, long time delay, short time pickup, short time delay, ground fault pickup ground fault delay and instantaneous settings. Each adjustment shall have discrete settings (fully adjustable) and shall be independent of other adjustments.
    - c. Circuit breaker trip system shall be a microprocessor-based true root-mean-square sensing designed with sensing accuracy through the thirteenth harmonic. Sensor ampere ratings shall be as indicated on the associated schedule.
    - d. Provide local visual trip indication for overload, short circuit and ground fault trip occurrences.
    - e. Provide long time pickup indication to signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker.

## 2.71 SURGE PROTECTIVE DEVICES (SPD)

A. As part of the switchboard, provide service entrance SPD specified in Section 26 43 13, Surge Protective Devices.

## 2.92 FACTORY TESTS

A. Each switchboard, as a complete unit, shall be given a single short-circuit current rating by the manufacturer. Rating shall be established by actual tests by the manufacturer, in accordance with UL specifications, and on equipment similar to the switchboard provided for this project.

## PART 3 - EXECUTION

#### 3.02 EXAMINATION

- A. Examine elements and surfaces were switchboard will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance.
- B. Verify that equipment foundations are level and ready to receive equipment.
- C. Verify field measurements are as indicated on architectural drawings.
- D. Verify that required utilities are available, in proper location, and ready for use.
- E. Beginning of installation indicates installer accepts conditions.

#### 3.21 INSTALLATION

- A. Provide equipment foundation (housekeeping pad).
- B. Level switchboard in place before mounting and bolt to the foundation. Assemble sections as required by the manufacturer and in accordance with NEMA PB 2.1.
- C. Frame and mount printed operating instructions, including control and key interlocking sequences and emergency procedures, on front of switchboards.

#### 3.25 CONNECTIONS

- A. Connect switchboards and components to wiring systems according to other sections of Division 16 and instructed by manufacturer's recommendations.
- B. Ground equipment according to Section 26 05 26, Grounding and Bonding, and as instructed by manufacturer's recommendations.
- C. Tighten electrical connectors and terminals according to manufacturer's published torquetightening values. Where manufacturer's values are not indicated, use those specified in UL 486A and UL 486B.

## 3.59 IDENTIFICATION

A. Identify field-installed wiring and components as specified in 26 05 00, Common Work Results for Electrical.

B. Nameplates: Provide identification nameplate for each switchboard and each section, including associated components, located on front of assembly.

## 3.60 FIELD QUALITY CONTROL

- A. Inspect, test, and adjust the equipment. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  - 1. Testing insulation resistance for each switchboard bus, components, and connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- B. Operate equipment and check controls, including high- and low-limit controls.
- C. Assure that the equipment functions properly by actual operation prior to final acceptance.

## 3.70 ADJUSTING

A. Set field-adjustable, circuit breaker trip characteristics as indicated.

## 3.75 CLEANING

- A. Clean interior and exterior of switchboards.
- B. Refinish painted surfaces damaged during construction to match the rest of the switchboard.

## 3.81 OPERATING INSTRUCTIONS

A. As specified in Section 26 05 00, Common Work Results for Electrical, provide operating instructions.

# END OF SECTION

#### **SECTION 26 24 16 - PANELBOARDS**

### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Circuit breaker panelboards, distribution and lighting and appliance branch-circuit types.
- 1.14 RELATED SECTIONS
  - A. Identification for Electrical Systems: Section 26 05 53.
  - B. Fuses: Section 26 28 13.
  - C. Surge protective devices: Section 26 43 13.

#### 1.20 REFERENCES

- A. ANSI/NECA 407: Recommended Practice for Installing and Maintaining Panelboards.
- B. NEMA 250: Enclosures for Electrical Equipment (1000 Volts Maximum).
- C. NEMA PB 1: Panelboards.
- D. NEMA PB 1.1: Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.
- E. NETA ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- F. UL 50: Enclosures for Electrical Equipment.
- G. UL 67: Panelboards.
- H. UL 1449: Surge Protective Devices.

#### 1.21 DEFINITIONS

- A. Circuit-Breaker Panelboards in this section:
  - 1. Distribution panelboard: Capable of accepting up to 1200-A branch breakers.
  - 2. Lighting and appliance panelboard: Maximum branch breaker amperage 125 A.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: For each type of panelboard, overcurrent protective device, surge protective device, accessory, and component indicated.

- C. Bill of Materials: Provide detailed list of components.
- D. Shop Drawings: For each type of panelboard, include the following details:
  - 1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings in panel schedule format.
  - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
  - 3. Detail bus configuration, current, and voltage ratings.
  - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
  - 5. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
- E. Operation and Maintenance Data: For panelboards and components to include in operation and maintenance manuals. In addition to items specified in Division 01 and Section 26 01 01, include the following:
  - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device.
  - 3. Copy of each printed panelboard schedule representing final version following installation.

## 1.40 QUALITY ASSURANCE

- A. Source limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.
- B. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency accepted by the authority having jurisdiction, and marked for intended location and application; listed as a complete assembly.
  - 1. UL label and local testing (where required): As specified in Section 26 05 00, Common Work Results for Electrical.
- C. Comply with referenced standards and listings previously identified including NEMA PB 1, NFPA 70, and UL 67.

## 1.49 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

## 1.50 DELIVERY, STORAGE, AND HANDLING

A. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

## 1.60 PROJECT CONDITIONS

- A. Interruption of existing electrical service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements.
  - 1. Notify Architect no fewer than seven days in advance of proposed interruption of electrical service. Provide applicable details of proposed outage including sequence of work and methods of providing temporary electrical service.
  - 2. Do not proceed with interruption of electrical service without written permission.

## 1.92 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Keys: Two spares for each type of panelboard cabinet lock.
  - 2. Furnish spare breakers for panelboards as indicated in schedule on drawings.

## PART 2 - PRODUCTS

## 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide scheduled Square D Company (Schneider Electric) panelboards or comparable product by one of the following:
  - 1. Eaton Corp.; Cutler-Hammer Products
  - 2. General Electric Company
  - 3. Siemens Energy & Automation, Inc.
  - 4. Square D Company (Schneider Electric)

## 2.30 PANELBOARDS, GENERAL

- A. UL listing: UL 67, listed and labeled.
- B. Integrated equipment short-circuit rating: Each panelboard, as a complete unit, shall have a short-circuit rating equal to or greater than the integrated equipment rating shown or scheduled on the drawings.
  - 1. Rating shall be established by testing in accordance with UL 67, with the overcurrent devices mounted in the panelboard. Make short-circuit tests on the overcurrent devices and on the panelboard structure simultaneously, by connecting the fault to each overcurrent device with the panelboard connected to its rated voltage source. The source shall be capable of supplying specified panelboard short-circuit current or greater.
  - 2. Testing of overcurrent devices only while individually mounted is not acceptable. Testing the bus structure by applying a fixed fault to the bus structure alone is not acceptable.
- 3. Mark each panelboard with its maximum short-circuit current rating at the supply voltage.
- 4. Series rating of panelboards with devices outside of the panelboard enclosure are not permitted.
- D. Enclosures: Flush- or surface-mounted as indicated, NEMA PB 1, Type 1, UL 50, galvanized steel.
  - 1. Size: Where multiple-width or multiple-section panelboards are indicated or required, each cabinet shall be the same width and height.
  - 2. Provide enclosure type as indicated below:
    - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
- D. Directory card: Inside panelboard door, mounted in transparent card holder with information as indicated in Part 3, Identification.
- E. Provisions for future devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- F. Furnish each unit with a master nameplate, listing standard manufacturer information including voltage, ampacity, frequency, and short-circuit ratings; manufacturer's model and project designations.

## 2.31 CIRCUIT-BREAKER PANELBOARDS

- A. Factory-assembled complete with breakers.
- B. Cabinets and fronts: Minimum 20 inches wide, wiring gutter space in accordance with UL 67, with minimum four-inch width on every side.
  - 1. Cabinet front: Hinged trim with entire front hinged to cabinet box with piano hinge and screw fasteners for surface mounted cabinets.
  - 2. Door: Required for sizes up to and including 600 amps.
    - a. Lock: Flush, cylinder tumbler type, with catch and spring-loaded stainless steel door pull. All panelboards shall be keyed alike. Provide two keys per lock. Provide extra keys as required in "Extra Materials" in Part 1 above.
    - b. Hinges: Steel, completely concealed.
- C. Circuit breakers: UL 489; voltage, continuous-current rating, and interrupting rating as indicated on the drawings.
  - 1. Breakers shall be 1-, 2- or 3-pole, with an integral crossbar to assure simultaneous opening of all poles in multipole circuit breakers.
  - 2. Operating mechanism: Overcenter, trip-free, toggle-type with quick-make, quick-break action. Handles shall have on, off, and tripped positions.
  - 3. Circuit breakers shall be able to be installed in the panelboard without requiring additional mounting hardware or disturbing adjacent units, bars, or branch circuit connections.
  - 4. Where indicated on the drawings, provide shunt-trip main breakers, standard main breakers, or lugs.

- 5. Main and branch circuit breakers shall have device ampacity rating engraved on the front or side of each breaker handle. The breaker rating shall be clearly visible without removing panelboard cover.
- 6. Circuit breakers shall be rated for use with 75 deg C wire (conductor temperature rating).
- 7. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 amps and larger.
- 8. Adjustable instantaneous-trip circuit breakers: Magnetic trip element with front mounted, field-adjustable trip setting.
- 9. Electronic trip circuit breakers: RMS sensing; field-replaceable rating plug or field replicable electronic trip; and the following field-adjustable settings:
  - a. Instantaneous trip.
  - b. Long- and short-time pickup levels.
  - c. Long- and short-time time adjustments.
  - d. Ground-fault pickup level, time delay, and l<sup>2</sup>t response.
- 10. Ground-fault circuit interrupter (GFCI) type circuit breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- 11. Tandem breakers are not permitted.
- D. Bussing assembly and temperature rise: Panelboard bus structure and main lugs or main circuit breaker shall have current ratings as shown on the panelboard schedule, established by heat rise tests conducted in accordance with UL 67.
  - 1. Conductor dimensions shall not be accepted in lieu of actual heat tests.
  - 2. Current-carrying parts of the bus structure shall be hard-drawn copper, 98 percent conductivity.
  - 3. Provide a separate copper ground bus with screw terminals for branch wiring and feed-through lugs.
  - 4. Where indicated on the drawings, provide a neutral bus sized for 200 percent of the panelboard bus rating. Panels with 200 percent neutrals shall be designed for use with nonlinear loads.
- E. Distribution panelboards: Distribution panelboard shall be capable of accepting up to 800 ampere branch breakers, or as indicated on drawing panel schedules. Current characteristics shall be as scheduled on the drawings.
- F. Branch circuit panelboards: Panelboard shall be capable of accepting 125-amp branch breakers.
  - 1. Branch breakers serving exit lights, fire alarm, emergency lighting, and security equipment shall be provided with handle-blocking devices which shall prevent accidental operation but not prevent tripping.

# 2.33 FUSIBLE BRANCH CIRCUIT PANELBOARDS

- A. Fusible branch circuit panelboards shall be as indicated in the panelboard schedule and provided where shown on the drawings.
  - 1. Emergency (life-safety) branch shall utilize fusible panelboards.

- B. Construction: Panelboard circuits 100-ampere and less shall incorporate fused overcurrent protection and disconnection means into a single integrated component.
  - 1. Panelboard shall be equipped with spare fuse compartment for storing replacement branch circuit fuses. Provide spare 20-ampere, single-phase fuses unless otherwise noted.
- C. Type: Deadfront, NEMA 1 panelboard with top or bottom feed, equipped with quick make, quick break fusible main and branch switch devices.
- D. Bus structure and main lugs or main switch: Current ratings as shown on the panelboard schedule. The bus structure shall accommodate plug-on bus connectors, sizes and ratings as indicated in the panelboard schedule.
- E. Fusible branch switches:
  - 1. Device shall be finer-safe, and incorporate dual-element, time-delay UL class CF power fuse with Class J performance.
  - 2. Device shall have visible circuit 'On' and 'Off' indication positions.
  - 3. Device shall have open fuse indicating light.
  - 4. Shall provide fuse amp rating. Device shall have interlocked fuse and disconnect so as not to allow fuse removal while fuse terminals are energized.
  - 5. Device shall have means to lockout in the 'On' or 'Off' position.
  - 6. Provide a circuit identification cardholder for each branch switch.
- F. Panelboard overcurrent protective devices shall be UL listed for use on a system capable of delivering not more than 200,000 rms symmetrical A at 600 V ac maximum when all main and branch switches are equipped with rated Class J fuses.
- G. Where panelboard main fuses are installed, fuses in panelboard branch circuits shall selectively coordinate with main fuses.
- 2.90 SOURCE QUALITY CONTROL
  - A. With branch circuit breakers installed, short-circuit test panelboards as complete units, in accordance with requirements of UL 67.

## PART 3 - EXECUTION

## 3.20 INSTALLATION

- A. Securely attach panelboards to the wall where indicated on the drawings. Install in accordance with NEMA PB 1.1 and manufacturer's written installation instructions.
  - 1. Mounting height:
    - a. 72 inches (1829 mm) to top of panelboard.
    - b. Panelboards taller than 72 inches (1829mm): Bottom edge no more than 4-inches (102 mm) above floor.

- c. Top breaker maximum height: No more than 6-feet, 7-inches (2.0 m) above the floor or working platform.
- B. Comply with applicable portions of NECA 407.
- C. Frame and mount printed circuit directory indicating type and location of equipment on each circuit.
- D. Wiring in gutters: Arrange conductors into groups, and bundle and wrap with wire ties.
- E. Install filler plates in unused spaces.
- F. Spare conduits: Where panelboards are recessed in wall construction, stub four 1-inch (27 mm) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.
- 3.25 CONNECTIONS
  - A. Connect panelboards and components to wiring and to ground as indicated.
  - B. Tighten electrical connectors and terminals according to manufacturer's published torquetightening values. Where manufacturer's values are not indicated, use those specified in UL 486A and UL 486B.

#### 3.59 IDENTIFICATION

- A. Materials: Refer to Division 26 Section " Identification for Electrical Systems." Identify units, auxiliary devices, controls, and wiring. Identify equipment ratings.
- B. Nameplates: Refer to Division 26 Section "Identification for Electrical Systems" for additional requirements. Provide identification nameplate for each panelboard and associated components located on front of assembly.
- C. Identify field-installed wiring and components. Refer to Division 26 Section "Identification for Electrical Systems" for additional requirements.
- D. Provide printed directory for each panelboard. Handwritten directories are not acceptable. Copying of panel schedules and descriptions on drawings is not acceptable. Circuit directory shall reflect final circuit installation. Include the following information:
  - 1. Panelboard designation and room location.
  - 2. Circuit breakers, size and number of poles.
  - 3. Circuit or feeder description including destination room name(s) and number(s).
  - 4. Clear description of type of load circuit serves.
  - 5. Panelboard ratings: Main bus ampacity, main circuit breaker or main lug ampacity, AIC rating.
  - 6. Incoming primary feeder size and source panelboard circuit designation.
- E. Room names and numbers on the panelboard circuit directories shall match names and numbers used by the Owner. Note that room names and numbers on the drawings may not match the Owner's final room name and numbering scheme.

## 3.60 FIELD QUALITY CONTROL

- A. Make insulation-resistance tests of each panelboard bus, component, and connecting supply, feeder, and control circuit.
- B. Make continuity tests of each circuit.
- C. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- D. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

## 3.75 CLEANING

- A. Clean interior and exterior of panelboards.
- B. Refinish painted surfaces damaged during construction to match the rest of the panelboard.

## SECTION 26 25 50 - GENERATOR DOCKING STATION

#### PART 1 - GENERAL

### 1.1 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL (Underwriters Laboratories, Inc.) Standards
- C. cUL (Underwriters Laboratories of Canada) Standards
- D. Comply with NFPA 70.
- 1.2 GUARANTEE/WARRANTY
  - A. The equipment installed under this contract shall be left in proper working order. Replace, without additional charge, new work or material which develops defects from ordinary use within one year.
  - B. New materials and equipment shall be guaranteed against defects in composition, design or workmanship. Guarantee certificates shall be furnished.

#### PART 2 - PRODUCTS

- 2.1 GENERATOR DOCKING STATION
  - A. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - 1. TRYSTAR: GDS Series.
- 2.2 GENERAL REQUIREMENTS
  - A. Enclosures:
    - 1. Pad mounted cabinet.
    - 2. Side and back accessible.
    - 3. Built for environmental conditions at installed location:
      - a. Outdoor Locations: NEMA 250, Type 3R.
    - 4. Enclosure material:
      - a. 0.100 Aluminum
    - 5. Front Door:
      - a. Hinged.
      - b. Gasketed.
      - c. Pad-lockable latch.

- 6. Finishes:
  - a. Paint after fabrication. Powder coated ANSI 61 light gray.
  - b. Custom colors available, consult factory.
- B. Phase, Neutral, and Ground Buses:
  - 1. Material: Silver-plated, Hard-drawn copper.
  - 2. Equipment Ground Bus: bonded to box.
  - 3. Isolated Ground Bus: insulated from box.
  - 4. Ground Bus: 25%, 50% or 100% of phase size.
  - 5. Neutral Bus: Neutral bus rated 100 percent of phase bus.
  - 6. Round edges on bus.
- C. Inputs Connectors (from roll-up device):
  - 1. E1016 Series male camlock panelmounts with flip covers for portable.
- D. Lockable rake system with reinforced support struts to reduce cable theft.(100-1200A only)
- E. Voltage & Phase
  - 1. 277/480V 3 phase 4w
- F. Amperage
  - 1. 2000A input.

## PART 3 - EXECUTION

- 3.1 EXAMINATION
  - A. Examine elements and surfaces to receive Generator Docking Station for compliance with installation tolerances and other conditions affecting performance of the Work.
  - B. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 INSTALLATION

- A. Surface, Flush or Base Mounted: Specified with order.
  - 1. Install anchor bolts to elevations required for proper attachment to Generator Docking Station.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

## 3.3 FIELD QUALITY CONTROL

A. Suggested Tests and Inspections to include the following:

- 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- 3. Perform the following infrared scan tests and inspections and prepare reports:
  - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each Generator Docking Station. Remove front panels so joints and connections are accessible to portable scanner.
- B. Generator Docking Station will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports, including a certified report that identifies Generator Docking Station and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Optional Manufacturer's Field Start-up: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections prior to turn-over to Owner.

## SECTION 26 27 16 - CABINETS AND ENCLOSURES

### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Indoor enclosures.
  - B. Weatherproof enclosures.
- 1.14 RELATED SECTIONS
  - A. Equipment foundations: Section 26 05 28.

## 1.30 SUBMITTALS

- A. Comply with Division 01 and Section 26 01 01.
- B. Product data: Each type of enclosure required for the project.

## PART 2 - PRODUCTS

- 2.11 INDOOR ENCLOSURES
  - A. Type 1 in accordance with NEMA 250 and conforming to UL 57, of size required by NEC to fit equipment or as shown on the drawings.
  - B. Construction: Code grade galvanized steel.
- 2.12 WEATHERPROOF ENCLOSURES
  - A. Type 3R in accordance with NEMA 250 and conforming to UL 57, of size required by NEC to fit equipment or as shown on the drawings.
  - B. Construction: Fabricated of 14-gage galvanized steel, with drip shield top and smooth, seam-free sides and back.
  - C. Doors: Double doors fabricated from 12-gage galvanized steel, overlap type without center post.
    - 1. Door gaskets: Neoprene, attached with oil-resistant adhesive and held in place with steel retaining strips.
    - 2. Full-length piano hinges.
    - 3. Locks: Keyed, with all keys alike. Provide two keys with each enclosure.
  - D. Provide steel channels in rear of cabinet for mounting metering equipment.

## 2.13 FINISHES

A. Satin gray enamel, inside and out.

## PART 3 - EXECUTION

## 3.20 INSTALLATION

A. Securely attach enclosure to wall, set on housekeeping pad, or hang on frame, as indicated.

## 3.21 LOCATIONS

A. Provide indoor type inside building and weatherproof type in exterior locations.

### **SECTION 26 27 26 - WIRING DEVICES**

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Receptacles
  - B. Emergency shutoff pushbuttons.
  - C. Floor boxes.
  - D. Audible signaling equipment.
  - E. Contactors.
- 1.14 RELATED SECTIONS
  - A. Nameplates: Section 26 05 53.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Each type of device used in the project.
- C. Samples: One sample of each type of wiring device and device plate.

#### PART 2 - PRODUCTS

#### 2.20 RECEPTACLES

- A. Acceptable Manufacturers:
  - 1. Pass and Seymour, Inc
  - 2. Leviton Manufacturing Co.
  - 3. Hubbell/Bryant Electric
  - 4. Cooper Industries/Eaton Wiring Devices.
- B. Provide devices conforming to UL 498 for receptacles, equal to the following Pass & Seymour catalog numbers or NEMA WD 1 and WD 6 configuration numbers:
  - 1. Duplex convenience receptacles: TR5362, NEMA5-20R, tamper resistant.
  - 2. GFCI receptacles: 2097TR, NEMA 5-20R, tamper resistant..
    - a. Exterior and wet locations: 2097 TRWR, NEMA 5-20R, weather-resistant.
    - b. Weatherproof cover: WIUC10-CL, while-in-use cover
- C. Device color:

- 1. General-purpose receptacles: Brown.
- 2. Computer/network receptacles: Gray.
- 3. Emergency power receptacles: Red.
- D. Device plates: Equal to P&S: Type 302 stainless steel, SS Series.

## 2.21 EMERGENCY SHUTOFF PUSHBUTTONS

- A. Emergency pushbutton to shut down equipment or circuits: Equal to Safety Technology International (STI) 2000 Series "Stopper Stations", UL listed and ADA compliant, with button recessed in housing; with STI "Bopper Stopper" hinged cover.
  - 1. Housing: Polycarbonate with stainless-steel back plate and spacers where recommended by manufacturer.
  - 2. Protective cover: Clear polycarbonate cover and hinge with stainless-steel hinge spring,
  - 3. Operation: Push to activate and turn to reset operation, or momentary operation as indicated on drawings.
  - 4. Color and identification indicated on drawings.
- B. Emergency power off: Yellow housing and custom label: EMERGENCY POWER OFF.
- C. Boiler gas-fired equipment shutdown: Yellow housing and custom label: EMERGENCY BOILER SHUTDOWN.

## 2.22 FLOOR BOXES

A. Floor box for power and communications: As specified in 16134, Boxes, complete with specification grade 20 A, 125 V receptacles as indicated on the drawings.

## 2.25 RELAYS

- A. Relays: Equal to Square D Company, Class 8501 Type C in NEMA 250 Type 1 enclosure.
- B. Contacts: Double-break, fine silver, convertible from normally open to normally closed contacts. Provide contact status indication.
- C. Coils: Molded construction, terminals provided with pressure wire connectors.
- D. Coil voltage and number of contacts shall be as indicated on the drawings.

## 2.30 TERMINAL BLOCKS

- A. Terminal blocks: Equal to Square D, screw-terminal type, size as required by NFPA 70, NEMA 250 Type 1 enclosure with hinged cover.
- 2.31 AUDIBLE SIGNALING EQUIPMENT
  - A. Alarm Bells: Equal to Edwards Signaling & Security, vibrating type 4-inch (102-mm) Model 340-4N5 120 V. Bells shall be electrically operated, heavy duty, having a minimum sound

rating of 85 db at 10 feet, with current characteristics indicated on the drawings; Hand/Off/Auto selector switch on cover.

- B. Pushbuttons
  - 1. Weatherproof bell pushbuttons: Equal to Edwards Company No. 852 flush-mounted on a nominal 4.5- by 3-inch plate finished in satin chrome, 125 volt at 6 amps, complete with rubber gasket between wall and plate. Normally open contacts.
  - 2. Pushbutton for buzzer: Equal to Edwards Company No. 821 locknut weatherproof-type mounted in plate No. 149-1 to fit standard switchbox.
- 2.40 CONTACTORS
  - A. Equal to Square D 8903, UL 508 listed, in NEMA 250 Type 1 enclosure, mechanically held, electrically operated, enclosed silver-alloy double-break contacts, coil-clearing contacts; withstand rating as indicated on the drawings; Hand/Off/Auto selector switch on cover.
    - 1. Provide contactor with two-wire control relay for two-wire control of mechanically held lighting contactor.

## PART 3 - EXECUTION

## 3.20 INSTALLATION

- A. Install devices in complete compliance with the manufacturer's recommendations.
- B. Attach nameplates securely to receptacle cover plates. Provide nameplates for all devices except 120-volt receptacles, identifying equipment and use.
- C. Provide a single cover plate where two or more devices are grouped together in one box.

#### SECTION 26 28 00 - LOW-VOLTAGE CIRCUIT PROTECTIVE DEVICES

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Disconnecting switches (disconnects).
- B. Enclosed circuit breakers.
- C. Elevator disconnecting switch.

#### 1.14 RELATED SECTIONS

- A. Motors: Sections 22 05 13 and 23 05 13.
- B. Fuses: Section 26 28 13.

#### 1.20 REFERENCES

- A. NEMA AB 1: Molded Case Circuit Breakers and Molded Case Switches.
- B. NEMA KS 1: Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- C. UL 98: Enclosed and Dead-Front Switches.
- D. UL 489: Molded Case Circuit Breakers and Circuit Breaker Enclosures.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 26 01 01.
  - B. Product data: Each type of disconnecting switch, enclosed circuit breaker, and elevator disconnecting switch.
- 1.40 QUALITY ASSURANCE
  - A. Comply with the following standards:
    - 1. NEMA KS 1 for disconnecting switches.
    - 2. UL 98.
    - 3. UL 198E
    - 4. UL 489 for enclosed circuit breakers.
  - B. UL label and local testing (if required): As specified in Section 26 05 00, Common Work Results for Electrical.

## PART 2 - PRODUCTS

## 2.21 DISCONNECTING SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Corp; Cutler-Hammer Products
  - 2. General Electric Company
  - 3. Siemens Energy & Automation Inc.
  - 4. Square D Company; Schneider Electric
- B. Properly size switches for number of poles and provide fused or non-fused as required for project conditions and to meet NFPA 70 requirements.
  - 1. Neutral kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  - 2. Auxiliary contact kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
- C. Fuse contacts and quick-make/quick-break jaws shall insure positive contacts with reinforcing spring clips or other approved means.
- D. Switches shall be front-operated.
- E. Current-carrying parts: Silver-plated copper.
- F. Hinges: Noncurrent-carrying.
- G. Switches shall be lockable in either open or closed position.
- H. Type:
  - 1. Nonfused switches: General-duty type on 120/208 V or 120/240 V systems, and heavyduty type on 277/480 V or 240/480 V systems.
  - 2. Fused switches: Heavy-duty type on all voltages.
- I. Enclosures: Indoors NEMA 250 Type 1; outdoors Type 3R, with raintight hubs.

### 2.22 ENCLOSED CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Corp; Cutler-Hammer Products
  - 2. General Electric Company
  - 3. Siemens Energy & Automation Inc.
  - 4. Square D Company; Schneider Electric

- B. Separately enclosed circuit breakers, as indicated, manually operated, trip-free from the handle, and provided with inverse-time, thermal-element overload protection and instantaneous magnetic short-circuit protection on all poles.
- C. Breaker sizes, calibrations and interrupting capacity: Noted on the drawings. Breakers shall be calibrated for 50 degrees C ambient and shall be rated for use with minimum 75 degree C wire.
- D. Type: Molded-case, NEMA AB 1.
- E. Operating handles shall clearly indicate the positions On, Trip, and Off.
- F. Provide shunt trip operation where indicated on the drawings.
- G. Enclosures: Indoors NEMA 250 Type 1; outdoors Type 3R, with raintight hubs.

## 2.23 ELEVATOR DISCONNECTING SWITCH

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Cutler-Hammer
  - 2. Cooper Bussmann, Inc.
  - 3. Mersen
  - 4. Littlefuse, Inc.
- B. Separately enclosed in NEMA 250 Type 1 enclosure with externally operable lockable handle allowing switch to be locked in the OFF position ensuring load side power isolation during servicing.
  - 1. Properly sized Class J fuses, equal to Cooper Bussmann JKS Limitron fuses, Class J fuse block, connected in series with molded case safety switch.
  - 2. Properly sized molded case switch, with 120 VAC shunt trip operation, connected in series with fuses.
  - 3. Control circuit: 120-Volt.
    - a. Control power transformer: Primary voltage as required for the motor, 120V secondary voltage; capacity to operate control devices and 100 percent spare capacity.
    - b. Primary and secondary fuse protection for each control power transformer: Class CC fuses, current-limiting rejection type, rated 0.1 to 30 A, 600 V, and 200 kA interrupting rating.
  - 4. Fire safety interface isolation relay: 3PDT, 10A, 120V relay with coil voltage as required to interface with the fire alarm system.
  - 5. Voltage monitoring relay: To monitor shunt trip voltage.
  - 6. Auxiliary control contacts:
    - a. One normally open and one normally closed primary auxiliary contact.
    - b. One normally open and one normally closed secondary auxiliary contact.
  - 7. Green power ON pilot light.

- 8. Ground lug.
- 9. Key-to-Test Switch.

## PART 3 - EXECUTION

### 3.20 INSTALLATION

- A. Install disconnecting switches where indicated and as required for motor outlets, transformers, and other equipment.
- B. Securely attach and properly connect disconnecting switches, enclosed circuit breakers, and elevator disconnecting switches.
- C. Provide a disconnecting switch for each motor, as required by NFPA 70, except where it is provided in a panelboard within sight and easy reach of the motor, and provide wiring and connections from source. Disconnecting switches shall be fused where protection is required or indicated on drawings and unfused elsewhere.

### SECTION 26 28 13 - FUSES

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Fuses.
- 1.14 RELATED SECTIONS
  - A. Motors: Sections 22 05 13 and 23 05 13.

## 1.20 REFERENCES

- A. UL 198E: Class R fuses.
- B. UL 198C: High-Interrupting-Capacity Fuses, Current Limiting Types.

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Each type of fuse.
- C. Published data on fuses shall include time/current curves, peak-let-through curves and I<sup>2</sup>t melting and clearing curves.

### 1.40 QUALITY ASSURANCE

- A. Comply with the following standards:
  - 1. UL 198E
  - 2. UL 198C, Class L fuses, also Classes G and J.
- B. UL label and local testing (if required): As specified in Section 26 05 00, Common Work Results for Electrical

## 1.92 EXTRA MATERIALS

A. Provide three spare fuses for each type of fuse in the work.

#### PART 2 - PRODUCTS

#### 2.23 FUSES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper Bussmann, Inc.
  - 2. Ferraz Shawmut Inc.

- 3. Littelfuse, Inc.
- B. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
- C. Fuses 0-600 amps for 600 V or 250 V, UL labeled Class RK1 with time delay, with a minimum short-circuit interrupting capacity of 200,000 rms symmetrical amperes, and shall carry 500 percent of rating for a minimum of 10 seconds.
  - 1. Fuses for disconnecting switches for packaged HVAC equipment: Size and type recommended by the equipment manufacturer and as required for equipment to meet UL rating.
- D. Fuses 601 amps and larger shall be UL labeled Class L with time delay, 600 V, with minimum short circuit interrupting capacity of 200,000 rms symmetrical amperes and dimensions to properly mount in switchboard or disconnecting switches.

## PART 3 - EXECUTION

## 3.20 INSTALLATION

A. Install fuses where indicated and as required for motor outlets, transformers, and other equipment.

## **SECTION 26 29 14 - ENCLOSED MOTOR CONTROLLERS**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Alternating-current motor starters (enclosed controllers) rated 600 V and less that are supplied as enclosed units.
  - 1. Magnetic motor starters and combination starters.
  - 2. Manual motor starters.

#### 1.14 RELATED SECTIONS

- A. Motors and variable-frequency drives: Sections 23 05 13 and 26 29 23.
- B. Fuses: Section 26 28 13.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Each type of motor starter included in the project, including dimensions, ratings, and data on features and components.
- C. Shop drawings: Composite wiring diagram showing the interlocking and control wiring.
- D. Operation and maintenance data: For operating and maintenance manuals, as specified in Section 16010.
- 1.40 QUALITY ASSURANCE
  - A. Source limitations: Obtain motor starters of a single type through one source from a single manufacturer.
  - B. Electrical components, devices, and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the authorities having jurisdiction, and marked for intended use.

#### 1.49 COORDINATION

- A. Coordinate layout and installation of motor starters with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for work space and for access.
- B. Coordinate features, accessories, and functions of each motor starter with ratings and characteristics of supply circuit, motor, control sequence, and duty cycle of motor and load.
  - 1. Refer to wiring diagrams required in the sections specifying the equipment.

## PART 2 - PRODUCTS

### 2.01 MOTOR STARTERS, GENERAL

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Square D Company (Schneider Electric) products, or comparable products by one of the following:
  - 1. Eaton Corp.; Cutler-Hammer Products
  - 2. General Electric Company
  - 3. Siemens Energy & Automation, Inc
  - 4. Square D Company (Schneider Electric)

## 2.20 MAGNETIC MOTOR STARTERS

- A. Enclosure: Surface-mounted, NEMA 250 Type 1, unless otherwise indicated.
  - 1. Outdoor locations: Type 3R.
  - 2. Kitchen areas: Type 4X, stainless steel.
  - 3. Wet or damp locations other than kitchens: Type 4.
- B. Motor starters and combination starters shall be across-the-line magnetic type, equal to Square D Company, Class 8536, Type S, rated in accordance with NEMA Standards, sizes, and horsepower ratings.
  - 1. Contacts: Double-break silver-alloy type, replaceable from the front without removing power wiring or removing the starter from its mounting.
  - 2. Overload protection: Solid-state overload relay, one-piece construction, interchangeable, with reset button set in cover.
    - a. Sensors in each phase: Matched to nameplate full-load current of the motor to which they connect and with appropriate adjustment for duty cycle.
  - 3. Starter shall operate only when protective relays are in place.
  - 4. Combination starters shall be lockable in the Off position.
  - 5. Circuit-breaker disconnect for combination starters: NEMA AB 1 thermal-magnetic type molded-case circuit breakers. Interlock with unit cover.
- C. Control circuit: 120-Volt.
  - 1. Control power transformer: Primary voltage as required for the motor, 120-V secondary voltage; capacity to operate connected indicating and control devices and 100 percent spare capacity.
  - 2. Primary and secondary fuse protection for each control power transformer: Class CC fuses, current-limiting rejection type, rated 0.1 to 30 A, 600 V, and 200 kA interrupting rating.
- D. Auxiliary control contacts:
  - 1. One spare normally open and one spare normally closed.
  - 2. Additional contacts required by the automatic temperature control system.

- E. Selector switches, indicating lights, and identification on each motor starter cover, complete with wiring and interconnections to starter and auxiliary control contacts:
  - 1. Selector switch: Hand-Off-Automatic (HOA), heavy-duty.
  - 2. Indicating lights: Push-to-test, 30.5 mm or 22 mm, transformer type, LED or neon. Indications:
    - a. Red for Running and green for Stopped.
  - 3. Identification: Printed or engraved nameplates for HOA switch and for each indicating light.
  - 4. Manual control devices: Four-button or four-position type, with Slow, Fast, Stop, and Automatic positions indicated by LED or neon lights.
- 2.21 MANUAL MOTOR STARTERS
  - A. Enclosures: NEMA 250 Type 1 for interior use and NEMA 250 Type 3R for exterior or damp or wet locations.
    - 1. Mounting: Flush-mounted in finished areas and where possible; surface-mounted elsewhere, with cover plates to suit the mounting.
    - 2. Indicating lights mounted in enclosure.
    - 3. Engraved plastic identification plates.
  - B. Manual motor-starting switch: Equal to Square D Class 2510, single- or two-pole as required, with built-in thermal overload protection.
  - C. Switch: Toggle, quick-make and quick-break, with self-indicating, trip-free handle, and means for locking in Off position.
  - D. Overload protection unit: Melting-alloy type, interchangeable; starter shall be inoperative if unit is removed.

## PART 3 - EXECUTION

## 3.20 INSTALLATION

- A. For equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For equipment not at walls, mount on lightweight structural-steel channels bolted to floor or to structure above ceiling.
- B. Provide wiring as indicated on the drawings.
- C. Applications: Magnetic motor starters for all equipment unless otherwise specified or indicated on drawings.
- D. Install starters, auxiliary contacts, and automatic control devices furnished with equipment, except those that are already mounted on the equipment, fully wired and connected. See coordination requirements specified in Part 1 above.

- E. Check the size of the overload protection, and change or adjust it as required, after the HVAC systems have been adjusted and balanced as specified in Section 23 05 93, Testing, Adjusting, and Balancing.
- F. Install fuses in each fusible switch. Comply with requirements of Section 26 28 13.

## **SECTION 26 29 23 - VARIABLE FREQUENCY DRIVES**

#### PART 1 – GENERAL

- 1.11 SECTION INCLUDES
  - A. Variable frequency drives, rated less than 600V, for speed control of three-phase, induction motors.
- 1.14 RELATED SECTIONS
  - A. Motors: Section 23 05 13.
  - B. Pumps: Section 23 21 23.
  - C. Energy recovery and dedicated outdoor air system units: Section 23 72 00.
  - D. Rooftop water source heat pump units: Section 23 81 46.
- 1.20 REFERENCES
  - A. ANSI/IEEE 399: Standard Practice for Industrial and Commercial Power Systems Analysis
  - B. ANSI/IEEE 519: Standard Practices and Requirements for Harmonic Control in Electric Power Systems
  - C. ANSI/UL Standard 508: Industrial Control Equipment.
  - C. NEMA: Application Guide for AC Adjustable Speed Drive Systems
  - E. NEMA ICS 61800-2: Adjustable Speed Electrical Power Drive Systems
  - F. NEMA ICS 7.0: Industrial Controls & Systems for Adjustable Speed Drives
  - G. NEMA ICS 7.1: Standard Standards for Construction and Guide Selection, Installation, and Operation of Adjustable Speed Drive Systems
  - H. NEMA MG 1: Motors and Generators
  - I. NETA ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems
  - J. NFPA 70: National Electrical Code
  - K. UL 508C: Standard for Safety for Power Conversion Equipment.
  - L. UL 508C: Standard for Safety for Power Conversion Equipment

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: For each type and rating of equipment, include electrical ratings, operating characteristics, manufacturers' technical data on features and functions, enclosures, and furnished accessories. Include product data for each of the following:
  - 1. Variable frequency drive (VFD).
    - a. List rated capacities and relationship to motor values including voltage, horsepower, rated current, and short-circuit ratings.
- C. Bill of Materials: Provide detailed list of components.
- D. Shop Drawings: For each type of unit, indicate the following:
  - 1. Dimensioned plans, elevations, and sections; weights; loads; required clearances; mounting arrangements; components; and location of each field connection.
  - 2. List of installed device and related equipment ratings and features including:
    - a. Unit type and standard details
    - b. Enclosure type
    - c. Nameplate and identification labels
    - d. Factory settings of installed devices
  - 3. Wiring Diagrams: Power, signal, and control wiring.
- E. Source quality-control test reports.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For each type of variable frequency drive and associated components, include in operation and maintenance manuals. In addition to items specified in Division 01, include the following:
  - 1. Detailed operating and programming instructions.
  - 2. Troubleshooting procedures.
  - 3. Detailed spare parts list.
  - 4. Warranty, executed and signed at the time of putting the unit in service.

#### 1.40 QUALITY ASSURANCE

- A. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application; listed as a complete assembly.
  - 1. UL label and local testing (where required): As specified in Section 26 05 00, Common Work Results for Electrical.

- B. Variable frequency drives shall be fully assembled, inspected, and tested at the factory prior to shipment.
- C. Installer Qualifications:
  - 1. Staff is authorized and factory-trained by manufacturer. Includes training in electrical safety as required by NFPA 70E and qualified as defined in NEMA PB 2.
  - 2. Maintains a service center location with staff factory-trained by manufacturer in the Baltimore/Washington, DC, metropolitan area.
  - 3. Service available 24 hours a day, seven days a week, 365 days a year.
  - 4. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
  - 5. Service and maintenance contracts available.
- D. Testing Agency Qualifications: Member company of NETA or a nationally recognized testing laboratory (NRTL).
  - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- E. Comply with referenced standards and listings previously identified including IEEE 519, NEMA MG 1, UL 508C, and NFPA 70.
- F. Verify motor, drive, and load compatibility. Motors shall be inverter duty rated, per NEMA MG1.

## 1.49 COORDINATION

- A. Ratings and functions of each variable frequency drive unit shall be coordinated with associated motor and connected load including the following:
  - 1. Load requirements such as torque, speed, and horsepower.
  - 2. Motor and power supply characteristics.
  - 3. Control and operational sequences.
  - 4. Ambient, environmental, and physical conditions of installation location.
- B. Coordinate layout and installation of drive and associated components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access.
- C. Coordinate method and location for mounting equipment including size and location of housekeeping pads and structural channel supports.
- D. Coordinate location of underslab and overhead conduit.
- E. Coordinate with ATC for proper control and communications functions.

## 1.50 DELIVERY, STORAGE, AND HANDLING

A. Store equipment indoors in clean dry space with uniform temperature to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

## 1.60 PROJECT CONDITIONS

- A. Product selection for restricted space:
  - 1. Drawings indicate maximum dimensions for drives and associated equipment, including clearances between drives, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
  - 2. Make all necessary field measurements to verify that equipment shall fit in allocated space in full compliance with minimum clearances specified in NFPA 70.
- B. Environmental conditions: Variable frequency drive assembly and associated components shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient Temperature: Minus 15 to plus 40 deg C.
  - 2. Relative Humidity: 5 to 95 percent, non-condensing.
  - 3. Altitude: Sea level to 3300 feet (1000 m).

#### 1.80 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of drive unit and associated auxiliary components that fail in materials or workmanship within specified warranty period:
  - 1. Warranty period: Two years from date of substantial completion.
  - 2. Warranty shall include all parts and labor.

## PART 2 – PRODUCTS

#### 2.01 MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide products manufactured by ABB, Inc., or comparable product by one of the following:
  - 1. ABB, Inc.
  - 2. Eaton Corporation; Cutler-Hammer Products
  - 3. Trane/Danfoss

## 2.20 VARIABLE FREQUENCY DRIVES

A. Description: Enclosed variable frequency, alternating-current (AC) motor controller assembly suitable for operation of inverter-duty, Design A and Design B, induction motors as defined by NEMA MG1. The drive shall be designed for variable torque applications.

- 1. Unit shall be a packaged assembly including power conversion components, disconnecting means, overcurrent and overload protection, and control components.
- B. Equipment ratings and design:
  - 1. Ratings: VFD shall be sized to match the motor load type served. The motor current, voltage, and/or horsepower ratings are scheduled on the drawings. The following drive ratings shall also apply:
    - a. Input power characteristics: Unit shall be capable of continuous operation under the following conditions.
      - (1) Voltage variation: Plus 10 percent or minus 15 percent, nominal 208VAC or 480VAC.
      - (2) Frequency variation: Plus or minus 5 percent, 60Hz.
      - (3) Power factor (input-primary side): 0.95 minimum.
    - b. Output power characteristics: 0 to Rated Input Voltage, 3-phase, 0 to 120Hz.
      - (1) Current: Drive shall be capable of continuous operation at rated full load motor current.
      - (2) Power factor (output-secondary side): 0.90 minimum.
    - c. Minimum efficiency: 95 percent at half speed; 97 percent at rated full speed.
    - d. Overload capability: 110 percent of the normal duty current rating for 60 seconds, and 180 percent for 3 seconds.
    - e. Short-circuit current (withstand) rating: Minimum 65 kA, without additional input fuses.
    - f. Audible noise: Motor and VFD combination noise level shall not be increased more than 2 dBA at 3 feet (1m), compared to motor operation from across-the-line motor control.
    - g. Output carrier frequency: Unit shall have adjustable frequency switching settings up to 15 kHz without derating the drive output characteristics. Drive selection size may be increased to comply.
  - 2. Design: Unit shall consist of the following components and characteristics:
    - a. Power conversion components: Microprocessor based control.
      - (1) Rectifier: Solid state, full-wave, diode-bridge rectifier used to convert AC input power to DC power, with metal-oxide-varistor (MOV) surge protection.
        - (a) Provide 6-pulse drives with harmonic filters for motor less than 75 HP.
      - (2) DC bus: DC-bus reactor and capacitor components to minimize reflected harmonics and manage DC power to inverter. Bus shall interface with VFD programmable logic controller, for continuous monitoring and protection of system components, and include short circuit protection and filtering.

- (3) Inverter: Insulated-gate-bipolar-transistor (IGBT) type employing pulse-widthmodulated (PWM) technology power supplies for sine-code, AC output waveform.
- b. Standard power conditioning components: Provide the following power conditioning and filter devices.
  - (1) Integral, DC link reactor.
  - (2) Integral, 3-phase, EMI/RFI filter capable of filtering out radio frequency interference (RFI) in the range of 10 kHz to 30 MHz.
- C. Construction:
  - 1. Enclosure: UL (NEMA 250) Type 12 (indoors) and Type 1 (within HVAC units) according to UL 508; as scheduled on the drawings.
  - 2. Completely assembled and tested by the manufacturer. Listed and labeled as a complete assembly under UL 508C.
  - 3. Furnish each unit with a master nameplate, listing standard manufacturer information including voltage, ampacity, frequency, and short-circuit ratings; manufacturer's model and project designations.
- D. Drive features:
  - 1. System interface
    - a. Digital display and keypad operator station, sealed and located on front of assembly.
      - (1) Operator interface shall provide complete programming, program copying, operating, monitoring, and diagnostic capabilities.
      - (2) Operator interface shall include menus and selections to display system characteristics such as metering, program parameters, settings, and messages. Standard displays shall include:
        - (a) Output frequency (hertz).
        - (b) Set-point frequency (hertz).
        - (c) Motor current (amperes).
        - (d) DC-link voltage (volts-dc).
        - (e) Motor torque (percent).
        - (f) Motor speed (rpm).
        - (g) Motor output voltage (volts).
        - (h) Historical information: Displays indicating current time and date, total run time, total power versus time log, and fault log.
      - (3) Keypad shall include Hand-Off-Auto selections in addition to programming and control keys.
      - (4) Security access: Capable of preventing access by unauthorized personnel and protecting data and system parameters.
    - b. System input characteristics capable of accepting remote signals from the Building Automation System (BAS) shall include the following:

- (1) Minimum of six programmable, multifunction digital inputs.
- (2) Minimum of two programmable analog inputs accepting current or voltage signals for speed reference.
- (3) Minimum of one external fault input, programmable for normally open or normally closed contact, used for connection of freeze, fire, smoke contacts, or high pressure limits.
- c. System output characteristics including the following:
  - (1) Minimum of three programmable, multifunction, digital, Form-C type, relay outputs.
  - (2) Minimum of two programmable analog outputs.
  - (3) Programmable loss-of-load, Form-C type, relay output dedicated to drive protection under motor failure condition.
- 2. Building Automation System (BAS) Interface: Factory-installed hardware and software package to enable the BAS to monitor, control, and display VFD status, alarms, and energy usage.
  - a. Network Communications: Ethernet based with RS-422/RS-485 communication port.
  - b. Integral communications card embedded with standard BAS protocols including Johnson Controls, Modbus, Siemens Building Technologies, and BACnet.
- E. Drive functions: The VFD shall include the following functions, either pre-programmed or fieldprogrammed according to project requirements.
  - 1. Minimum of three programmable preset speeds.
  - 2. The ability to automatically reset and restart after an overcurrent, overvoltage, undervoltage, or over-temperature condition; overload fault; loss of phase, or loss of input signal.
  - 3. Capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to programmed set point without drive tripping or component damage.
  - 4. Capable of adjusting acceleration and deceleration ramp control time from 1 to 360 seconds.
  - 5. Equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be 12 cycles (200 milliseconds), based on full load and no inertia. Control logic shall incorporate programmable ride-through with minimum one-second (60 cycles).
  - 6. Stop modes shall be field-selectable allowing the VFD to ramp or coast to a stop.
- F. Drive and motor protection: Include the following electrical protection and safety features, factory mounted and wired within the VFD enclosure.
  - 1. Input disconnecting means and overcurrent protective device: Integral, NEMA AB1, thermal magnetic, molded-case circuit breaker, with door interlocked, padlockable handle mechanism connected to input line side of drive.

- a. Circuit breaker shall be selected to provide trip-free operation. Breaker trip size and thermal curve shall be selected to allow VFD to operate the motor under continuous running and starting conditions as recommended by the motor manufacturer.
- b. Service personnel shall be able to circumvent the main power disconnect and open the bypass enclosure without disconnecting power. A specific tool and mechanism shall be provided to accomplish this occurrence while meeting all code and safety requirements.
- 2. Transient voltage surge suppression (TVSS): Integral, system to provide three-phase protection against damage from supply voltage surges.
- 3. Motor and VFD overload and overtemperature protection: NEMA ICS 2, solid-state, overload relay protection monitoring both motor and VFD characteristics. Relay shall be interconnected with motor thermal couple.
- 4. Protective relays or functions for the following conditions:
  - a. Overvoltage
  - b. Undervoltage
  - c. Phase loss
  - d. Phase reversal
  - e. Ground fault
- 5. Programmable, critical frequency lock-out: Multi-range selection, preventing VFD from operating load continuously at an unstable speed.
- 6. Control fuses utilized within the drive enclosure shall be 100,000A current limiting type. Input AC power fusing is not acceptable.
- G. Comply with requirements of NEMA ICS 7, NEMA ICS 61800-2, and UL 580C.
- 2.21 DRIVE CONTROL AND OPERATION
  - A. VFD shall operate according to the following scenarios:
    - 1. "Hand": VFD shall start and speed controlled manually through user interface.
    - 2. "Off": VFD shall stop or disregard start signal.
    - 3. "Auto": VFD shall start via external contact closure or control signal reference.
  - B. VFD shall run at programmable preset speed if input reference signal is lost.

## 2.22 DRIVE ISOLATION AND BYPASS (INDOORS ONLY)

- A. Description: Unit shall include mechanically and electrically interlocked bypass feature to isolate drive from the motor manually or automatically. Isolating switch arrangement shall be non-load break to isolate drive while motor is operating in bypass mode. Assembly shall be prewired and interconnected with drive unit. Bypass shall include contacts, separate solid –state motor overload relay protection, circuit breaker disconnect, control transformer, controller, and selector switches required for complete bypass operation.
- B. Bypass controller: Two-contactor-style arranged to isolate the power converter and permit safe troubleshooting and testing while motor is operating in bypass mode.
  - 1. Bypass contactor: Load-break, IEC or NEMA rated.

- 2. Output isolating contactor: Non-load beak, IEC or NEMA rated.
- 3. Isolating switch: Non-load break switch, pad-lockable, door mounted handle mechanism.
- C. Bypass configuration: NEMA ICS 2, full-voltage (across-the-line), non-reversing type, providing control of motor in bypass or test mode. A Drive/Off/Bypass/Test multi-position selector switch shall control the bypass contactor and the drive output contactor and be mounted on the enclosure door. LED indicator and the drive output contactor and be mounted on the enclosure door. LED indicator lights shall be mounted on enclosure door designating the following conditions:
  - 1. "Drive": the bypass contactor is open and the drive output contactor is closed. The motor is operated at the adjustable speed delivered from the drive.
  - 2. "Off": Contactors are open. N The motor is disconnected from the bypass and drive.
  - 3. "Bypass": The drive output contactor is open, and the bypass contactor is closed. The motor is operated at full speed from the bypass starter at AC line voltage and frequency. The drive power is disconnected and can be serviced.
  - 4. "Test": The drive output contactor is open, and the bypass contactor is closed. The motor is operated at full speed from the bypass starter at AC line voltage and frequency. Drive remains connected to input power source for operational test while motor is running in bypass.
- D. Bypass and VFD shall be rated as single package, UL tested and listed.
- E. The drive output contactor shall open when a stop command is given, isolating the motor from the drive. Start/Stop signals and safety interlocks shall work in both drive and bypass modes.
- F. Bypass shall incorporate applicable functions and protective features as previously listed for drive unit.
- 2.90 SOURCE QUALITY CONTROL
  - A. Test and inspect variable frequency drive units and associated controls according to requirements in NEMA ICS 61800-2 and UL 508C.
    - 1. Perform tests at rated full load to ensure proper operation.
    - 2. Provide three certified copies of factory test reports.
  - B. Each drive shall undergo a burn-in test at 100 percent inductive or motor load prior to final testing.
- PART 3 EXECUTION
- 3.02 EXAMINATION
  - A. Examine project submittals for compliance with electrical distribution system requirements outlined on the drawings and in electrical specification sections.
- 3.20 INSTALLATION

- A. Install drive units in locations shown on drawings. Equipment shall not be located further from the equipment it serves than the maximum distance recommended by the drive manufacturer.
- B. Install wiring between drive and motor in ferrous metallic conduit, with separate conduits for power input, power output, and control wiring.
  - 1. Maintain minimum separation between conduits of 3 inches.
- C. Service engineers trained and authorized by the variable-frequency drive manufacturer at the service center shall provide start-up service, including physical inspection of drive and connected wiring and final adjustments to meet specified performance requirements.

## 3.59 IDENTIFICATION

- A. Materials: Refer to Section 26 05 53 for requirements on identification of electrical systems. Identify units, devices, fuse blocks, relays, controls, and wiring. Identify equipment ratings.
- B. Nameplates: Refer to Section 26 05 53 for requirements on identification of electrical systems. Provide nameplate for each drive unit and associated components located on front of assembly.
- C. Control components mounted within the assembly shall be identified corresponding to designations on manufacturer's drawings using tags and other identification materials.
- D. Operating Instructions: Provide fabricated frame on side of each unit to house operating instruction manuals.

## 3.60 FIELD QUALITY CONTROL

- A. Test variable frequency drives by operating them in all modes with associated components and motors. Perform tests recommended by manufacturer under supervision of manufacturer's factory-authorized representative. Tests shall include simulation of various building conditions through the BAS control system.
- B. Coordinate tests with system balancing of fan and pump equipment.
- C. Perform mechanical and visual inspection of equipment installation including verification of wiring and components, connections, enclosures, and auxiliary devices and components.
- D. Perform testing in compliance with NETA ATS. Perform manufacturer standard tests including the following:
  - 1. Test insulation resistance and circuit continuity for power and control wiring.
  - 2. Verify voltage values follow nameplate ratings at drive input and output terminals.
- E. Correct deficiencies and retest equipment until equipment is operational. Report results and identify corrections in writing. Where necessary, replace damaged and malfunctioning equipment.
- F. Record field adjustable settings.

## 3.70 ADJUSTING

- A. Program variable frequency drives for required operations as outlined by the mechanical control sequences.
- B. Set field-adjustable elements such as switches, relays, timers, and trip devices as required for proper system operation and coordination with related power and control systems.
- 3.75 CLEANING
  - A. Upon completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Clean components internally using methods and materials recommended by the manufacturer.
- 3.80 SYSTEM STARTUP
  - A. Provide factory-authorized service representative to perform startup service.
- 3.81 OPERATING INSTRUCTIONS
  - A. As specified in Sections 26 01 01, provide operating instructions.
  - B. Provide at least two sessions of four consecutive hours of additional instruction time for each system specified in this section.

## SECTION 26 32 13 - GENERATORS, WEATHER-PROTECTED

### PART 1 – GENERAL

#### 1.11 SECTION INCLUDES

- A. Packaged engine generator set for standby, emergency power application including the following:
  - 1. Diesel engine with electronic generator set controls, governor, and voltage regulator.
  - 2. Located in outdoor, weather-protected, sound-attenuated enclosure.
  - 3. Complete with remote annunciator, sub-base fuel tank, and generator accessories.

## 1.14 RELATED SECTIONS

- A. Sections specifying requirements for commissioning are specified in Division 01.
- B. Grounding and bonding: Section 26 05 26.
- C. Equipment foundations: Section 26 05 28.
- D. Transfer switches: Section 26 36 00.

### 1.20 REFERENCES

- A. ANSI/NECA/EGSA 404: Standard for Installing Generator Sets.
- B. CFR Title 40, Protection of Environment.
- C. IEEE 115: Test Procedures for Synchronous Machines.
- D. IEEE 446: Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
- E. NECA/EGSA 404: Standard for Installing Generator Sets.
- F. NEMA MG 1: Motors and Generators.
- G. NETA ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- H. NFPA 30: Flammable and Combustible Liquids Code.
- I. NFPA 37: Installation and Use of Stationary Combustion Engines and Gas Turbines.
- J. NFPA 70: National Electrical Code.
- K. NFPA 110: Emergency and Standby Power Systems.
- L. UL 1236: Battery Chargers for Charging Engine Starter Batteries.

M. UL 2200: Stationary Engine Generator Assemblies.

## 1.21 DEFINITIONS

- A. CFR: Code of Federal Regulations.
- B. EPA: Environmental Protection Agency.
- C. NIST: National Institute of Standards and Technology
- D. NSPS: New Source Performance Standards.

## 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: For each type of packaged generator set indicated. Include rated capacities, operating characteristics, manufacturers' technical data on features and functions, finishes, and furnished accessories. Include product data for each of the following:
  - 1. Engine generator set.
    - a. Thermal damage curve for generator.
    - b. Time-current characteristic curves for generator protective device.
    - c. Documentation proving that generator(s) provided have sufficient starting kVA to start the loads under any load sequence.
  - 2. Generator accessories including batteries and battery charger, silencer, and jacket heater.
  - 3. Remote alarm annunciator panel.
  - 4. Enclosure components and accessories.
  - 5. Sub-base fuel tank.
- C. Bill of materials: Provide detailed list of components.
- D. Shop drawings: For each type of generator set and related equipment, detail assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
  - 2. Design calculations: Calculate requirements for designing vibration isolation bases.
  - 3. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
  - 4. Wiring diagrams: Power, signal, and control wiring.
  - 5. Piping schematics for fuel system, lubricating oil, jacket coolant, and cooling water.
- E. Source quality-control test reports.
  - 1. Certified summary of performance tests: Certify compliance with specified requirement to
meet performance criteria for sensitive loads.

- 2. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
- 3. Report of sound generation.
- 4. Report of exhaust emissions showing compliance with applicable regulations.
  - a. Factory certification of compliance with EPA emissions regulations.
- F. Field quality-control test reports.
- G. Operation and maintenance data: For packaged engine generator sets, accessories, and remote annunciator panel to include in operation and maintenance manuals. In addition to items specified in Division 01, include the following:
  - 1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
  - 2. Detailed operating instructions for event conditions.
  - 3. Fuel adjustment procedures and maximum tolerances of wear on bearings and other rubbing surfaces that will require corrective measures.
  - 4. Sub-base fuel tank.
- H. Warranty: Certificate of special warranty.
- I. Air quality permits: Submit air quality construction and operational permits for Owner record.
- 1.40 QUALITY ASSURANCE
  - A. Generator accessories, appurtenances, and installation of the same, shall comply with referenced codes and standards listed in Part 1 and applicable federal, state, and local codes and regulations.
  - B. Comply with requirements for commissioning specified in Division 01.
  - C. Emissions: Equipment shall be certified to U.S. EPA Stationary Emission Regulation, 40 CFR, Part 60.
  - D. Permits: Serve as the Owner's representative during the application process. Collect generator information, prepare and submit required applications for air quality construction and operational permits required by the State of Maryland Department of the Environment in compliance of state environmental regulations. Include payment for applicable permit costs. Approved permits and registration shall be issued to the Owner.
  - E. Equipment shall bear UL label, and shall be locally tested by an electrical testing specialist, acceptable to local authority having jurisdiction where required.
  - F. Source limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
  - G. Installer qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this project.

- 1. Installer has training in electrical safety as required by NFPA 70E and is qualified as defined in NEMA PB 2.
- H. Testing agency qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
  - 1. Testing agency's field supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- I. Service and maintenance agency qualifications: Manufacturer's authorized service and maintenance representative characteristics shall include the following:
  - 1. Located in the Baltimore/Washington, DC metropolitan area.
  - 2. Staff is factory employed and trained.
  - 3. Service available 24 hours a day, seven days a week, 365 days a year.
  - 4. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
  - 5. Service and maintenance contracts available.

## 1.49 COORDINATION

- A. Obtain interconnection diagrams, interface hardware, accessory components, and installation manual for generator, and other components of the system. Coordinate installation to provide a complete, integrated, operating generator system.
  - 1. Coordinate installation and interface connections with other emergency power supply system equipment.
- B. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

## 1.60 PROJECT CONDITIONS

- A. Environmental conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient temperature: 5 to 40 deg C.
  - 2. Relative humidity: 0 to 95 percent.
  - 3. Altitude: Sea level to minimum 1000 feet (300 m).

## 1.80 WARRANTY

- A. Special warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period:
  - 1. Warranty period: Five years from date of substantial completion.
  - 2. Warranty shall include all parts and labor.

# 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

# 1.91 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fuses: One for every ten of each type and rating, but no fewer than one of each.
  - 2. Indicator lamps: One for every five of each type used, but no fewer than two of each.
  - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
- B. Provide fuel required for testing, re-testing, and demonstrations.
- C. Provide fuel to fill storage tank to rated capacity upon completion of work.

# 1.92 MAINTENANCE SERVICE

A. Initial maintenance service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

# PART 2 – PRODUCTS

## 2.01 MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide products manufactured by Kohler Power Systems Co.; Generator Division, or comparable product by one of the following:
  - 1. Caterpillar; Power Generation
  - 2. Cummins Power Generation/Onan.
  - 3. Detroit Diesel; Spectrum Generators.
  - 4. Generac.

5. Kohler Power Systems Co.; Generator Division.

# 2.20 GENERATOR SET

- A. Generator set characteristics: The generator set system shall comprise of a package of equipment including:
  - 1. A diesel-engine and alternator assembly to provide emergency electric power.
  - 2. Generator-mounted start-stop control system with remote control capability.
  - 3. Mounted accessories as specified.
  - 4. Factory-assembled and -tested, engine-generator set.
- B. Generator set ratings:
  - 1. Duty rating shall be based on emergency/standby service.
  - 2. Operate at 1800 rpm and 480/277 volts AC, 3-phase, 4-wire, 60 hertz.
  - 3. The generator set shall be rated at values indicated on the drawings running and starting kVA values at 0.8 pf based on the project conditions listed in Part 1.
- C. Performance characteristics:
  - 1. The engine-generator set shall be able to handle the starting step load effects of the connected equipment.
  - 2. Generator set characteristics shall not exceed the following:
    - a. Starting voltage dip: 30 percent.
    - b. Peak voltage dip: 30 percent.
    - c. Frequency dip: 15 percent.
    - d. Voltage regulation (no load to full load): Plus or minus 1 percent of rated output voltage.
    - e. Voltage regulation (random): Plus or minus 0.5 percent of rated output voltage.
    - f. Frequency regulation (steady-state): Isochronous.
    - g. Frequency regulation (random): Plus or minus 0.25 percent of rated frequency from no load to full load.
  - 3. AC output waveform: Distortion at no load measured line-to-line or line-to-neutral.
    - a. Total harmonic distortion (THD): Less than 5 percent
    - b. Singe harmonic: Less than 3 percent.
    - c. Telephone influence factor (TIF): Less than 50, as determined by NEMA MG 1.
    - d. Telephone harmonic factor (THF): Less than 3, as determined by IEC 60034.
  - 4. Steady-state frequency stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
  - 5. Sustained short-circuit current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
  - 6. Start time: Comply with NFPA 110, Type 10, system requirements.

7. Excitation system: Performance shall be unaffected by voltage distortion caused by nonlinear load.

# D. Engine:

- 1. Diesel engine: Water-cooled inline or Vee-type, four-cycle, compression ignition diesel engine shall meet specifications when operating on No. 2 domestic burner oil. Diesel engines requiring premium fuels will not be considered. The engine shall be equipped with filters for fuel, lube oil, and in-take air; lube oil cooler; fuel transfer pump; fuel priming pump; and gear driven water pump.
  - a. The engine governor shall maintain frequency regulation as indicated in performance characteristics above.
  - b. Safety devices: Safety shutoffs for high water temperature, low oil pressure, overspeed, and engine overcrank.
- E. Generator: Three-phase, single bearing, synchronous type built to NEMA MG 1 standards.
  - 1. Alternator: Brushless, 4-pole, 2/3 pitch windings, 125 degrees C standard temperature rise. Class H insulation shall be used on the stator and rotor, and both shall be further protected with 100 percent epoxy impregnation and an overcoat of resilient insulating material on end coils to protect against fungus or abrasion. The generator shall incorporate a resettable thermal protector for exciter/regulator protection against extended low power factor loads. The generator shall be twelve lead, wye connected.
  - 2. Regulator: Permanent magnet excitation for power source to voltage regulators, solid-state controlled, exciter/regulator, matching the characteristics of the generator and engine. Voltage regulation with adjustable electronic isochronous governor. Readily accessible voltage droop, voltage level, and voltage gain controls shall be provided. The solid state regulator module shall be shock mounted and epoxy encapsulated for protection against vibration and atmospheric deterioration.
  - 3. The subtransient reactance of the alternator shall not exceed 12 percent, based on the standby rating of the generator set.
- F. Mounting:
  - 1. Unit shall be capable of installation on rail system within enclosure base and include vibration isolation as required.
- G. Cooling system: Closed loop, liquid-cooled system with engine mounted radiator and blower type fan, sized to maintain safe operation at 104 degrees F (40 degrees C) maximum ambient temperature. The radiator shall be equipped for a duct adapter flange connected to exterior cabinet with flexible connection.
  - 1. Centrifugal jacket water pump: Built on the engine and driven from the engine crankshaft or camshaft, ample capacity to circulate the required flow of engine jacket water through the radiator to remove the total heat rejected from the engine to the jacket water and lubricating oil at 110 percent rated load in 104 degrees F (40 degrees C) ambient while maintaining the optimum jacket water temperature leaving and entering the engine recommended by the engine manufacturer.

- 2. Thermostatic control valve: Shall maintain constant water temperature to the engine. Provide modulating type thermostatic valves using self-contained thermostats without external bulbs. Provide valves with one or more interchangeable thermostatic elements. Provide nonadjustable type thermostat with operating temperature factory set at the temperature recommended by the engine manufacturer. Design valve so that in event of thermostatic element failure it will fail safe, permitting water flow through the engine.
- H. Fuel system: Diesel
  - 1. Fuel oil system shall consist of the following tanks:
    - a. Sub-base fuel tank for generator set.
  - 2. Provide an engine mounted fuel filter, fuel pressure gauge, and integral engine fuel priming pump, completely piped from integral day tank to diesel engine.
  - 3. Provide generator with fuel-water separator.
  - 4. Conform to NFPA 30 and NFPA 37 and the requirements herein. Employ a mechanical fuel injection system using a common rail system or an individual pump system. Provide injection pumps as an integral part of the engine and driven by the engine camshaft. Provide suitable adjustments for timing and for balancing of cylinder pressures. Provide the following items:
    - a. A built on positive displacement fuel oil supply pump driven from the engine crankshaft or camshaft. Pump capacity shall suit engine requirements under the maximum load condition.
    - b. A suitable positive displacement fuel oil priming pump for priming the fuel system, if required, to assure quick starting, and arranged to operate with the automatic starting system.
    - c. Fuel oil filters in the piping ahead of the injection pumps. Provide generator unit with a parallel filter arrangement having built in changeover valves allowing either filter to be used independently. Filters shall have replaceable spin-on canister elements.
- I. Exhaust system:
  - 1. Provide a silencer, including flexible exhaust fitting, properly sized and installed according to the manufacturer's recommendation. Mounting shall be provided by the installing contractor. The silencer shall be mounted so that its weight is not supported by the engine.
    - c. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
      - 1) Minimum sound attenuation of 25 dB at 500 Hz.
      - 2) Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
  - 2. Exhaust pipe size shall be sufficient to ensure that exhaust backpressure does not exceed the maximum limitations specified by the generator set manufacturer.

- J. Automatic starting system:
  - 1. Starting motor: DC electric starting system with positive engagement drive. The motor voltage shall be as recommended by the engine manufacturer.
  - 2. Automatic controls: Fully automatic generator set start-stop controls in the generator control panel. Controls shall provide shutdown for low oil pressure, high water temperature, overspeed, and overcrank; and one auxiliary contact for activating accessory items. Controls shall include a multi-cycle, cranking limit with lockout contacts for starting by switch on remote panel.
- K. System accessories:
  - 1. Jacket water heater: Unit mounted thermal circulation type water heater incorporating a thermostatic switch, capable of maintaining engine jacket water to 90 degrees F in ambient temperature of minus 10 degrees F. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
  - 2. Starting and station batteries: Lead-acid storage battery set of the heavy duty starting type. 24Vdc battery voltage shall be compatible with the starting system. The battery set shall be of sufficient capacity to provide for 1 1/2 minutes total cranking time without recharging. Include a battery rack and necessary cables and clamps.
  - 3. Battery charger: UL 1564 listed. Engine starting, current limiting battery charger to automatically recharge batteries. The charger shall have adjustable float and equalize voltage. DC amperage output shall be no less than 10 amperes. Output voltage shall be compatible with starting system. AC input voltage shall be 120V. Charger shall include fused overload protection; circuit breaker overcurrent protection; solid-state, silicon diode full wave rectifiers; voltage surge suppressors; DC voltmeter and AC ammeter; temperature voltage regulator; relays indicating AC power failure, low-, and high-battery voltage.
- L. Generator control panel:
  - 1. Type: Generator mounted NEMA 250 Type 1, vibration isolated, dead front, made of sheet metal gauge steel, with lockable hinged door.
  - 2. Panel shall contain, but not be limited to, the following equipment:
    - a. Voltmeter, 2 percent accuracy.
    - b. Ammeter, 2 percent accuracy.
    - c. Ammeter voltmeter, phase selector switch.
    - d. Frequency meter, dial type. (45 65 Hz)
    - e. Automatic starting controls.
    - f. Voltage level adjustment rheostat.
    - g. Dry contacts for remote alarms wired to terminal strips.
    - h. Fault indicators for low oil pressure, high water temperature, overspeed, and overcrank.
    - i. Three position selector switch with the following functions: auto, manual, off/reset.
    - j. Emergency stop switch.
    - k. Panel light.
    - 1. Running time meter
    - m. Oil pressure and water temperature gauges

- 3. Remote outputs for monitoring.
- 4. Accessory: Anti-condensation space heater.
- M. Main line and auxiliary distribution circuit breakers:
  - 1. Type: Molded-case circuit breaker, size as indicated on drawings. Circuit breaker shall conform to standards established by UL 489, and NFPA 70. Circuit breaker trip elements shall have inverse time delay for overload conditions and instantaneous magnetic tripping for short-circuit protection.
  - 2. The circuit breaker trip curve shall be coordinated with alternator thermal damage curve as required by generator manufacturer data.
    - a. Generator/exciter field circuit breakers do not meet the specified electrical standards and are unacceptable for line protection.
  - 3. Shunt trip device: The shunt trip shall open the generator circuit breaker in the event of an engine shutdown signal, and shall operate from the cranking battery voltage.
  - 4. Circuit breakers shall be lockable in the open position.

#### 2.21 GENERATOR ENCLOSURE

- A. Manufacturer's standard enclosure: Prefabricated weather-resistant, sound attenuated enclosure sized to house the generator, sub-base fuel tank, battery charger, batteries, and required accessories. Enclosure shall be factory-assembled by the generator manufacturer.
- B. Sheet metal steel enclosure primed with corrosion protection and painted with electrostaticallyapplied powder coat finish of manufacturer's standard color. Enclosure shall include roof, side walls, and end walls. Hardware shall be stainless steel.
  - 1. Lifting provisions: Capacity to support total assembly weight during rigging.
  - 2. Access doors: Provide sufficient access for maintenance and operation from outside the enclosure.
    - a. Handles key lockable, all doors keyed alike.
  - 3. Air intake and sound attenuation louver openings shall be screened to limit entry of rodents.
  - 4. Roof shall be designed to prevent collection of rainwater.
  - 5. Provide factory-mounted exhaust silencer inside the enclosure. Exhaust shall exit the enclosure through a rain collar and terminate at a rain cap. Exhaust connections to the generator set shall be made with seamless flexible connections.
- C. Sound attenuation: Enclosure shall be constructed to mitigate noise level to 85 dBA maximum at 23 feet (7 m) from enclosure at rated generator output.
- D. Accessories:
  - 1. Enclosure manufacturer shall provide the hardware required to mount the exhaust silencers while maintaining the enclosure's weather resistance.

- 2. Minimum two-duplex, 120V, GFCI receptacles with weatherproof covers located on opposite sides of the enclosure, mounted on exterior for general maintenance.
- 3. Vaporproof, lighting fixtures and toggle switches mounted within enclosure to illuminate generator controls and equipment.
- 4. External emergency stop pushbutton.

# 2.23 FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Sub-base tank: Mounted in unit base, factory installed and piped in accordance with appropriate local codes and regulations, complying with UL 142. Provide the following features:
  - 1. Tank shall be designed and supplied as an engineered system meeting the requirements for the generator it serves, including inlet flow control devices, other valves, supply pumps, overflow return pump, level and pump controls, indicators, alarms, and other devices, in an integrated, operational system.
  - 2. Standards: System shall meet the applicable requirements of NFPA 30, 31, and 37, and UL 80 and 142, and shall be labeled in accordance with UL 142 and 508.
  - 3. Capacity: Based on 48 hours of continuous operation at 100 percent rated generator power output.
  - 4. Mounting: Sub-base tank sized and coordinated for placement between generator set mounting skids.
  - 5. Construction: Rectangular atmospheric tank, dual walled, steel, all welded, meeting requirements of the specified standards for outdoor use with fuel oil, and meeting factory leak test at 5 psi.
    - a. Base: Welded steel channels designed to be bolted to concrete foundation.
    - b. Cover: Removable, steel. Include inspection port.
    - c. Connections: ASTM A 53 Schedule 40, black iron, from the tank to engine as recommended by the manufacturer, each connection to fixed installed piping with unions permitting tank to be removed or serviced.
    - d. Fuel level gauge.
  - 6. Finishes, tank and containment basin:
    - a. Interior: Epoxy coating.
    - b. Exterior: Primed and painted with manufacturer's standard industrial black enamel finish.
  - 7. Inlet devices.
  - 8. Monitoring system: Provide contacts from each base tank for monitoring by the power monitoring system for the following functions:
    - a. Tank alarms: high level, low level, overflow, tank leak.

## 2.30 VIBRATION ISOLATION DEVICES

A. Elastomeric isolator pads: Oil- and water-resistant elastomer, arranged in single or multiple layers, molded with a non-slip pattern and galvanized-steel baseplates of sufficient stiffness for

uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

- 1. Material: Double layer, standard neoprene.
- B. Restrained spring isolators: Freestanding, steel, open-spring isolators with seismic restraint.
  - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4 inch (6 mm) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
  - 2. Outside spring diameter: Not less than 80 percent of compressed height of the spring at rated load.
  - 3. Minimum additional travel: 50 percent of required deflection at rated load.
  - 4. Lateral stiffness: More than 80 percent of rated vertical stiffness.
  - 5. Overload capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

# 2.31 REMOTE ALARM ANNUNCIATOR PANEL

- A. Surface-mounted panel, complying with the requirements of NFPA 110, Level 1 equipment, providing visible and audible alarm signals powered by the storage battery of the generator. Unit enclosure: Fabricated of sheet steel, with removable front panel. The front panel shall contain LED type indicating lamps (visible signals) as listed below. The enclosure shall contain the required printed circuits, internal wiring, terminal block and battery voltage sensors. Provide knockouts for external wiring through bottom of box.
- B. Provide on face of panel the following switches:
  - 1. STOP-START pushbutton to start generator without load.
  - 2. Lamp test pushbutton.
  - 3. Audible alarm: Silence switch.

(See Schedule, next page)

LAMP LEGEND	GENERATING SET CONDITION INDICATED	DERANGEMENT SIGNALS Audible Visible	
EXERCISING	Generator exercising	No	Yes
GENERATING	Generating Power to Load	Yes	Yes
OVERCRANK	Failed to Start	Yes	Yes
LOW ENG TEMP	Low Lube Oil Pressure	Yes	Yes
HI ENG TEMP PRE	Excessive Engine Temperature Pre- Alarm	Yes	Yes
HI ENG TEMP	Excessive Engine Temperature	Yes	Yes
LOW OIL PRESS PRE	Low Lube Oil Pressure Pre-Alarm	Yes	Yes
LOW OIL PRESS	Low Lube Oil Pressure	Yes	Yes
OVERSPEED	Engine Overspeed	Yes	Yes
LOW FUEL	Low Fuel Supply	Yes	Yes
LOW COOLANT	Low Engine Coolant Level	Yes	Yes
AUTO SWITCH	Control Switch Not in Automatic Position	Yes	Yes
LOW CRANK VOLT	Low Engine Cranking Voltage	Yes	Yes
LOW BATT VOLT	Low Battery Voltage	Yes	Yes
HI BATT VOLT	High Battery Voltage	Yes	Yes
ALARM CONTACT	Contacts for Common Alarm	Yes	Yes

# 2.32 MONITORING SYSTEM

- A. Monitoring system: Provide contacts from generator for monitoring by the power monitoring system for the following functions:
  - 1. Generator off.
  - 2. Generator running.
  - 3. Generator exercising.
  - 4. Generator alarms: Overcrank, low oil pressure, high or low engine temperature, overspeed, batteries.
- B. Provide control interface for monitoring the generator status through the building fire alarm system and building automation system.

#### 2.40 SYSTEM OPERATION

- A. Loss of normal power:
  - 1. System is given signal to start by one of the automatic transfer switches or a remote device. Loss of power can occur at any automatic transfer switch, which can cause the generator to start. On receipt of this signal, generator shall automatically start, accelerate to rated frequency and build up to rated voltage.
  - 2. Priority shall be set to actuate the automatic transfer switch designated in the following order:
    - a. ATS-1: Life safety
    - b. ATS-2: Optional stand-by.
  - 3. After the first transfer switch closes to the bus, subsequent transfer switches shall close to the bus after pre-determined time delays.
- B. Failure of generator to start:
  - 1. If a unit fails to start, after the overcrank time delay (in the generator set control) has expired, the unit will be shut down, and an alarm will sound.
- C. Return of normal power:
  - 1. When normal power has been restored to the normal power system bus and sensed at each transfer switch, the loads shall be transferred back to normal source.
  - 2. The generator shall operate until all transfer switches have returned to normal power switch position and operate at no load for a cool-down period. When the cool-down period has been completed, the generator shall shut down.
  - 3. If a system start signal is received during the cool-down period, generator shall remain online and operate as described in "Loss of Normal Power" above.

## 2.90 SOURCE QUALITY CONTROL

- A. Prototype testing: Perform factory performance tests using prototype generator of same engine model and alternative configuration, and assembled with like components and accessories. Provide three certified copies of the successful test reports.
  - 1. Tests: Comply with NFPA 110, Level 1, energy converters in Paragraphs 3.2.1, 3.2.1.1, and 3.2.1.2.
  - 2. Alternator tests: Comply with IEEE 115.
  - 3. Equivalent components and accessories: Submit evidence that items furnished with the unit, but that are not identical to those on the prototype, are reliable and compatible with the application.
- B. Project-specific equipment testing: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project.
  - 1. Factory tests on the equipment shall be performed at rated load and rated power factor. Generator sets that have not been factory tested at rated power factor will not be

acceptable. Manufacturer shall perform a complete operational test on the generator set prior to shipping from the factory. Tests shall include: operational run at full load, maximum power, voltage regulation, transient and steady state governing, single step load pickup, and function of safety shutdowns.

2. The manufacturer shall provide three (3) certified copies of factory test reports.

## PART 3 – EXECUTION

#### 3.02 EXAMINATION

A. Examine rough-in requirements for connecting piping and wiring for generator and verify conditions. Verify actual locations of connections before packaged engine-generator installation.

#### 3.05 PREPARATION

A. Battery equalization: Equalize charging of battery cells according to manufacturer's written instructions.

## 3.20 INSTALLATION - GENERATORS

- A. Install generators, complete with controls, accessories, sub-base tanks, and enclosure, as indicated on the drawings and in accordance with manufacturer's recommendations.
- B. Comply with generator manufacturer's written installation and alignment instructions and with NFPA 37 and 110.
- C. Install the remote alarm annunciator panel where indicated on drawings.
- D. Set generators plumb and level.
- E. Install generators so as to provide access for maintenance and service, including removal of drivers and accessories.
- F. Install piping, wiring, accessories, and appurtenances in accordance with the applicable specifications. Ground equipment.
- G. Comply with applicable portions of NECA 404.
- H. Generator and enclosure accessories shall be connected to the building electrical distribution system via branch circuits and feeders as indicated on drawings.

#### 3.59 IDENTIFICATION

- A. Materials: Refer to Section 26 05 53 for requirements on identification of electrical systems. Identify units, devices, fuse blocks, relays, controls, and wiring. Identify equipment ratings.
- B. Nameplates: Refer to Section 26 05 53 for requirements on identification of electrical systems. Provide nameplate for each unit and associated components located on front of assembly.

- C. Control components mounted within the assembly shall be identified with tags and other identification materials, and correspond to designations on manufacturer's drawings.
- D. Operating instructions: Provide fabricated frame on side of unit to house operating instruction manuals.

# 3.60 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
  - 1. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections; and to assist the Contractor in testing.
- B. Tests and inspections:
  - 1. Perform tests recommended by manufacturer. Perform electrical tests and visual and mechanical inspection for "AC Generators and or Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 2. NFPA 110 acceptance tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
  - 3. Battery tests: Record individual cell voltages.
    - a. Measure charging voltage and voltages between available battery terminals for fullcharging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    - c. Verify acceptance of charge for each element of the battery after discharge.
    - d. Verify that measurements are within manufacturer's specifications.
  - 4. Battery-charger tests: Verify specified rates of charge for both equalizing and float charging conditions.
  - 5. System integrity tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks. Retain subparagraph below for long, restricted exhaust systems.
  - 6. Voltage and frequency transient stability tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  - 7. Harmonic-content tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
  - 8. Noise level tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations, and compare measured levels with required values.
- C. Coordinate generator testing with tests for transfer switches and run them concurrently.

- D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- E. Leak test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units; retest and reinspect as specified above.
- I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- J. The unit shall operate without undue noise or vibration, or excessive heating. Correct defects and retest until unit is operating satisfactorily.
- K. Demonstrate satisfactory operation of each feature required of the generator set and accessories.
- L. Test emergency power system: After completion and acceptance of the generator tests, perform an operational test of the emergency power system. Perform a power failure test on the emergency electrical system. This shall be performed by interrupting the normal power source and verifying proper generator start and transfer switch operation.
- M. Report results of tests and inspections in writing. Record adjustable device settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

# 3.61 ACCEPTANCE TESTING

- A. In addition to the factory and field tests required in Part 2, perform a scheduled on-site test and demonstration of the completely installed generator before making final electrical connections.
- B. Test shall be witnessed by the Architect and manufacturer's representative. Manufacturer's representative shall conduct demonstrations.
- C. Provide and utilize loadbank for testing.
- D. Test procedures: Test the generator in accordance with NFPA 110 and as follows:
  - 1. Test the generator for at least two hours under full load, starting and stopping at least five times.
    - a. The unit shall operate without undue noise or vibration, or excessive heating. Correct defects and retest until unit is operating satisfactorily.

b. Demonstrate satisfactory operation of each feature required of the generator set and accessories.

# 3.75 CLEANING

A. Upon completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Clean components internally using methods and materials recommended by the manufacturer.

## 3.81 OPERATING INSTRUCTIONS

A. As specified in Section 26 05 00, provide operating instructions.

# END OF SECTION

## SECTION 26 36 00 - TRANSFER SWITCHES

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Transfer switches rated 600 V and less, including automatic transfer switch.
- 1.14 RELATED SECTIONS
  - A. Sections specifying requirements for commissioning are specified in Division 01.
  - B. Generators: Section 26 32 13.

#### 1.20 REFERENCES

- A. NFPA 110: Emergency and Standby Power Systems.
- B. UL 1008: Transfer Switch Equipment.
- 1.30 SUBMITTALS
  - A. General: Comply with Division 01 and Section 26 01 01.
  - B. Shop drawings: Wiring diagrams showing detail wiring for transfer switch, differentiating between manufacturer-installed and field-installed wiring, and including power and control wiring.
  - C. Product data: Include ratings and dimensioned plans, sections, and elevations showing minimum clearances, conductor entry, gutter space, installed features and devices, and material lists for each switch.
  - D. Certifications:
    - 1. Product certificate signed by manufacturer certifying that products furnished comply with requirements and that switches have been tested for applicable load ratings and short-circuit closing and withstand ratings.
    - 2. Qualifications of manufacturer's representative.
  - E. Operation and maintenance data: For each type of product to include in maintenance manuals specified in Division 01. Include all features and operating sequences, both automatic and manual. List factory settings of relays and provide relay-setting and calibration instructions, including software, where applicable.
  - F. Source quality-control test reports.
  - G. Field quality control test reports.

## 1.40 QUALITY ASSURANCE

- A. Automatic transfer switch shall comply with UL 1008. Where specified requirements exceed requirements of UL 1008, switch shall meet the stricter requirements.
- B. Comply with requirements for commissioning specified in Division 01.
- C. Manufacturer's representative shall be factory-authorized and -trained in the installation, testing, and operation of the specified equipment.

# 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

# PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

- A. Cummins Power Generation (Onan) units are the basis for design of the Project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 01 and the article "Product Options" in Section 26 01 01, and submit shop drawings as specified in the article "Submittals" above.
  - 1. Automatic Switch Co. (ASCO)
  - 2. Cummins Power Generation (Onan)
  - 3. Kohler Power Systems
  - 4. Russelectric, Inc.
  - 5. Zenith Controls, Inc.

# 2.31 AUTOMATIC TRANSFER SWITCH

- A. Compatible with local power supply, which is 480/277 volts, 3-phase, 4-pole; Level 1 equipment according to NFPA 110; rated in accordance with UL 1008 for continuous loading and total system transfer and shall be suitable for motor, resistance heating, electric-discharge lighting, and tungsten filament lamp loads.
- B. Switching arrangement: Double-throw design, mechanically interlocked to prevent simultaneous connection of both power sources. The contact driving system shall be mechanically held and electrically operated.
  - 1. Contacts: Silver alloy, capable of making or breaking any load within the rating of the switch.

- a. Contacts that close to start the engine generator: Include a time delay of transfer switch and engine starting signals, factory set at 10.0 seconds (adjustable from 0-5 minutes).
- C. Controls: Solid-state.
- D. Provide close differential voltage sensing of all phases of both the normal and alternate sources of power.
  - 1. Settings: Factory preset for:
    - a. Dropout at 87 percent of nominal voltage (adjustable 75-98 percent)
    - b. Pickup at 95 percent of nominal voltage (adjustable 85-100 percent).
- E. The transfer of the load shall occur only if the alternate source has attained factory setting of 95 percent of nominal voltage (adjustable 85-100 percent) and 95 percent of nominal frequency (adjustable 90-100 percent) and the transfer to alternate time delay has expired. The time delay shall be factory set for 0 seconds. (Field adjustable range of 0 to 2 minutes.)
  - 1. Upon return of the normal source to within the limits of the voltage sensor, the switch shall retransfer to the normal source after a retransfer to normal time delay. The time delay shall be factory preset for 15 minutes. (Field-adjustable range of 0.5 to 30 minutes.)
- F. Time delay for engine generator cooldown: Unloaded, running, factory-set at 5 minutes (adjustable 0-5 minutes).
- G. Pilot lights: Green, indicating that the normal source is connected to the load, and red, indicating that the alternate source is connected to the load.
- H. Test switch: Simulates a normal source outage.
- I. Reset switch: To manually retransfer the automatic transfer switch to the normal source, except that retransfer shall occur automatically if alternate source fails.
- J. Inphase monitor control for transfer and retransfer of motor loads.
- K. Enclosure: NEMA 250, Type 1; NEMA ICS 6; and UL 508.
- L. Terminal block: Termination of all auxiliary contacts, switches, pilot lights, and appurtenances mounted in transfer switch enclosure.
- L. Clearly label and identify each indicating light and switch as to its purpose or function.
- M. Automatic solid-state exerciser without load for 0.5 weekly.
- N. Relay protection:
  - 1. Full-phase voltage on normal side.
  - 2. Three-phase voltage frequency on generator side.

P. Overlapping neutral transfer contacts for ground fault sensing coordination.

# 2.90 SOURCE QUALITY CONTROL

A. Factory-test components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test in accordance with NEMA ICS 1.

PART 3 - EXECUTION

- 3.20 INSTALLATION
  - A. Install each unit level and plumb, securely attached to wall.
  - B. Connect wiring as indicated on the drawings and in accordance with manufacturer's recommendations.
  - C. Identify components.
- 3.60 FIELD QUALITY CONTROL
  - A. Perform tests and inspection and prepare test reports.
    - 1. Manufacturer's field service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections; and to assist the Contractor in testing.
  - B. Tests and inspections:
    - 1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
    - 2. Perform tests recommended by manufacturer. Perform electrical tests and visual and mechanical inspection for both automatic transfer switches and generator docking station described under "Emergency Systems, Automatic Transfer Switches" specified in NETA Acceptance Testing Specification except perform automatic transfer switch specific tests for automatic transfer switches only. Certify compliance with test parameters.
      - a. Check for electrical continuity of circuits and for short circuits.
      - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
      - c. Verify that manual transfer warnings are properly placed.
      - d. Perform manual transfer operation.
    - 3. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
      - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
      - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
      - c. Verify time-delay settings.

- d. Verify pickup and dropout voltages by data readout or inspection of control settings.
- e. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- C. Coordinate automatic transfer switch tests with tests of generator and run them concurrently.
- D. Utilize mobile industrial towable generator set for generator docking station tests.
- E. Report results of tests and inspections in writing. Record adjustable relay settings and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- F. Remove and replace malfunctioning units and retest as specified above.
- G. Prepare test and inspection reports.
- 3.61 ACCEPTANCE TESTING
  - A. Testing of automatic transfer switches shall be witnessed by the Owner's representative and manufacturer's representative. Manufacturer's representative shall conduct demonstrations.
- 3.75 ADJUSTING AND CLEANING
  - A. Inspect and clean surfaces and repair damaged finishes to match original finish.
  - B. Clean interior of equipment according to manufacturer's instructions.
- 3.81 OPERATING INSTRUCTIONS
  - A. As specified in Section 26 05 00, provide operating instructions.
  - B. Coordinate this training with that for generator equipment.

# END OF SECTION

## **SECTION 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES**

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. A complete lightning protection system for buildings as indicated on the drawings.
  - B. Include lightning protection to the project if the alternate for lightning protection should be accepted. Refer to Division 01.
- 1.14 RELATED SECTIONS
  - A. Conduit: Section 26 05 33.
  - B. Grounding: Section 26 05 26.
  - C. Alternates: Division 01.

#### 1.20 REFERENCES

- A. NFPA 780: Installation of Lightning Protection Systems.
- B. UL 96: Lightning Protection Components.
- C. UL 96A: Installation Requirements for Lightning Protection Systems.

#### 1.21 DEFINITIONS

- A. LPI: Lightning Protection Institute.
- B. NRTL: National recognized testing laboratory.

#### 1.30 SUBMITTALS

- A. Comply with Division 01 and Section 260101.
- B. Shop drawings: For air terminals and mounting accessories.
  - 1. Detail lightning protection system, including air-terminal locations, conductor routes and connections, and bonding and grounding provisions.
  - 2. Indicate use of raceway, and provide data on how concealment requirements will be met.
  - 3. Provide scaled drawings of proposed layout.
- C. Product data: For each type of product specified, including roof adhesive, if used, submit evidence to establish that materials are manufactured, furnished, and recommended for their intended use by a lightning protection manufacturer who is a Manufacturer Member of the Lightning Protection Institute.
- D. Qualification data: For firms and persons specified in "Quality Assurance" Article. Include data on listing or certification by an NRTL or LPI.

- E. Certifications:
  - 1. Certifications required by "Field Quality Control" in Part 3 below.
- F. Reports: Tests and inspections required by "Field Quality Control" in Part 3 below.
- G. Project records:
  - 1. Drawing: As required by Division 01 and Section 260101, at the same scale as contract documents, showing the locations of air terminals, cable routes, connections and grounding, and other components installed; to be made part of Operation and Maintenance manuals.
  - 2. Forms and final documentation as required in "Field Quality Control" in Part 3 below.

# 1.40 QUALITY ASSURANCE

- A. Install system under the supervision of the manufacturer's authorized and approved representative qualified as follows:
  - 1. Actively engaged in the installation of lightning protection systems.
  - 2. Having a satisfactory record of performance, including providing adequate service, as demonstrated by at least 5 systems of the same type, and similar size and duty, which have performed for not less than 2 years.
  - 3. Certified Member in good standing of the Lightning Protection Institute.
- B. Electrical components, devices, and accessories: Comply with applicable requirements of NFPA 70.
- C. Comply with UL 96 and UL 96A.

## 1.71 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
- B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.
- C. Coordinate installation of counterpoise conductor and ground rods with installation of other buried systems and components.

# PART 2 - PRODUCTS

# 2.01 ACCEPTABLE MANUFACTURERS

- A. Manufacturers/Installers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Advanced Lightning Systems, Inc.
  - 2. Bonded Lighting Protection Systems, Inc.

- 3. Brazill Brothers & Associates, Inc.
- 4. Dillon Lightning Protection Systems, Inc.
- 5. East Coast Lightning Equipment, Inc.
- 6. Heary Bros. Lightning Protection Co. Inc.
- 7. Thompson Lightning Protection, Inc.

## 2.20 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96.
- B. Air terminals and conductors: NFPA 780 Class I solid copper unless otherwise indicated.
  - 1. Air terminals: Blunt end. Air terminals shall be approved by Architect prior to installation.
  - 2. Stack-mounting air terminals: Solid copper.
  - 3. Air terminals installed on single-ply roof membrane: Designed for this application.
- C. Ground rods, ground loop conductors, and concrete-encased electrodes: Comply with Section 260526 and with standards referenced in this section.
- D. Conduit: Schedule 40 PVC, minimum trade size 1 inch (27 mm).

## PART 3 - EXECUTION

#### 3.20 INSTALLATION

- A. Do not begin work until shop drawings have been approved. Notify Architect 24 hours in advance of concealing lightning protection work.
- B. Install lightning protection components and systems according to UL 96A.
- C. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops; make no bends sharper than 90 degrees and minimum bending radius of 8 inches.
- D. Conceal the following conductors unless otherwise indicated on drawings.
  - 1. System conductors.
  - 2. Down conductors.
  - 3. Conductors inside building.
  - 4. Conductors in normal view from exterior locations at grade within 200 ft (60 m) of building.
- E. Cable connections: Use approved exothermic-welded connections for all connections between conductors and ground rods.
- F. Air terminals shall extend not less than 10 inches (255 mm) above the objects they are to protect.
- G. Counterpoise conductors shall be buried a minimum of twenty four-inches below finished grade.

## 3.21 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Install conductors in conduit within wall cavities and where conditions would cause deterioration or corrosion of conductors.
- 3.22 GROUNDING AND BONDING
  - A. Provide equipment grounding and bonding connections sufficiently tight to ensure permanent and effective grounds and bonds.
- 3.60 FIELD QUALITY CONTROL
  - A. On completion of the installation, perform ground resistance test and submit a copy of the results. Ground resistance shall not exceed 10 ohms. Test, correct, and retest until results are satisfactory.
  - B. Provide UL inspection and submit Master Label C.

# END OF SECTION

# SECTION 26 43 13 - SURGE PROTECTIVE DEVICES

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

A. Surge protective devices (SPD) for the protection of ac electrical circuits from the effects of lightning-induced currents, substation switching transients, and internally generated transients resulting from inductive or capacitive load switching.

#### 1.14 RELATED SECTIONS

- A. Switchboards: Section 26 24 13.
- B. Circuit breaker: Section 26 24 16, Panelboards.

## 1.21 DEFINITIONS

- A. SPD: Surge protective device.
- B. LED: Light-emitting diode.
- C. MCOV: Maximum continuous operating voltage.
- D. MOV: Metal-oxide varistor.
- E. VPR: Voltage protection rating.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. Product data: Provide manufacturer's catalog information, including unit dimensions and rated capacities for each type of unit included in the project.
- C. Certifications:
  - 1. Cover page of manufacturer's UL test report for each type of unit, showing that the unit is UL 1449 Third Edition listed.
  - 2. Provide UL 1449 Third Edition listing documentation verifying the following:
    - a. Voltage protection rating (VPR)
    - b. Maximum continuous operating voltage (MCOV)
  - 3. Electromagnetic interference certification in accordance with UL 1283.

## 1.40 QUALITY ASSURANCE

A. Every SPD shall be UL 1449 Third Edition listed and labeled.

- B. UL data and visual inspection takes precedence over manufacturer's published documentation.
- C. A single manufacturer shall provide secondary service SPD at each branch circuit panelboard where indicated.

#### 1.80 WARRANTY

- A. In addition to the general project warranty and correction period, provide manufacturer's special warranties providing unlimited replacements of suppressor modules if they are destroyed by transients. Length of warranties:
  - 1. Service entrance SPD: Ten years.
  - 2. Secondary service SPD: Ten years.

#### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. Service entrance SPD: Basis-of-design product: Subject to compliance with requirements, provide service entrance SPD manufactured by Schneider Electric (Square D), or comparable product by one of the following:
  - 1. Eaton Corporation; Cutler-Hammer Products
  - 2. General Electric Company
  - 3. Siemens Industry, Inc.
  - 4. Schneider Electric; Square D Products (basis-of-design)
- B. Secondary service SPD: Basis-of-design product: Subject to compliance with requirements, provide SPD manufactured by Advanced Protection Technologies, or comparable product by one of the following:
  - 1. Advanced Protection Technologies (basis of design)
  - 2. Eaton Corp.; Cutler-Hammer Products
  - 3. General Electric Company
  - 4. Liebert Corp. Div. of Emerson
  - 5. Siemens Industry, Inc.
  - 6. Schneider Electric; Square D Products
  - 7. Surge Suppression Inc.

## 2.21 SERVICE ENTRANCE SPD

- A. Provide service entrance SPD factory installed and integral to the switchboard specified in Section 26 24 13, Switchboards.
- B. Suppression components shall be MOV based, serviceable, and replaceable.
- C. SPD shall provide surge current paths for the following modes of protection: L-N, L-G, and N-G.

- D. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of 50dB at 100 kHz.
- E. Provide terminals for the necessary power and ground connections. Each terminal shall accommodate wire sizes of No. 10 to No. 1 AWG.
- F. SPD shall meet or exceed the following criteria:
  - 1. Peak (maximum) surge current rating (L-N + N-G): 150 kA per phase (8/20 μs waveform).
  - 2. The UL 1449 Third Edition; voltage protection ratings (VPR) shall not exceed the following:

System Voltage	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>
480/277V	1200V	1200V	1200V

3. UL 1449 listed maximum continuous operating voltage (MCOV):

System Voltage	Allowable System Voltage Fluctuation	MCOV
480Y/277V	15 percent	320V

- G. SPD shall be equipped with the following diagnostics:
  - 1. Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
  - 2. Audible alarm with on/off silence function and diagnostic test function.

## 2.22 SECONDARY SERVICE SPD FOR BRANCH CIRCUIT PANELBOARDS

- A. Provide an externally mounted SPD, equal to Advanced Protection Technologies, XAS Series. SPD integral with panelboard shall not be acceptable.
- B. Suppression components shall be MOV based, serviceable, and replaceable.
- C. SPD shall provide surge current paths for the following modes of protection: L-N, L-G, and N-G.
  - D. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of 50dB at 100 kHz.
  - E. Provide terminals for the necessary power and ground connections. Each terminal shall accommodate wire sizes of No. 10 to No. 1 AWG.
  - F. SPD shall meet or exceed the following criteria:
    - 1. Peak (maximum) surge current rating (L-N + N-G): 100 kA per phase ( $8/20 \mu$ s waveform).
    - 2. The UL 1449 Third Edition; voltage protection ratings (VPR) shall not exceed the following:

System Voltage L-N L-G N-G

208Y/120V 700V 800V 700V

3. UL 1449 listed maximum continuous operating voltage (MCOV):

System VoltageAllowable System Voltage FluctuationMCOV208Y/120V25 percent150V

- G. SPD shall be equipped with the following diagnostics:
  - 1. Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
  - 2. Audible alarm with on/off silence function and diagnostic test function.

#### PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Install per manufacturer's installation instructions and recommendations.
  - B. Install units plumb, level and rigid without distortion.
- 3.21 INSTALLING SERVICE ENTRANCE SURGE PROTECTIVE DEVICES
  - A. Install on the load side of the main service disconnect.
  - B. Keep conductors between SPD and point of attachment short and straight.
  - C. Bond SPD ground to the service entrance ground.

## 3.22 INSTALLING SURGE PROTECTIVE DEVICES FOR PANELBOARDS

- A. Install SPD external to panelboards where indicated on Drawings.
- B. SPD shall be installed per manufacturer's installation instructions with lead lengths as short (less than 12 inches) and straight as possible. Gently twist conductors together.
  - 1. Rearrange circuit breaker locations in panelboards to ensure short and straightest possible leads to each SPD.

#### 3.23 ADJUSTMENTS AND CLEANING

- A. Remove debris from SPD and wipe dust and dirt from all components.
- B. Repaint marred and scratched surfaces with touch up paint to match original finish.
- 3.60 FIELD QUALITY CONTROL
  - A. Check tightness of accessible mechanical and electrical connections to ensure proper torque is applied per manufacturer's recommendations.

- B. Check installed panelboards for proper grounding, fastening and alignment.
- C. Test and inspections:
  - 1. Perform each visual and mechanical inspection and electrical test in accordance with NETA Acceptance Testing Specifications in section, Surge Arresters, Low-Voltage Surge Protection Devices. Certify compliance with test parameters.
  - 2. After installing SPD devices but before electrical circuitry has been energized, test for compliance with requirements.
  - 3. Complete startup procedures according to manufacturer's written instructions.
- D. SPD device shall be considered defective if it does not pass tests and inspections.

# END OF SECTION

# SECTION 26 51 00 – INTERIOR LIGHTING

## PART 1 - GENERAL

## 1.11 SECTION INCLUDES

- A. Lighting fixtures, including lamps, drivers, and accessories.
- B. Emergency lighting control transfer relay device.

## 1.14 RELATED SECTIONS

- A. Sections specifying requirements for LEED rating are specified in Division 01.
- B. Commissioning requirements: Divisions 01.
- C. Modular dimming controls: Section 26 09 36.
- D. Stand-alone lighting controls: Section 26 09 23.

# 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. LEED submittal:
  - 1. Product data:
    - a. Energy and Atmosphere (EA), Prerequisite 2: For minimum energy performance.
    - b. Indoor Environmental Quality (IEQ), Credit 6.1: For controllability of systems lighting.
    - c. Sustainable Sites (SS), Credit 8: For light pollution reduction.
- C. Product data: For each type of lighting fixture indicated, arranged in order of fixture designation. Include data on features, accessories, and the following:
  - 1. Dimensions of fixtures, photometrics and efficiency, wattage, reflectors, glassware, voltage, suspension, and appurtenances.
  - 2. Certified results of laboratory tests for fixtures and lamps for photometric performance.
  - 3. Emergency lighting unit battery and charger.
  - 4. LED drivers
  - 5. Lumen output, rated color temperature, and manufacturer's LED binning procedures.
  - 6. Fire rated troffer cover.
- D. Coordination drawings: Reflected ceiling plans and sections drawn to scale and coordinating fixture installation with ceiling grid, ceiling-mounted items, and other components in the vicinity. Include work of all trades that is to be installed near lighting equipment.
- E. Shop drawings: Show details of nonstandard or custom fixtures. Indicate dimensions, weights, method of field assembly, components, features, and accessories.

- 1. Wiring diagrams: Detail wiring for fixtures and differentiate between manufacturerinstalled and field-installed wiring.
- F. Samples: If contractor has selected fixtures not identical to scheduled fixtures, as permitted in Part 2 below as an option, Architect may require submittal of samples.
  - 1. One complete fixture of each approved type, except as otherwise instructed by the Architect.
  - 2. Install approved samples as work of the project, in locations as directed, as standards for all fixtures of the same type.
  - 3. Ascertain that the fixture will fit in the available space and is coordinated with adjacent and connected products.
- G. Field test reports: Provide test results for compliance with performance requirements.
- H. Maintenance data: For lighting fixtures to include in maintenance manuals specified in Division 01.
- I. Warranties: Special warranties specified in this section.
- 1.40 QUALITY ASSURANCE
  - A. UL label and local testing (if required): As specified in Section 26 05 00, Common Work Results for Electrical.
  - B. Comply with requirements for LEED certification and commissioning specified in Division 01.
  - C. Fixtures, emergency lighting units, and accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
  - D. Comply with NFPA 70.
  - E. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

## 1.49 COORDINATION

- A. Fixtures, mounting hardware, and trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.
- 1.80 WARRANTY
  - A. Special warranty for batteries: Written warranty, executed by manufacturer agreeing to replace rechargeable batteries that fail in materials or workmanship within specified warranty period.
    - 1. Special warranty period for batteries: Manufacturer's standard, but not less than 10 years from date of substantial completion. Full warranty shall apply for first year, and prorated warranty for last nine years.

- B. Special warranties for LED fixtures: Written warranty, executed by manufacturer agreeing to replace LED fixture that fail in materials or workmanship within specified warranty period.
  - 1. Special warranty period for LED fixtures: Five years from date of manufacture, but not less than four years from date of Substantial Completion.

#### 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Divisions 01 for Commissioning Requirements.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

#### PART 2 - PRODUCTS

## 2.01 MANUFACTURERS

- A. Basis-of-design products: Fixtures indicated in the Fixture Schedule on the drawings are the basis of design of the project.
  - 1. Subject to compliance with requirements, provide the scheduled products. Unnamed products will only be considered and approved according to Bidding and Contracting requirements and Division 01 requirements for substitutions.
- B. Subject to compliance with requirements, provide products by one of the following:
  - 1. Drivers:
    - a. Philips/Advance
    - b. Osram Sylvania
    - c. Universal Lighting Technologies
    - d. Lutron
    - e. EldoLED

## 2.20 FIXTURES, GENERAL

- A. Fixtures shall comply with UL 1598 and be complete with sockets, casings, fittings, holders, shades, glassware, lamps, and appurtenances, wired and completely assembled.
- B. Metal parts: Free from burrs, sharp corners, and edges.
- C. Sheet metal components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- D. Doors, frames, and other internal access: Smoothly operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

- E. Metal finishes: Painted after fixture fabrication.
- F. Reflecting surfaces: Minimum reflectance as follows, unless otherwise indicated:
  - 1. White surfaces: 85 percent.
  - 2. Specular surfaces: 83 percent.
  - 3. Diffusing specular surfaces: 75 percent.
  - 4. Laminated silver metalized film: 90 percent.
- G. Lenses, diffusers, covers, and globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated, exactly as scheduled or specified in optical details and lighting characteristics.
  - 1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
  - 2. Lens thickness: 0.125 inch (3 mm) minimum, unless greater thickness is indicated.
- H. Wire guards:
  - 1. Wire guards: 14 gauge welded wire guard, four foot length, baked white enamel, 2 inch by 2 inch grid pattern mounted with four hinge-latch clips with captive knurled thumb screws.

# 2.21 LED DRIVERS

- A. Driver shall operate from a 120-volt or 277-volt, 60-Hz input power source and be suitable for outputting power to 12-volt or 24-volt LED lamp sources, as required.
- B. Drivers, where specified, shall be capable of being dimmed. Dimmable drivers shall be controlled by a Class 2 low-voltage 0-10VDC controller.
- C. Performance Criteria:
  - 1. Driver shall have a Class A sound rating.
  - 2. Driver shall have a power factor (PF) greater than 0.90.
  - 3. Driver shall have Total Harmonic Distortion (THD) of input current equal to or less than 20 percent.
- D. Driver shall meet FCC and Title 47 CFR regulations for EMI/RFI.
- E. Driver shall comply with ANSI C62.41 Class A requirements for transient protection.

## 2.23 EXIT SIGNS

- A. General requirements: Exit signs shall meet the Energy Star Program requirements to operate on 5 W or less input power per face. Comply with UL 924 and the following:
  - 1. Sign colors and lettering size: Comply with authorities having jurisdiction.
- B. Internally lighted signs: As follows:

1. Lamps for ac operation: Light-emitting diodes, 70,000 hours minimum rated lamp life.

### 2.24 EMERGENCY LIGHTING UNITS

- A. General requirements: Self-contained units. Comply with UL 924. Units include the following features:
  - 1. Battery: Sealed, maintenance-free, lead-acid type with minimum 10-year nominal life and special warranty.
  - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
  - 3. Operation: Relay automatically turns lamp on when supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps, and battery is automatically recharged and floated on charger.
  - 4. Wire guard: Where indicated, heavy-chrome-plated wire guard arranged to protect lamp heads or fixtures.

#### 2.26 EMERGENCY LIGHTING CONTROL TRANSFER RELAY DEVICE

- A. Internal type (single fixture): Self-contained, modular unit mounted within fixture body. UL 924 listed as "emergency lighting equipment" and UL listed for field installation.
  - 1. Capable of bypassing the local switching means when normal utility power has been lost.
  - 2. Device shall consist of a test switch, normal power indicator light and an alternate power indicator light.
  - 3. Rated for 120 through 277-volts AC, up to 3 amperes of lighting load.
  - 4. Emergency lighting control relay control device: Equal to Bodine, Model GTD.
- B. External type (multiple fixture): Self-contained, modular unit mounted within accessible ceiling. UL 1008 listed as "automatic transfer switch" and UL listed for field installation.
  - 1. Capable of bypassing the local switching means when normal utility power has been lost.
  - 2. Device shall consist of a remote test switch, normal power indicator light and an alternate power indicator light in a common faceplate. This remote indicating station shall be mounted in an acoustical ceiling tile or drywall ceiling near the device whenever the location of the transfer relay device is obstructed from view.
  - 3. Rated for 120 through 277-volts AC, up to 20 amperes of lighting load.
  - 4. Emergency lighting control relay control device: Equal to Bodine, Model GTD20A.

#### 2.65 LAMPS, LED

- A. The LED manufacturer shall provide the quantity and wattage of LEDs required to achieve the defined lighting output set forth by the lighting fixture manufacturer.
- B. LED lamps shall be integrated into an engineered package for the specific lighting fixture application, including heat dissipation components.

- C. Color temperature: As specified in lighting fixture schedule, with a tolerance of plus or minus 100K and within a range of three macadam ellipses. Noticeable color temperature variation between adjacent lighting fixtures shall be considered a failure to meet these specifications and shall be replaced at no cost to the owner.
- D. Minimum performance characteristics:
  - 1. Life: Minimum lumen maintenance of L70 at 50,000 hours, as defined by IES LM-80.
  - 2. Lumen Output: Based on absolute photometry, lumens (total luminous flux exiting the physical luminaire), as specified on contract drawings and schedules.
  - 3. Color Rendering Index: Rated at 85 or higher.

## 2.72 FIXTURE SUPPORT COMPONENTS

- A. Comply with Section 26 05 00, Common Work Results for Electrical, for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-stem hangers: 1/2-inch (12-mm) steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.
- C. Twin-stem hangers: Two, 1/2-inch (12-mm) steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.
- D. Rod hangers: 3/16-inch- (5-mm-) minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- F. Aircraft cable support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

## 2.82 FINISHES

- A. Fixtures: Manufacturer's standard, unless otherwise indicated.
  - 1. Paint finish: Applied after fabrication over corrosion-resistant treatment or primer, free of defects.
  - 2. Metallic finish: Corrosion-resistant.

## PART 3 - EXECUTION

## 3.05 PREPARATION

- A. Before ordering the light fixtures, consult with the installer of the ceilings to ensure that the correct fixture trim is supplied and installed. Provide the supports and accessories required for installation in each ceiling system.
- B. Before ordering the light fixtures, verify the specified voltage with the voltage shown on the drawings to ensure the correct voltage is supplied.
### 3.20 INSTALLATION

- A. Furnish and install a complete lighting fixture for every outlet indicated on the drawings so that every outlet shall be properly provided with a suitable fixture of type specified, of wattage indicated.
- B. Fixture wire shall bear UL label. Fixture wiring within fixture housing and concealed channels shall be type THHN.
- C. Furnish fixtures in the quantities, sizes, and types indicated on drawings.
- D. Where a letter designating fixture type is adjacent to a row of fixtures, it shall be understood that all fixtures in the row shall be of this type.
- E. Provide recessed fixtures with flexible conduit connector and wire (fixture whip), or a removable wiring access plate, so that they may be wired without removing integral parts of the fixture. Plate shall be screwed to fixture housing and conduit shall be securely attached and grounded to fixture to meet NEC requirements.

### 3.21 FIXTURE SUPPORT

- A. Support from building structure: Provide fasteners appropriate to the supporting substrate, and wire, jack chain, or rods as specified for particular fixture types below.
  - 1. Provide channels bolted or welded between joists where required to obtain proper spacing for lighting supports.
  - 2. Connections to joists or beams: Beam clamps. For wire supports, wrap wire securely around structural member.
  - 3. Connections to concrete: Embedded, as specified in Section 26 0533, Conduits.
- B. In suspended plaster and drywall ceilings, fixtures may be supported from the suspended ceiling construction. Fasten box and fixture supports securely to suspension system. Where fixtures are surface-mounted, cut neat holes in the plaster as required for supports.
- C. Recessed fixtures in suspended acoustical ceilings: Coordinate fixture installation with ceiling installer. Ensure that ceiling supports are located to clear fixtures.
  - 1. Support from building structure: Use fasteners specified in Section 26 05 33, Conduits, and No. 10 wire.
    - a. Provide 2 supports for each individual fixture, one at each corner of fixture. In continuous rows, install additional supports at each joint.
- D. Lighting fixtures mounted in gymnasium with open bar joists: Attach to a structural channel attached to the top of the joists with fixture mounted flush with the bottom of the joists. Provide lenses and electrical devices with safety chains.
- E. Surface-mounted and stem-suspended fixtures on or below suspended acoustical ceilings: Supported from the building structure above with No. 10 wire.

- 1. Provide four supports for each individual fixture, two at each end of fixture. In continuous rows, install an additional support at each joint.
- 2. Surface-mounted fixtures mounted on low-density ceilings shall be provided with spacers where required.
- F. Where it is necessary for a fixture to be installed directly below an air duct, install two hanger rods, one on each side of the duct, bolted to a channel or angle suspended from the hangers under the duct, and support the fixtures from the suspended channel or angle.

### 3.59 IDENTIFICATION

- A. Adhesive film labels: Refer to Division 26 Section "Identification for Electrical Systems" for requirements.
  - 1. Identify interior lighting fixtures on emergency circuit.
  - 2. Identify locations of lighting relay room controllers.
  - 3. Identify locations of emergency lighting control transfer relay devices.

### 3.70 ADJUSTMENT PERIOD

A. Occupancy adjustments: When requested within 6 months of date of Substantial Completion, provide on-site assistance in adjusting fixtures to suit occupied conditions. Provide up to 2 visits to project outside of normal occupancy hours for this purpose. Some work may be required after dark.

#### 3.75 CLEANING

A. Light fixtures, used for temporary lighting during construction, shall be cleaned free of construction dirt to like-new condition.

## **END OF SECTION**

### **SECTION 26 56 00 - EXTERIOR LIGHTING**

#### PART 1 - GENERAL

- 1.11 SECTION INCLUDES
  - A. Poles
  - B. Fixtures
- 1.14 RELATED SECTIONS
  - A. Sections specifying requirements for LEED rating and commissioning are specified in Division 01.
  - B. Conduits: Section 26 05 33.
  - C. Wires and cables: Section 26 05 19.
  - D. Equipment foundations: Section 26 05 28.
  - E. Excavation and fill for electrical work: Section 26 05 01.

### 1.20 DEFINITIONS

- A. Bracket: An attachment to a standard, on which a luminaire is carried.
- B. Luminaire: A lighting device consisting of a light source together with its direct appurtenances, including globe, reflector, refractor, housing, and such support as is integral with the housing. The standard and the bracket are not part of the luminaire.
- C. Pole: A support generally used to carry overhead lighting distribution circuits.
- D. Standard (lamp post): A support used to carry a luminaire, provided with
  - 1. Internal attachments for wiring and
  - 2. External attachments for brackets (if any) and luminaire.

### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 26 01 01.
- B. LEED submittal:
  - 1. Product data:
    - a. Energy and Atmosphere (EA), Prerequisite 2: For minimum energy performance.
    - b. Indoor Environmental Quality (IEQ), Credit 6.1: For controllability of systems lighting.
    - c. Sustainable Sites (SS), Credit 8: For light pollution reduction.

- C. Product data: Submit for each type of fixture, pole and standard.
  - 1. Type
  - 2. Wattage
  - 3. Voltage
  - 4. Efficiency
  - 5. Suspension
  - 6. Glassware
  - 7. Finished diameters
  - 8. Mounting heights
  - 9. Lamps
  - 10. LED drivers
  - 11. Length and diameter of poles and standards
  - 12. Appurtenances
- D. Shop drawings shall show complete dimensions of complete assembled unit with accessories. Include wiring diagrams, showing clearly manufacturer-installed and field-installed wiring.
- E. Photometric data: Point-to-point, indicating footcandle readings minimum 10 feet on centers along the horizontal plane, for layout shown on the site plans. Provide complete data to a point where the calculations indicate zero foot candles.
- F. Samples: If contractor has selected fixtures not identical to scheduled fixtures, as permitted in Part 2 below as an option, Architect may require submittal of samples.
  - 1. One complete fixture of each approved type, except as otherwise instructed by the Architect.
  - 2. Install approved samples as work of the project, in locations as directed, as standards for all fixtures of the same type.
  - 3. If substitute fixtures should be requested, submit samples as required.
  - 4. For selection, manufacturer's complete line of colors and textures.

## 1.40 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 26 05 00, Common Work Results for Electrical.
- B. Comply with requirements for LEED certification and commissioning specified in Division 01.
- 1.50 DELIVERY, STORAGE, AND HANDLING
  - A. Deliver glassware and lamps in their original cartons, clearly labeled.
- 1.85 COMMISSIONING
  - A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01 for Commissioning Requirements.
  - B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

# PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. Basis-of-design products: Fixtures indicated in the Fixture Schedule on the drawings are the basis of design of the project.
  - 1. Subject to compliance with requirements, provide the scheduled products. Unnamed products will only be considered and approved according to bidding and Contracting requirements and Division 01 requirements for substitutions.
- B. Subject to compliance with requirements, provide products by one of the following:
  - 1. LED drivers:
    - a. EldoLED
    - b. Lutron
    - c. Osram Sylvania
    - d. Philips/Advance
    - e. Universal Lighting Technologies
  - 2. Lamps:
    - a. General Electric
    - b. Osram Sylvania
    - c. Philips
    - d. Venture

## 2.11 CONCRETE

A. Concrete shall be 3,000 psi strength.

## 2.21 ELECTRICAL POLES AND STANDARDS

- A. Metal lighting poles and standards: Provide metal, raceway-type, lighting poles and standards, of sizes and types indicated, comprised of shafts and tenon joints. Equip with grounding connections readily accessible from handhole or transformer base access doors; and construct of the following materials and additional construction features:
  - 1. Material: Spun aluminum.
  - 2. Configuration: Anchor base type with hand hole and cover where indicated.
  - 3. Metal lighting standard accessories: Provide accessories including anchor bolts, as recommended by lighting standard manufacturer, of sizes and materials needed to meet erection and loading application requirements.

#### 2.23 EXTERIOR LIGHTING FIXTURES

A. Provide lighting fixtures of sizes, types, and ratings scheduled, complete with, but not limited to, housings, energy-efficient ballasts, starters, and wiring.

## 2.25 LED DRIVERS

- A. Driver shall operate from a 120-volt or 277-volt, 60-Hz input power source and be suitable for outputting power to 12-volt or 24-volt LED lamp sources, as required.
- B. Drivers, where specified, shall be capable of being dimmed. Dimmable drivers shall be controlled by a Class 2 low-voltage 0-10VDC controller.
- C. Performance criteria:
  - 1. Driver shall have a Class A sound rating.
  - 2. Driver shall have a power factor (PF) greater than 0.90.
  - 3. Driver shall have Total Harmonic Distortion (THD) of input current equal to or less than 20 percent.
- D. Driver shall meet FCC and Title 47 CFR regulations for EMI/RFI.
- E. Driver shall comply with ANSI C62.41 Class A requirements for transient protection.
- 2.26 LAMPS
  - A. Lamps, LED:
    - 1. The LED manufacturer shall provide the quantity and wattage of LEDs required to achieve the defined lighting output set forth by the lighting fixture manufacturer.
    - 2. LED lamps shall be integrated into an engineered package for the specific lighting fixture application, including heat dissipation components.
    - 3. Color temperature: As specified in lighting fixture schedule, with a tolerance of plus or minus 100K and within a range of three macadam ellipses. Noticeable color temperature variations between adjacent lighting fixtures shall be considered a failure to meet these specifications and shall be replaced at no cost to the Owner.
    - 4. Minimum performance characteristics:
      - a. Life: Minimum lumen maintenance of L70 at 50,000 hours, as defined by IES LM-80.
      - b. Lumen output: Based on absolute photometry, lumens (total luminous flux exiting the physical luminaire), as specified on contract drawings and schedules.
      - c. Color rendering index: Rated at 85 or higher.

# PART 3 - EXECUTION

## 3.20 INSTALLATION, GENERAL

A. Install poles, accessories, and fixtures as indicated, in accordance with manufacturer's written instructions, applicable requirements of NFPA 70, NESC and NEMA standards, and with recognized industry practices.

## 3.21 INSTALLING POLES

- A. Provide reinforced concrete bases as shown on the drawings Chamfer exposed edges of concrete. Grout base plates to concrete bases to provide proper leveling.
- B. Base size and depth shall be as indicated on the drawings.
- C. Use belt slings or rope, not chain or cable, to protect finishes when raising and setting finished poles and standards.
- D. Where poles and standards are indicated to be embedded in soil, set to depth required for adequate structural support, but not less than minimum 5 foot 6 inches below finish grade.
- E. Set poles and standards plumb. Support adequately during backfilling, or when anchoring them to the foundations.
- F. Provide sufficient space encompassing hand-access and cable-entrance holes for installation of underground cabling where indicated.
- G. Fasten electrical lighting fixtures and brackets securely to indicated structural supports, including poles/standards; and ensure that installed fixtures are plumb and level.
- H. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the National Electrical Code.

# 3.23 GROUNDING

- A. Provide equipment grounding connections for poles and standards as indicated, and in accordance with Section 260526, Grounding and Bonding. Tighten connections to comply with tightening torques specified in UL 486A.
- 3.60 FIELD QUALITY CONTROL
  - A. At the date of substantial completion, replace lamps in exterior lighting fixtures which are observed to be noticeably dimmed after Contractor's use and testing, as judged by the Architect.
- 3.70 ADJUSTING AND CLEANING
  - A. Aim adjustable lighting fixtures and lamps in night test of system. Verify that measured illuminance values comply with approved photometric diagram.
  - B. Clean lighting fixtures of dirt and debris upon completion of installation.
  - C. Protect installed fixtures from damage during construction period.
- 3.80 DEMONSTRATION

A. Upon completion of installation of exterior lighting fixtures, and associated electrical supply circuitry, apply electrical energy to circuitry to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

# **END OF SECTION**

# SECTION 27 00 00 - GENERAL COMMUNICATIONS PROVISIONS

### PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This Section includes the following:

Scope of Work.

- 1. Intent of Drawings.
- 2. Pre-Bid Site Visit.
- 3. Definitions.
- 4. General Standards of Materials.
- 5. Products and Substitutions.
- 6. Applicable Codes.
- 7. Guarantees and Certificates.
- 8. Quiet Operation and Vibration Control.
- 9. Temporary Shutdown of Existing Systems.
- 10. Coordination.
- 11. Shop Drawings, Product Data, and Samples.
- 12. Owner Instruction.

#### 1.3 SCOPE OF WORK

A. The scope of the work included under Division 27 of the specifications shall include complete systems as shown in the Contract Documents and specified herein. Any work reasonably inferable or required to result in a complete installation or the intended operation and performance of the systems, shall be included in the Base Bid except where there is specific reference to exclusion and incorporation in other quotations.

#### 1.4 INTENT OF DRAWINGS

- A. Provide complete and functional systems for the project. The systems shall conform to the details stated in the specifications and shown on the drawings. Items or work not shown or specified, but required for complete systems, shall be provided and conform with accepted trade practices. The drawings and specifications are presented to define specific system requirements and serve to expand on the primary contract requirements of providing complete systems. The drawings are diagrammatic and indicate the general arrangement and routing of the systems included in this contractors work.
- B. Do not scale the drawings. Because of the scale of the drawings, it is not possible to indicate offsets, fittings, valves, or similar items which may be required to provide complete operating

systems. Carefully investigate conditions affecting the work associated with this project. Check and verify dimensions and existing conditions at the site. Install systems in such a manner that interferences between pipes, conduit, ducts, equipment, architectural and structural features are avoided. Provide items required to meet the project conditions without additional cost to the owner.

- C. These documents may not explicitly disclose final details required for a complete systems installation; however, contractors shall possess the expertise to include the necessary appointments of complete operating systems.
- D. Contractors shall be "Experienced" (as defined in Division 1) in this type of construction and realize the extent of the work required.
- E. BICSI Certification of Workers
  - 1. The contractor will employ a minimum of one Registered Communications Distribution Designer (RCDD) certified by and in good standing with BICSI. This RCDD must be a direct full time employee of the contractor and the contractor will continue a minimum of one RCDD throughout the duration of the project. An RCDD shall remain assigned to the project from start to finish and be available to provide guidance to the installation team.
  - 2. Ortronics/Berk-Tek must be able extend a NetClear 25-year Static, Dynamic and Applications Warranty to the end user once the Telecommunications contractor fulfills all requirements under Ortronics and Berk-Tek OASIS Program. At least 30 percent of the copper installation and termination crew must be certified by Berk-Tek and Ortronics or by BICSI with a Technician Level of training.

## 1.5 PRE-BID SITE VISIT

A. Bidders shall visit the site and become completely familiar with existing conditions prior to submitting their bid. No extra charges shall be allowed as a result of existing conditions

## 1.6 DEFINITIONS

- A. Specific terminology, as used herein, shall have the following meanings:
  - 1. "Finished Space" ... Space other than mechanical rooms, electrical rooms, furred spaces, pipe chases, unheated spaces immediately below roof, space above ceilings, unexcavated spaces, crawl spaces, tunnels, and interstitial spaces.
  - 2. "Conditioned"...Spaces directly provided with heating and cooling.
  - 3. "Unconditioned"...Spaces without heating or cooling including ceiling plenums.
  - 4. "Indoors"...Located inside the exterior walls and roof of the building.
  - 5. "Outdoors"...Located outside the exterior walls and roof of the building.

## 1.7 GENERAL STANDARDS OF MATERIALS

A. Equipment and materials, unless otherwise noted, shall be new and of first quality, produced by manufacturers who have been regularly engaged in the manufacture of these products for a period of not less than five years.

- B. Equipment of one type shall be the products of one manufacturer; similar items of the same classification shall be identical, including equipment, assemblies, parts and components.
- C. Materials furnished shall be determined safe by a nationally recognized testing organization, such as Underwriters' Laboratories, Inc., or Factory Mutual Engineering Corporation, and materials shall be labeled, certified or listed by such organizations. Where third party certification is required for packaged equipment, the equipment shall bear the appropriate certification label.
- D. With respect to custom made equipment or related installations which are constructed specially for this project, the manufacturer shall certify the safety of same on the basis of test data. The Owner shall be furnished copies of such certificates.

## 1.8 PRODUCTS AND SUBSTITUTIONS

- A. Where a specific manufacturer's product is specified, the Contract Amount shall be based on that product only. Any substitutions from the specified product shall be offered as a Substitution Request. Refer to Division 1 for requirements. Substitutions shall not be permitted after the bidding phase without a Substitution Request Form included with the bid.
- B. Where several manufacturers' products are specified, the Contract Amount shall be based upon the specified products only. Any substitutions from the specified products shall be offered as a Substitution Request. Refer to Division 1 for requirements. Substitutions shall not be permitted after the bidding phase without a Substitution Request Form included with the bid.
- C. Where only one manufacturer's product is specified, the associated systems have been designed on the basis of that product. Where several manufacturers' products are specified, the associated systems have been designed on the basis of the first-named manufacturer's product. When products other than those used as the basis of design are provided, the contractor shall pay additional costs related to submissions review, redesign, and system and/or structure modifications required by the use of that product.
- D. It is the intent of these specifications that service organizations follow the above substitution procedures.

## 1.9 APPLICABLE CODES

- A. Materials furnished and work installed shall comply with applicable codes listed in Division 1, with the requirements of the local utility companies, and with the requirements of governmental departments or authorities having jurisdiction.
- 1.10 GUARANTEES AND CERTIFICATES
  - A. Defective equipment, materials or workmanship, including damage to the work provided under other divisions of this contract resulting from same, shall be replaced or repaired at no extra cost to the Owner for the duration of the stipulated guarantee periods.
    - 1. Unless specifically indicated otherwise, the duration of the guarantee period shall be one (1) year following the date of Substantial Completion. Temporary operation of the equipment for temporary conditioning, testing, etc., prior to occupancy will not be considered part of the warranty period.

## 1.11 QUIET OPERATION AND VIBRATION CONTROL

- A. Equipment and associated items shall operate under conditions of load without sound or vibration deemed objectionable by the Architect. In the case of moving equipment, sound or vibration noticeable outside of the room in which it is installed, or noticeable within the room in which it is installed, shall be deemed objectionable. Sound or vibration deemed objectionable shall be corrected in an approved manner at no extra cost to the Owner. Vibration control shall be provided by means of approved vibration isolators and installed in accordance with the isolator manufacturer's recommendations.
- B. The sound pressure levels around mechanical and electrical equipment (fans, pumps, motors, etc.) in equipment spaces shall not exceed 85 dBA at any point three (3) feet from the equipment, with all equipment in the room operating. The sound criteria applies to the complete range of each piece of equipment.

### 1.12 TEMPORARY SHUTDOWN OF EXISTING SYSTEMS

- A. Plan installation of new work and connections to existing work to insure minimum interference with regular operation of existing systems. Some temporary shutdown of existing systems may be required to complete the work.
- B. Submit to the Owner in writing for approval, proposed date schedule, time, and duration of necessary temporary shutdowns of existing systems. Submit schedule at least fifteen (15) calendar days in advance of intended shutdown. Shutdowns shall be made at such times as shall not interfere with regular operation of existing facilities and only after written approval of Owner. The Owner reserves the right to cancel shutdowns at any time prior to the shutdowns. To insure continuous operation, make necessary temporary connections between new and existing work. Bear costs resulting from temporary shutdowns and temporary connections. No additional charges shall be allowed for Owner-canceled shutdowns that must be rescheduled.
- C. Shutdowns must be performed by the Owner. Do not shut-down any system. The Owner reserves the right to require a walk-through of any shutdown prior to the shutdown. Following electrical shutdowns, verify that affected motors are rotating in the proper direction. Bear costs associated with reverse rotated motors.

### 1.13 COORDINATION

- A. Coordinate and furnish in writing to the Architect information necessary to permit the work to be installed satisfactorily and with the least possible interference or delay.
- B. <u>Coordination drawings shall be prepared as defined in Division 1. No installation of permanent</u> systems shall proceed until the coordination drawings are reviewed by the Architect. No extra charges shall be allowed for changes required to accommodate installation of systems provided under other divisions of this contract.
- C. Coordination drawings shall be developed from individual system shop drawings and contractor fabrication drawings. Electronic or other reproduced engineering design drawings used as coordination drawings are not acceptable.
- D. When work is installed without proper coordination, changes to this work deemed necessary by the Architect shall be made to correct the conditions without extra cost to the Owner.

E. The value of the coordination drawings shall be identified as a line item in the Schedule of Values. If the coordination drawings are not submitted as required, their value shall credited to Owner in accordance with the provisions of Article 7 of the General Conditions. The value of coordination drawings shall be a minimum of two (2.0) percent of this Contract Amount.

# 1.14 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

- A. Shop drawings, product data, and samples shall be submitted in accordance with the provisions of Division 1.
- B. The following shall be submitted by the Contractor for review:
  - 1. Scale shop drawings showing system components with sizing indicated, including but not limited to:
    - a. equipment locations
    - b. raceways
    - c. insert and sleeve locations
    - d. hangers, anchors and guides
    - e. expansion joints
    - f. access doors
  - 2. Product data for system components and materials (including construction standards).
  - 3. Samples of finishes and trim exposed to view, such as fixture trim, escutcheon plates and similar items.
- C. The value of shop drawings, product data and samples shall be identified as a line item in the Schedule of Values. If the shop drawings, product data and samples are not submitted as required, their value shall credited to Owner in accordance with the provisions of Article 7 of the General Conditions. The value of these items shall be a minimum of one (1.0) percent of this Contract Amount.

# 1.15 OWNER INSTRUCTION

- A. After final tests and adjustments have been completed, furnish the services of qualified personnel to instruct representatives of the Owner in the operation and maintenance procedures for equipment and systems installed as part of this project. Operation and maintenance instructions for major items of equipment shall be directly supervised by the equipment manufacturer's representative. Supply qualified personnel to operate equipment for sufficient length of time as required to meet governing authorities' operation and performance tests and as required to assure that the Owner's representatives are properly qualified to take over operation and maintenance procedures. Minimum instruction period shall be 20 man hours. The instruction period shall be broken into segments at the discretion of the Owner.
  - 1. Notify the Architect, the Owner's representative and equipment manufacturers' representatives, by letter, as to the time and date of operating and maintenance instruction periods approved by the Owner at least one (1) week prior to conducting same.
  - 2. Forward to the Architect the signatures of all those present for the instruction periods.

# PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

# END OF SECTION

# SECTION 27 05 00 - COMMON WORK FOR COMMUCATIONS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

### A. Section Includes:

- 1. Communications equipment coordination and installation.
- 2. Common communications installation requirements.
- 3. Demolition
- 4. Waterproofing.
- 5. Weatherproofing locations.
- 6. Cutting and Patching.
- 7. Painting.
- 8. Equipment Foundations, Supports, Piers and Attachments.
- 9. Equipment Guards and Rails.
- 10. Cleaning, Protecting and Adjusting.
- 11. Welding.
- 12. Sleeves for raceways and cables.
- 13. Sleeve seals.
- 14. Grout.

### 1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.
- C. Wiring: Cable and/or wire installed in Raceway.

## 1.4 SUBMITTALS

A. Product Data: For sleeve seals.

### 1.5 WATERPROOFING

A. Where work pierces waterproofing, including waterproof concrete, the method of installation shall be approved by the Architect prior to performing the work. Furnish necessary sleeves, caulking and flashing required to make openings absolutely watertight.

## 1.6 WEATHERPROOFING LOCATIONS (WP)

- A. Communication apparatus, such as outlet boxes, switches, connection panels, speakers, cameras, and other devices shall be weatherproof gasketed type, NEMA Types 3 or 4 in the following instances:
  - 1. On surface of exterior face of building, including areas where not under canopies, cast boxes with threaded hubs must be used and under canopies steel boxes with gasket connections to devices.
  - 2. In any areas where specifically noted "WP" or required by the NEC or Regulations mentioned herein.
  - 3. Within air conditioning enclosures.
  - 4. In underground splice boxes.
  - 5. On building roof.
  - 6. Within vivarium locations.
  - 7. In unconditioned spaces subject to exterior ambient conditions such as loading docks and parking garages.

## 1.7 CUTTING AND PATCHING

- A. Provide cutting and patching necessary to install the work specified herein. Patching shall match adjacent surfaces. Refer to Division 1, Cutting and Patching for specific directions.
- B. No structural members shall be cut without prior approval of the Architect; such cutting shall be done in a manner directed by him.
- C. Provide ceiling removal and replacement where work above ceilings is required. Replace ceiling components damaged in the process.
- D. Provide patching where communications devices are removed from walls, ceilings or floors.

## 1.8 ACCESSIBILITY

- A. Coordinate to ensure the sufficiency of the size of shafts, and chases, and the adequacy of clearances in hung ceilings and other areas required for the proper installation of this work.
- B. Locate equipment which must be serviced, operated or maintained in fully accessible positions. Locations in ceilings requiring access shall be coordinated with, but not limited to lights, curtain tracks, and speakers. Equipment requiring access shall include, but is not necessarily limited to, motors, junction boxes, fire dampers, controllers, switchgear, etc.

- C. Indicate the locations of access doors for each concealed device, concealed behind finished construction and requiring service on the coordination drawings. Equipment below floor slab or finished grade shall also be indicated on the coordination drawings.
- D. Furnish access doors under this division for installation by General Contractor. Coordinate during bidding phase with General Contractor. Locations of access doors in finished construction shall be submitted in sufficient time to be installed in the normal course of the work.
  - 1. Manufacturers: Subject to compliance with requirements, furnish access doors by one of the following:
    - a. Bar-Co., Inc.
    - b. J. L. Industries
    - c. Karp Associates, Inc.
    - d. Nystrom, Inc.
  - 2. Materials and Fabrication:
    - a. General: Furnish each access door assembly manufactured as an integral unit, complete with all parts and ready for installation.
    - b. Steel Access Doors and Frames: Fabricate units of continuous welded steel construction, unless otherwise indicated. Grind welds smooth and flush with adjacent surfaces. Furnish attachment devices and fasteners of type required to secure access panels to types of support shown.
    - c. Frames: Fabricate from 16-gauge steel.
      - 1) Fabricate frame with exposed flange nominal 1 inch wide around perimeter of frame for units installed in the following construction:
        - a) Exposed Masonry
      - 2) For gypsum drywall or veneer gypsum plaster, furnish perforated frames with drywall bead.
      - 3) For installation in masonry construction, furnish frames with adjustable metal masonry anchors.
      - 4) For full-bed plaster applications, furnish frames with galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.
    - d. Flush Panel Doors: Fabricate from not less than 14-gauge sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175°. Finish with manufacturer's factory-applied prime paint.
      - 1) For fire-rated units, provide manufacturer's standard insulated flush panel/doors, with continuous piano hinge and self-closing mechanism.
    - e. Locking Devices: Furnish flush, screwdriver-operated cam locks of number required to hold door in flush, smooth plane when closed.

## 1.9 PAINTING

- A. Painting requirements of this section shall conform to Division 9.
- B. Provide surface preparation, priming, and final coat application in strict accordance with manufacturer's recommendations.
- C. Provide prime coat painting for the following:
  - 1. Indoor miscellaneous steel and iron provided under this Division of the specifications.
  - 2. Indoor hangers and supports provided under this Division of the specifications.

## 1.10 EQUIPMENT FOUNDATIONS, SUPPORTS, PIERS AND ATTACHMENTS

- A. Provide necessary foundations, auxiliary steel, supports, pads, bases and piers required for equipment specified in this division; submit drawings in accordance with Shop Drawing Submittal requirements prior to the purchase, fabrication or construction of same.
- B. Construction of foundations, supports, and pads where mounted on the floor, shall be of the same materials and same quality of finish as the adjacent and surrounding floor material.
- C. Equipment shall be securely attached to the building structure in an approved manner. Attachments shall be of a strong and durable nature and any attachments that are, in the opinion of the Architect, not strong enough shall be replaced as directed, with no additional cost to the Owner.

# 1.11 CLEANING, PROTECTING AND ADJUSTING

- A. Cleaning
  - 1. General cleaning requirements are specified in Division 1.
  - 2. Upon completion of the work, clean the exterior surface of equipment, accessories, and trim installed. Clean, polish, and leave equipment, accessories, and trim in first-class condition.
- B. Protection of Surfaces
  - 1. Protect new and existing surfaces from damage during the construction period.
  - 2. Provide plywood or similar material under equipment or materials stored on floors or roofs. Provide protection in areas where construction may damage surfaces.
  - 3. Surfaces damaged during the construction shall be repaired or replaced at the cost of the Contractor at fault. The method or repairing or replacing the surface shall be approved by the Owner and Architect.
- C. Protection of Services
  - 1. Protect new and existing services from damage during the construction period.

- 2. Repair, replace, and maintain in service any new or existing utilities, facilities, or services (underground, overground, interior, or exterior) damaged, broken, or otherwise rendered inoperative during the course of construction.
- 3. Services damaged during the construction shall be replaced at the cost of the Contractor at fault. The method used in repairing, replacing, or maintain the services shall be approved by the Owner and Architect.
- D. Protection of Equipment and Materials
  - 1. Equipment and materials shall be stored in a manner that shall maintain an orderly, clean appearance. If stored on-site in open or unprotected areas, equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.
  - 2. Equipment and material, if left unprotected and damaged, shall be repainted or otherwise refurbished at the discretion of the Owner. Equipment and material is subject to rejection and replacement if, in the opinion of the Architect or the manufacturer's engineering department, the equipment has deteriorated or been damaged to the extent that its immediate use or performance is questionable, or that its normal life expectancy has been curtailed.
  - 3. During the construction period, protect equipment from damage and dirt.
- E. Adjusting
  - 1. After the entire installation has been completed, make required adjustments to all systems until performance requirements are met.

## 1.12 SPECIAL TOOLS

A. Provide the Owner's representative with two (2) sets of special tools required for operation and maintenance of equipment provided.

## 1.13 WELDING

- A. General Requirements
  - 1. This paragraph covers the welding of systems. Deviations from applicable codes, approved procedures and approved shop drawings shall not be permitted. Materials or components with welds made off the site shall not be accepted if the welding does not conform to the requirements of this specification. Develop and qualify procedures for welding metals included in the work. Certification testing shall be performed by an approved independent testing laboratory. Bear costs of such testing.
  - 2. Certified welders, previously certified by test, may be accepted for the work without recertification provided that all of the following conditions are fulfilled:
    - a. Submit copies of welder certification test records in accordance with this Division and Division 1 requirements.
    - b. Testing was performed by an independent testing laboratory.
    - c. The welding procedures and welders are certified in accordance with the "ASME Boiler and Pressure Vessel Code," and base materials, filler materials, electrodes,

equipment, and processes conform to the applicable requirements of this specification.

- d. Certification has been within a one (1) year period from the start of the project.
- 3. Filler metals, electrodes, fluxes and other welding materials shall be delivered to the site in manufacturers' original packages and stored in a dry space until used. Packages shall be properly labeled and designed to give maximum protection from moisture and to assure safe handling.
- 4. Submit welding certificates for review. Each welder assigned to work covered by this specification shall be certified by performance tests using equipment, positions, procedures, base metals, and electrodes or bare filler wires.
- 5. Before assigning welders to the work, provide the architect with their names, together with certification that each individual is certified as specified. No welding work shall start prior to submissions. The certification shall state the type of welding and positions for which each is certified, the code and procedure under which each is certified, date certified, and the firm and individual certifying the certified tests.
- 6. Each welder shall be assigned an identifying number, letter, or symbol that shall be used to identify his welds. A list of the welders' names and symbol for each shall be submitted. To identify welds, either written records indicating the location of welds made by each welder shall be submitted, or each welder shall apply his mark adjacent to his weld using an approved rubber stamp or felt-tipped marker with permanent, weatherproof ink or other approved methods that do not deform the metal. For seam welds, identification marks shall be placed adjacent to the welds at 3 foot intervals. Identification by die stamps or electric etchers shall be confined to the weld reinforcing crown, preferably in the finished crater.

# PART 2 - PRODUCTS

# 2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
  - 1. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
    - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

### 2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Advance Products & Systems, Inc.
    - b. Calpico, Inc.
    - c. Metraflex Co.
    - d. Pipeline Seal and Insulator, Inc.
  - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - 3. Pressure Plates: Stainless steel. Include two for each sealing element.
  - 4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

## 2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

# PART 3 - EXECUTION

## 3.1 COMMON REQUIREMENTS FOR COMMUNICATIONS INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Coordinate piping systems installed at a required slope.
- F. Apply for detailed and specific information regarding the location of equipment as the final location may differ from that indicated on the drawings. Outlets, equipment or wiring improperly placed because of failure to obtain this information shall be relocated and re-installed without additional expense to the Owner. Determine the actual direction of door

swings, so that local switches and other controls shall be installed at the lockside of doors, unless otherwise noted. Improperly located switches shall be relocated without additional expense to the Owner.

- G. The design shall be subject to such revisions as may be necessary to overcome building obstructions. No changes shall be made in location of outlets or equipment without written consent of the Architect and Owner.
- H. Unless otherwise mentioned or indicated, mounting heights of outlets are shown on the drawings or in the specification. Dimensions given shall be considered to be from center of outlet to finished floor.
- I. Coordinate the location and elevation of all communications devices and fixtures with the architectural interior elevation plan and reflective ceiling plan prior to installation.
- J. Properly rough in for the communications raceways and equipment under this contract and modify as required for coordination during the construction period.
- K. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- L. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- M. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

## 3.2 WELDING

- A. Perform welding in accordance with qualified procedures using certified welders. Welding shall not be done when the quality of the completed weld could be impaired by the prevailing working or weather conditions. Welding of hangers, supports, and plates to structural members shall conform to AWS specifications.
- B. Field bevels and shop bevels shall be by mechanical means or by flame cutting. Where beveling is by flame cutting, thoroughly clean surfaces of scale and oxidation just prior to welding. Beveling shall conform to ANSI B31.1 and AWS B3.0.
- C. Replace and reinspect defective welds. Repairing defective welds by adding weld material over the defect or by peening shall not be permitted. Welders responsible for defective welds must be re-certified.
- D. Store electrodes in a dry heated area, keep free of moisture and dampness during fabrication operations. Discard electrodes that have lost part of their coating.

### 3.3 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Communications penetrations occur when raceways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, fire-rated floor, or wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry
  - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- J. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- K. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- L. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

## 3.4 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve

seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

## 3.5 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 firestopping section.

### 3.6 DUST, DIRT AND NOISE

- A. Carry out new work and make changes, relocations, and installations with a minimum of noise. Site areas and new equipment, floors and walls, shall be adequately protected from dust and dirt caused by the work. Protection shall include suitable temporary barriers or coverings. The exterior and interior premises of each building shall be kept clean as possible during construction. Damages to surfaces or equipment as a result of negligence shall be replaced or corrected as required.
- B. School activities may be under way during much of the construction period. It is imperative that school functions and activities are given priority and the highest level of respect. Contractor functions which may be excessively noisy or disruptive shall be scheduled for times when school functions will not be interrupted or disturbed.

### 3.7 ENVIRONMENTAL AIR PLENUMS

A. In spaces over hung ceiling which are used for environmental air handling purposes as defined by Article 300.22C of the National Electric Code, power data and communications cable must be in conduit or of the type cable rated for air plenum use. Cable type and/or raceway is generally indicated on the drawings and specifications although the Contractor shall be responsible to clearly define ceiling space used for environmental air purposes.

## 3.8 SPECIAL ENGINEERING SERVICES

A. In the instance of complex or specialized telecommunications, security, and audiovisual systems that are included in Division 27; the installation, final connections, and testing of such systems shall be made under the direct supervision of competent authorized service engineers who shall be in the employ of the respective equipment manufacturer. Provide the Owner with copies of instruction manuals and booklets for each system and piece of equipment installed. Provide any additional instruction to the Owner over and above the listed above in the care, adjustment, and operation of all parts of the communications systems.

# **END OF SECTION**

# SECTION 27 15 00 - DATA, VOICE AND VIDEO SYSTEMS

## PART 1 - GENERAL

- 1.1 Related Documents:
  - A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

## 1.2 Scope

- A. Provide a complete system of wired voice and data outlets, suitable for distribution and utilization of signals from the Baltimore County Public Schools supplied telephone systems, computer data networks and Cable Television
- B. The data network wiring shall be suitable for a minimum 1000 Mega-Bits per second (Mb/s) data network.
- C. The Data and Voice Structured Cabling and Outlet System shall include, but is not necessarily limited to:
  - 1. Category 6 Unshielded Twisted Pair (UTP) Data Cable
  - 2. Category 6 Unshielded Twisted Pair (UTP) Voice (Telephone) Cable
  - 3. Workstation Jacks
  - 4. Workstation Multi-Jack Outlets
  - 5. Wall mounted swing patch panel racks or stand-alone data cabinets
  - 6. Type 110 Wiring Punchblocks for voice cables
  - 7. Category 6 Patch Panels for data cables 48 port patch panels shall be used
  - 8. Complete system testing in accordance with accepted industry standard test means and methods

## 1.3 STANDARDS:

- A. Voice and data outlets, wiring and associated work shall be in strict accordance with the requirements of the Baltimore County Public Schools Department of Technology.
- B. Cable television outlets, wiring and associated work shall be in strict accordance with the requirements of Comcast and Verizon cable TV standard and coordinated with Physical Facilities.

## 1.4 COLOR CODING:

A. All cabling, jacks, inserts and other system components shall be color coded to identify data versus voice (telephone) facilities. Color codes shall be as specified below, in accordance with the standards set by the Baltimore County Public Schools Department of Technology.

## B. Color coding:

1.	Data Wiring and Jacks:	Blue
2.	Wireless access point cabling:	Purple/Violet
3.	Voice (Telephone) wiring and jacks:	Gray
4.	Fiber optics – multi mode (OM3):	Orange
5.	Fiber optics – single mode:	Yellow
6.	Cable TV:	Black
7.	Emergency/alarm wiring:	Red

## 1.5 SYSTEM DESCRIPTION:

- A. System includes provision of combination data and/or voice single or multi-jack outlets at locations and in configurations indicated on the drawings, with station cables from each jack to the appropriate termination as specified herein.
- B. Typical workstation outlet configurations shall be as indicated in the Schedule of Telecommunications Outlets on the drawings. Where both voice and data jacks are indicated to be provided in the same outlet, the voice jack shall be located at the upper left position.
- C. Wall mounted telephone outlets shall be provided with a single, flush mounted RJ-45 modular wiring jack mounted in a stainless steel wall plate with wall telephone instrument mounting lugs.
- D. Outlets designated on the plans for pay phones shall consist of a single gang coverplate with single 3/8" diameter bushed hole. Coil 24" slack station cable within outlet box for direct connection to pay telephone instrument by the telephone supplier.

## 1.6 SUBMITTALS:

- A. General: Submit the following according to Division 26 Specification Sections.
- B. Product Data and Shop Drawings: Submit these items, and the Certifications specified below, as a complete package. Submittal will not be reviewed if it is incomplete.
  - 1. A complete schedule of equipment and materials that are to be furnished for the work. Accompanying the schedule shall be manufacturer's specifications or cut sheets for each major component. Original specification sheets or clear copies of same shall be submitted on all items. Manufacturers name, make and model number shall appear on each sheet. Submittals shall be bound in booklet form with cover sheet and index, and presented in a neat and logical order in a binder. Submittals shall contain installation, operation and programming manuals of the system to provide the Owner and Engineer complete information as to system features, functions and capabilities.

- 2. Complete drawings of equipment racks and special assemblies. Each drawing shall show all equipment with its manufacturer and model number.
- 3. Complete drawings detailing installation locations of equipment, cable quantities and types with terminal block or patch panel locations. Submit Shop Drawings of each proposed system indicating the proposed system configuration and all specified requirements. Shop Drawing shall indicate proposed cable routing, detail installation locations of equipment, cable quantities, cable types, and terminal block locations. All Shop Drawings shall be Contractor's original drawings. Submission of Engineer's Contract Drawings as Shop Drawings is not permitted. Clear and detailed sets of floor plans for the complete building shall be furnished showing the locations of all equipment and devices and their required interconnections. The interconnections shown shall indicate the number, size, and type of wires as described in this Specification. The layout of all telecommunications system equipment, devices, and conduit routings shall closely follow that shown on the Drawings.
- 4. Certification reports for all data wiring run shall be emailed to gvukov@bcps.org, in Fluke Linkware format, or cvs for import into Baltimore County Public Schools DOT Information Services tracking system.
- 5. Submit dimensional outline drawing of systems control cabinet(s) and racks showing relative position and size of all major components and equipment involving dimensions, elevations, and terminations. Each drawing shall indicate all equipment with its manufacturer and model number shown.
- 6. Submit wiring diagrams showing typical connections for all systems and equipment. Include detailed one-line drawings of each system. Each system drawing shall show proposed circuit numbers for all cables and terminal connections. Provide typical wiring termination details for all devices.
- 7. The Contractor shall submit a certificate with the RCDD signature, registration number, and seal verifying the completeness and accuracy of the design and installation. All distribution designs shall be submitted with the RCDD signature, registration number, and seal.
- C. Provide Operation and Maintenance Manuals, as specified in Division 1 and Division 26, for work specified in this Section. Include complete service information, including schematics, prints of the Special System Drawings, interconnecting diagrams for this particular project, and parts lists to permit quick and efficient maintenance and repair of the equipment by a qualified technician. Provide a separate binder with copies of all system test reports.
- D. A schedule/count of data, phone, wireless, and other low voltage cabling/jacks for each closet must be submitted after the bids are issued so that a proper network design can be performed. This information is required so that the correct number of network switches can be designed and ordered for the project. This information must be provided to the BCPS Network Support Services Manager, or designee.

## 1.7 QUALITY ASSURANCE

- A. Installer Qualifications:
  - 1. The installing contractor shall submit proof of having installed at least six (6) similar Data And Voice Structured Cabling And Outlet Systems. These systems shall have been in service for a minimum of three (3) years. These systems must have been within a fifty (50) mile radius of the project location. Included with this proof shall be the customer name, customer contact and telephone number, and, if applicable, the architect and electrical engineer on the project. The Architect and Owner retain the right to reject any installing contractor who, in their sole judgment, has not met the above criteria or has received a less than favorable reference from any of the submitted references OR from any other customer for which the installing contractor has performed similar installations, whether or not such customer has been listed on the submittal.
  - 2. In order to assure full compliance with all codes and regulations, the installing contractor must have on its regular staff a Master Electrician licensed within the jurisdiction in which the installation occurs. Proof of such licensing must be included with the original submittal.
  - 3. The Contractor shall make application for all necessary permits, licenses and inspections as required by the Authority Having Jurisdiction, and shall pay all fees and charges appurtenant thereto.
  - 4. The installing contractor must be certified by the manufacturer of the Cabling System being proposed for installation. Proof of such certification must be included with the original submittal.
- B. Manufacturer Qualifications: Materials proposed for use on this project shall be provided by a manufacturer experienced in manufacturing components listed and labeled under EIA/TIA-568A and who comply with these Specifications.
- C. Comply with NFPA 70, "National Electrical Code."
- D. Comply with the latest editions of following industry standards:
  - 1. ANSI/EIA/TIA 568A Commercial Building Telecommunications Cable Standard
  - 2. EIA/TIA 569A Commercial Building Standard for Telecommunications Pathways and Spaces
  - 3. EIA/TIA 606 Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings
  - 4. EIA/TIA 607 Commercial Building Grounding and Bonding Requirements for Telecommunications
  - 5. ANSI X3T9.5 Fast Ethernet 100Base-T LAN (FDDI): Defines standard for 100 Mb/s LAN based on either optical fiber cable or Unshielded Twisted Pair (UTP).
  - 6) ANSI/BICSI 001-2009 Information Transport Systems Design Standard for K-12 Educational Institutions

E. Nationally Recognized Testing Laboratory (NRTL) Listing: System components of types and ratings for which NRTL listing or labeling service is established and components shall be listed and labeled.

F. Maryland State Department of Education Standards for Telecommunications Distribution – current version

## 1.8 WARRANTY

- A. Special Warranty Requirements:
  - 1. The proposed Systems will be covered by a two part certification program provided by a single manufacturer and that manufacturer's certified vendor. Manufacturer shall administer a follow-on program through the Vendor to provide support and service to the purchaser.
  - 2. The first part is an assurance program which provides that the certified system will support the applications for which it is designed, during the 15 year warrantee of the certified system.
  - 3. The second portion of the certification is a fifteen-year warranty provided by the manufacturer and the vendor on all products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, etc.).
  - 4. In the event that the certified system ceases to support the certified application(s), whether at the time of cut-over, during normal use or when upgrading (e.g. ATM), the manufacturer and vendor shall commit to promptly implement corrective action.

# PART 2 - PRODUCTS

# 2.1 VOICE / DATA TWISTED PAIR CABLES, CONNECTORS, AND TERMINAL EQUIPMENT

- A. Voice / Data Horizontal wiring: all horizontal cabling within the building will be CAT6 UTP Plenum solid conductor. Voice / Data cable shall be Hubbell NextSpeed C6 Cable or approved equal.
- B. Station cables for data jacks shall be four (4) pair Category 6 unshielded twisted pair (UTP), plenum-rated solid conductor cable conforming to the ANSI/TIA/EIA-568-B.2 Category 6 component specifications standards. Cable frequency capability shall be 250 MHz or greater (typically up to 500MHZ) and shall exceed IEEE 802.3ab and IEEE 802.3af. Extend two station cables from each jack to the location indicated in the Schedule of Telecommunications Outlets on the drawings, and terminate on Category 6 patch panel. Installation design and routing must ensure that a total length of cable is less then 90 meters.
- C.. Station cables for voice jacks shall be four (4) pair Category 6 unshielded twisted pair (UTP), plenum-rated solid conductor cable conforming to the ANSI/TIA/EIA-568-B.2 Category 6 component specifications standards. Cable frequency capability shall be 250 MHz or greater and shall exceed IEEE 802.3ab and IEEE 802.3af. Extend one station cable from each jack to the location indicated on the drawings, and terminate on CAT6 Patch Panels. Only Voice backbone

cable shall terminate on type 110 punchblocks. Neatly wrap all unterminated pairs at fax, modem, pay phone and similar outlets around the outer cable sheath for future use.

- D. UTP Cable Connecting Hardware: Comply with EIA/TIA-568A, TSB 40. Insulation displacement connector (IDC) type, using modules designed for use with punch-down caps or tools.
  - 1. IDC Terminal Block Modules: Integral with connector bodies, including plugs and jacks where indicated.
  - 2. IDC Connecting Hardware: Consistent throughout Project.
- E. Jacks and Jack Assemblies for UTP Cable: Modular, color-coded, RJ-45 receptacle units with integral IDC-type terminals.
- F. Workstation Outlets: Multiple jack/connector assembly mounted in a single gang faceplate.
  - 1. Faceplate: High-impact modular white or ivory ABS plastic.
  - 2. Mounting: Semi-flush, except as otherwise indicated. All unused mounting spaces shall be equipped with a blank insert. Blank modules shall be Hubbell SFB10, or approved equal.
  - 3. Legend: Provide jacks in color corresponding to those specified above under "Color Codes." Label jacks, "Voice" or "Data" as appropriate to use. Provide facilities for insertion of machine printed jack identification label behind clear plastic cover. Install machine printed labels at each jack location.
  - 4. Category 6 outlets shall be Hubbell IFP14OW faceplate, and Hubbell HXJ6OR NEXTSPEED 6 System modular jacks, or approved equal.
- F. Voice/Data Patch Cords.
  - 1. Provide Category 6 Modular Patch Cords for each voice/data assigned port on the patch panel.
  - 2. Category 6 patch cords shall be Hubbell NEXTSPEED 6 System, or approved equal.
  - 3. Provide factory assembled enhanced Category 6 patch cables (350 MHz) to connect the computer workstations to the network outlets and to patch the network switches to the patch panel. All patch cables shall have built-in strain relief and be blue in color. Total patch cords supplied to be equal to twice the number of network outlets. One-fourth to be ten (10) feet long, one-fourth to be seven (7) feet long, one-fourth to be five (5) long and one-fourth to be three (3) feet long. In addition, the successful bidder shall provide forty (40) white patch cords; twenty to be five (5) feet long and twenty to be three (3) feet long.
  - 4. Provide factory assembled enhanced Category 6 patch cables (350 MHz) to connect telephones to network outlets. These shall be ten (10) feet long and white in color. The quantity should be equal to the number of installed telephone outlets plus 20%. In addition, the successful bidder will provide an equal number of red factory assembled enhanced Category 6 patch cables (350 MHz) to patch telephone connections in wiring closets. Half of the red cables to be five (5) feet long and half to be seven (7) feet long.
- G. Termination of station cables at voice and data jacks shall be in accordance with EIA/TIA 568A, Designation T568B for Category 6 cable. Verify jack termination scheme with Baltimore County Public Schools Department of InformationTechnology (contact Network Support Services Manager, at 443-809-3858) prior to termination.

H. Wireless data drops – all locations calling for wireless access point cabling/jacks must have two drops installed per location. All cables must be home run to the nearest wiring closet on the same floor as the drop. At a minimum wireless access point drops should be installed in every classroom, offices, conference rooms, cafeteria, library, auditorium, gym (mounted at least 8 feet above finished floor – 2 minimum per gym – one on each side of the gym), and in every hallway spaced approximately 80 feet between each drop, and must follow the color coding indicated above. Outdoor wireless locations must be wired to using exterior rated CAT6 cabling. A minimum of one access point location (two CAT6 drops minimum) at the front outside of the building, one or more to provide coverage to all parking lots and bus loops at the building, and one or two locations facing playgrounds, stadiums, and other outdoor areas where teachers and students may wish to use laptops/tablets/etc. for educational purposes.

## 2.2 DATA PATCH PANELS:

- A. All data station cables shall be terminated in Category 6 patch panels.
- B. Patch Panels shall be 48 port, Category 6. Modular patch panels shall be Hubbell NEXTSPEED 6 System, or approved equal.
- C. Data Patch Panels shall be modular panel mounting multiple, numbered jack units with connectors of the IDC type at each jack to provide permanent termination of conductor pair groups of installed cables. Patch Panels shall be Category 6 48 port as required to provide the necessary number of ports for the installation plus at least 20% spare ports (minimum fifteen (15) empty ports) for future expansion.
- D. Mounting: Mount in equipment cabinets, with vertical and horizontal cable management brackets, as specified below.
- E. Appropriate number of patch cables must be supplied to allow all jacks, including wireless and data, to be patched down to BCPS supplied network switches and stations. Patch cables for the connection from patch panel to network switch are to be 7 feet; patch cables for connection from station jack to end device are to be 14 feet, all CAT6 and provided by the low voltage contractor.

# 2.3 VOICE BACKBONE CABLES AND TERMINATION PUNCHBLOCKS

- A. Voice backbone cables shall be Hitachi 39053-50, Berk-Tek power sum Cable Part Number 530354, Helix/Hi-Temp Super CAT100E Number 803308, or approved equal.
- B. Terminate voice backbone cables on type 110 punchblocks. Voice Termination Punchblocks shall be AT&T 110-300 or approved equal. Provide a sufficient quantity of the required 110 type hardware to terminate all voice backbone cables being installed under this contract. Provide all required stand-off brackets, D-Rings, and cable dressing hardware to provide, a neat and workmanlike installation.

## 2.4 FIBER OPTIC SYSTEM CABLING AND TERMINATONS:

- A. Backbone :All wiring closets (IDF) will be interconnected to the main Data/Telco Equipment room (MDF) by 24 strand multi-mode fiber optic cable (OM3 50/125 micron) and 24 strand single-mode (9/125 micron) terminating into the enclosures marked "Wiring". Fiber optic cables shall be Amp/Pirelli, Berk-Tek or approved equal.
- B. All fibers shall terminate into rack mounted enclosures marked "Wiring", with "LC" connector fiber patch panels.
  - 1. Furnish and install rack-mounted fiber optic cable distribution enclosures at all Telecommunications Rooms (MDF and IDF Room locations). Capacity shall be as required to terminate all strands of fiber.
  - 2. Provide strain relief for fiber optic cabling system.
  - 3. The Fiber Optic Distribution Enclosure (FODE) shall be Hubbell FCR350SP36R and FCR525SPR rack mount enclosures with Hubbell FSP adapter plates.
  - 4. The Fiber Optic Distribution Enclosure (FODE) shall have connector panels that snap into the side of the module and accommodate SC connectors.
- C. Fiber Optic Connectors shall be LC type. Fiber optic connectors shall be Hubbell 2Quick LC, or approved equal.
- D. Fiber Optic Patch Cords shall be provided for each fiber terminated. Fiber patch cords shall be Hubbell OptiChannel LC type paired cords patch cords or approved equal. Fiber patch cord shall each by 3 meters in length.

## 2.5 EQUIPMENT RACKS/CABINETS:

- A. Wiring Closets and Main Data Room:
  - 1. Equipment racks shall provide EIA standard mounting provisions, with pre-drilled, pretapped holes to accommodate industry standard 19" patch panels and rack mounted equipment.
  - 2. For wall enclosure mounting: provide an APC AR100 or approved equal, 13 rack unit enclosure, fully enclosed with hinged, locking, safety glass front door, black, and hinged locking rear door. Rack shall include 120 volt, 100 cfm ventilation fan. Locate where indicated on drawings. (Must be pre-approved prior to use within building Use #3 below as a standard.)
  - 3. For floor enclosure mounting: provide an Middle Atlantic ERK-4425 (enclosure for servers/switches) or approved equal, 42 44 rack unit enclosure, complete with all front and side panels, and all required accessories. Rack shall include 120 volt, 100 cfm ventilation fan. Or Middle Atlantic RL10-45 or approved equal 2 post racks for patch panels. Locate where indicated on drawings.
  - 4. Provide complete horizontal and vertical cable management facilities in each rack. Vertical wire management shall be Hubbell VC76H, and horizontal wire management Hubbell HC219ME3N or approve equals. Each IDF shall be connected to the MDF. Provide a minimum of four (4) rows of 5Ccount split front "D" ring horizontal cable

management panels per rack. Provide power outlet strips in the equipment racks as shown on the Drawings. Power Outlet surge strip shall be Wiremold Part Number JT06B2B or approved equal.

5. Provide APC NET9RMBLK 120 volt power strip with minimum 9 NEMA 5-15R plug-in ports, within cabinet, as appropriate.

### B. UNINTERRUPTABLE POWER SUPPLY

1. UPS will be provided by BCPS DOT – requires at least one L5-30 outlet per rack/enclosure located within 6 feet of mounting location of UPS units, above the enclosures – see section 2.7 for more details on the room layouts

2. Provide grounding per EIA/TIA 607 requirements.

### 2.6 VIDEO OUTLETS, CABLES AND MISCELLANEOUS EQUIPMENT

- A. Provide input cable from Utilities Demarq to MDF. Input cable shall be Time Fiber TX Series Flexible Feeder model # 02852V TX15AQ-VBV Flame Retardant Quad Shield terminated with Amphenol ACC-15BAFFT10U or Gilbert G-15Q-BAFF TX Quad connectors specific to this cable. Coil twenty (20) feet slack cable at CATV/telephone backboard for connect to cable television service by Comcast Cable Television or Verizon.
- B. Video Drop Cable shall be a plenum rated quad shielded RG-6 coaxial cable with an 18 AWG solid copper center conductor, a 100% Bifoil shield and a 65% aluminum braid shield. Video drop cable shall be West Penn or approved equal. Video (RF) Jacks shall be standard "F" connector feed through type jacks, Ortronics 6090017 or approved equal. Video System RG-6 Connector shall be a two piece crimp on type. Provide Blonder Tongue BTF-561 or approved equal.
- C. Coaxial cable for system trunk line distribution from the MDF shall be Commscope RG-11 (Series 11) Quad Shield Plenum Series #2287K. Commscope is specified due to its construction characteristics of a copper clad steel center conductor and aluminum braid over aluminum tape shielding. Coaxial cable for drop cable from system tap offs shall be Commscope RG-6 (Series 6) Quad Shield Plenum Series #2227V and K.
- D. Trunk lines of RG-11(Series 11) coaxial cable shall not exceed 500 feet. Classroom distribution lines (drop cables) of RG-6 (Series 6) shall not exceed 150 feet.
- E. System Tap offs shall be Toner Model TGT four (4) and/or eight (8) port Tap offs or Blonder-Tongue Model SRT-4A four (4) and SRT-8A eight (8) port Tap offs.
- F. All terminators shall be Blonder-Tongue stock #4670 BTF-TP, Gilbert GTR-59A or equivalent and be installed on all unused ports throughout the plant.

G. CATV system outlets shall be configured into the designated Technology wall plate by providing, one
(1) CATV system outlet with one (1) AMP part # 1339121-1 "F" Series Coupler Insert, color TBD. Hubbell also approved.

# 2.7 VIDEO PROJECTOR – CABLING AND CEILING PLATE MOUNTS

- A. Provide ceiling-mounted projector plate mounts at all locations as indicated on the drawings. Approved grid-mounted 24" x 24" projector drop-in tile (lightweight suspended ceiling kit) plates are Peerless model # CMJ455. Projector ceiling plates shall be mounted in accordance with all of the manufacturer's installation requirements. Electrical contractor shall coordinate installation of Projector ceiling plate's AC outlet and communication outlet with the power and communication drops and the various ceiling fixtures as indicated on project drawings. Coordinate installation of the projector ceiling plate's location with the center of the room's projection screen and coordinate the throw distance(s) (the distance from ceiling mounted projector plate to the screen surface) with the Owner. Provide a minimum of 6' of above ceiling slack in the flexible metallic power cable to accommodate future minor relocation of ceiling mounted projector plates. Communications contractor shall likewise provide a minimum of 6' of above ceiling slack of in-room HI-Low audio/video/VGA cabling to the projector plates. Provide as indicated on the drawings, at the High Projector outlet, 36" of slack with connectors to extend to the Owner's In the future, the Owner will complete the installation of the ceiling mounted projectors. projectors with the addition of compatible projector brackets and extension columns (as needed). Data/Video projectors, screens, projector brackets and extension columns are not provided in this specification.
- B. Projector/monitor High-Low Outlets shall be provided as detailed on the drawings.

# PART 3 – EXECUTION/CLOSET LAYOUTS

- 3.1 EXAMINATION:
  - A. Examine pathway elements to receive cable. Check raceways and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation. Do not proceed with installation until unsatisfactory conditions have been corrected.
- 3.2 INSTALLATION:
- A. Wiring Methods:
  - 1. Install station cables to individual outlets in raceway within walls.
  - 2. Install horizontal runs of station cables exposed above finished ceilings. Provide "J" hooks or other suitable cable management devices at intervals not to exceed 5'-0" on center.

- B. Install components as indicated, according to manufacturers' written instructions. Use techniques, practices, and methods that are consistent with the Category 6 rating of the components and that assure Category 6 performance of completed and linked signal paths, end-to-end.
- C. Install cable without damaging conductors, shield, or jacket.
- D. Do not bend cable in handling or installation to smaller radii than minimums recommended by manufacturers.
- E. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
  - 1. Pull cables simultaneously where more than one is being installed in the same raceway or cable run.
  - 2. Use pulling compound or lubricant where necessary. Use compounds that will not damage conductor or insulation.
  - 3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage media or raceway.
- F. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.
- G. Secure and support exposed cable at intervals not exceeding 30 inches and not more than 6 inches from boxes, cable trays, fittings, racks, frames, and terminals.
- H. Separation of Wires: Comply with EIA/TIA-569 rules for separation of unshielded copper voice and data system cables from potential EMI sources, including electrical power lines and equipment.
- I. Make splices, taps, and terminations only at outlets, terminals, and cross-connect and patch panels.
- J. Use splice and tap connectors compatible with media types.
- K. Termination of station cables at voice and data jacks shall be in accordance with EIA/TIA 568A, Designation T568B for Category 6 cable. Verify jack termination scheme with Baltimore County Public Schools Department of Technology (contact Greg Vukov, Network Support Manager, at 410.887.3858 x. 497 or Judson Porter, Business Operations Manager, at 410.887.7838) prior to termination.

# 3.3 CABLE ROUTING

- A. Wiring for the voice/data/video system shall be installed in cable tray and supported by J hooks, installed four (4') apart. Exposed wiring run in the gymnasium, mechanical rooms, and other rooms where there is no drop ceiling shall be installed in EMT conduit above 10'-0" AFF and in surface metal raceway below 10-0" AFF. EMT conduit in mechanical rooms may be installed in EMT conduit below 10'-0" AFF.
- B. All voice and data horizontal cables shall not exceed 90 m (295 ft) from the telecommunications outlet in the work area to the horizontal cross connect. The combined length of jumpers, or patch cords and equipment cables in the telecommunications closet and the work area should not

exceed 10m (33 feet) total, including 3 m (10 feet) at the station and 6 m (20 feet) at the closet. Every effort will be made to route cables so as not to exceed 90 meters in length. Contractor will identify any cable runs exceeding 90 meters from proposed MDF/IDF location and shall provide solution to meet the 90-meter requirement.

- C. Horizontal pathways shall be installed or selected such that the minimum bend radius of horizontal cables is kept within manufacturer specifications both during and after installation. Cable bends shall be no less than four (4) times the cable outer diameter or 1.00".
- D. In open ceiling cabling, cable supports shall be provided by means that are structurally independent of the suspended ceiling, its framework, or supports. These supports shall be spaced no more than 1.2 m (4 feet) apart.
- E. Telecommunications pathways, spaces and metallic cables which run parallel with electric power cables or lighting cables shall be installed with a minimum clearance of 300 mm (12 inches). Communication cables shall not be run parallel with electric power cables for more than 10 m (33 feet) if their separation is less than 300 m (12 inches).
- F. Cables routed in a suspended ceiling shall not be draped across the ceiling tiles. Cable supports shall be mounted a minimum of 75 mm (3 in) above the ceiling grid supporting the tiles.
- G. Cables run exposed above accessible ceilings shall be run in bundles of a size for installation. Bundle by use of cable ties, taking care not to cinch cables. Cable shall be supported from roof structures, joists and other appropriate structural members by means of J hooks. J hooks shall not exceed spacing of four (4) feet. In no case shall any cable be supported from below by contact with the ceiling system. The data, telecommunication and video cabling systems shall be separated into bundles and separated by a minimum of 12". Provide cable ties to secure cables to each "J" hook. Avoid cinching cables.
  - 1. All voice and data telecommunications cable installed above suspended ceilings shall be supported by 2" "J" hooks spaced at a maximum of 48". For support of high density (>50 cables) bulk cable where 48" spacing results in the bowing of cable, the Contractor shall divide bulk cable into smaller parallel streams or decrease the spacing of the "J" hooks sufficiently to adequately support the cable.
  - 2. Where voice and data telecommunication wiring is supported by "J" hooks, wire shall be run neatly bundled with tie wraps. Tie wraps shall be spaced randomly between 6" and 10" apart, 8" on the average. Tie wraps shall be snug, but capable of being easily rotated about the cable bundle so as to secure the cable without binding, deforming or damaging it. Cable deflection shall be less than 5" between "J" hooks.
  - 3. Fiber optic and Category 6 UTP backbone cable shall be run separately from the horizontal distribution cable. This shall be accomplished by running said cable parallel to horizontal distribution cabling supported on the back-side of the "J" hooks used for the horizontal cabling or by supporting the backbone cable separately from the horizontal. In either case, the backbone cabling shall not be tie wrapped together with the horizontal distribution cable.
  - 4. "J" hooks shall be supported directly by the building structure. "J" hooks shall be supported on minimum 3/8" threaded rod anchored to the side hallway walk, or to the slab above. "J" hooks shall *not* be attached to or supported by ceiling supports, piping or piping supports, or duct work or duct work supports.
  - 5. Install cabling below or to the side of the duct work, just above the suspended ceiling. Extend "J" hooks down to support the cabling at that level.
H. Where wire and cable penetrate walls or other structural elements or pass above inaccessible areas of the building, install EMT sleeves sized to accept sizes of run, as follows (in no case shall sleeves exceed 40% fill ratio):

IPS/TRADE SIZE	NUMBER OF CABLES			
0.75-inch	2			
1.00-inch	4			
1.25-inch	8			
1.50-inch	11			
2.00-inch	18			
2.50-inch	27			
3.00-inch	41			
3.50-inch	55			
4.00-inch	71			

### 3.4 INSTALLATION AT EQUIPMENT ROOMS AND WIRING CLOSETS

- A. Provide adequate length of conductors and cables. Train the conductors to terminal points with no excess. Provide ten (10) foot service loop for each copper cable within Equipment Room. Use cable management system to restrain cables, to prevent straining connections, and to prevent bending cables to radii smaller than allowed.
- B. Mount voice backbone punchblocks, terminal strips, and other connecting hardware on plywood backboards, except as otherwise indicated. Provide additional 3/4-inch fire retardant treated plywood backboards where required for mounting of equipment.
- C. Mount data patch panels in floor or wall mounted electronic racks, with cable management. Do not fill racks to more than 50% capacity to allow spare room for Owner furnished equipment. Provide additional racks, to match existing, where required to maintain rack space.
- D. Group connecting hardware for cables into separate logical fields.
- E. Communication grounding / earthing and bonding shall be in accordance with applicable codes and regulations. It is recommended that the requirements of IEC 1000-5-2, ANSI/TIA/EIA-607, or both, be observed throughout the entire cabling system. Provide 12" ground bus bars and #6 solid copper ground wires from the ground bus bars to the building ground. Provide #6 ground from the ladder cable rack to the ground bus bars.

F. Provide a minimum of one 4' w x 8' h x 3/4" fire-retardant-treated plywood backboard, painted white, two feet off the floor to top. Secure backboard with a minimum of eight (8) screws. Plywood backboard shall conform to Product Standard PS1, Grade B-D, with exterior glue and one side finished.

# 3.5 SLACK

- A. In the work area, a minimum of 300 mm (12 in) should be left at outlets, while 1 m (3 ft) be left at the backboard or rack, and 6 m (20 feet) in the closet area.
- B. In telecommunications rooms a minimum of 6 m (20 ft) of slack should be left for all cable types. This slack must be neatly managed on trays or other support types. "All cable types" includes all voice/data/video backbone cables and fiber optic backbone cables.
- C. All unused cables shall be properly terminated, as specified, with 10 m (33 feet) extra cable neatly coiled and tie-wrapped at the workstation end of cable in the ceiling space.
- D. Where wireless access point devices are installed, provide a minimum of 3 m (10 feet) of cable coiled, tie-wrapped, and supported in the ceiling space.

### 3.6 FIRE STOP

- A. Provide properly installed firestop systems to prevent or retard the spread of fire, smoke, water, and gases through the building. This requirement applies to openings designed for telecommunications use that may or may not be penetrated by cables, wires, or raceways. Contractor shall seal all floor, ceiling, and wall penetrations.
- B. Provide fire and smoke stopping in accordance with all applicable codes.
- C. Provide fire-rated seals for all penetrations through fire-rated floors and walls. Provide UL listed fire sealant, Dow Corning Silicon foam, or approved equal. Provide UL listed expanding fire barrier and expanding type grout.
- D. Provide Cable pathwat firestopping devices for cables exiting/entering telecommunications rooms (MDF/IDF). Provide STI EZ Path or approved equal.

# 3.7 CABLE TIE WRAPS

- A. Tie wraps shall be used a appropriate intervals to secure cable and to provide strain relief at termination points. These wraps shall not be over tightened to the point of deforming or crimping the cable sheath. Tie wraps shall be attached with screws to walls, backboards, and other structures. Tie wraps shall be spaced between 6" and 10" apart, 8" on the average.
- B. Hook cable managers should be used in the IDF/MDF room where reconfiguration of cables and terminations may be frequent. Cable Managers shall be Polygon Softcinch Series, or approved equal.

C. No "stick-on" cable wraps, raceways, or terminal devices are acceptable.

# 3.8 IDENTIFICATION

- A. Identify system components in compliance with the applicable requirements of Division 26 and the following specifications:
- B. Follow EIA/TIA recommendations and Owner's standards for identification of voice and data jacks, cables and terminations.
- C. Workstation: Label cables within outlet boxes. Label each jack with a unique identifying nomenclature.
- D. Distribution Racks and Frames: Label each unit and field within that unit.
- E. Within Connector Fields, in Wiring Closets and Equipment Rooms: Label each connector and each discrete unit of cable-terminating and connecting hardware.
- F. Cables, Generally: Label each cable within 4 inches (100 mm) of each termination and elsewhere as indicated.
- G. Exposed Cables and Cables in Cable Trays: Label each cable at intervals not exceeding 15 feet (4.5 m).
- H. Cable Schedule: Post at a prominent location in each IDF Room and equipment room. List incoming and outgoing cables and their designations, origins, and destinations. Protect with a rigid frame and clear plastic cover. Provide a diskette copy of final comprehensive schedules for the project in the software and format.
- I. All Horizontal wiring shall be terminated into the enclosures marked "Wiring" using 48 port CAT6 patch panels, with cable management placed accordingly, in accordance with ANSI/TIA/EIA-568-B(.1, .2, .3), 568-3, 569-B, 598-C, and 758-A standards, using T568-B standard punch downs.
- J. All cabling must be labeled properly at both the station end and the closet termination point. Labels shall be resistant to environmental conditions and fading.

K. Workstation: Label cables within outlet boxes. Label each jack with a unique identifying nomenclature –



- L. Wireless access point cabling/cabling terminated above a ceiling must have the jack label applied to the ceiling grid, as well as the end termination point to allow for quick visual inspection by field network technicians for future troubleshooting. Preference is to have wireless outlets installed in a surface mount CAT6 2 port box that is mounted above the ceiling tiles. Ceiling tile locations of the jacks should be marked on the grid facing into the room.
- M. Distribution Racks and Frames: Label each unit and field within that unit.
- N. Within Connector Fields, in Wiring Closets and Equipment Rooms: Label each connector and each discrete unit of cable-terminating and connecting hardware.
- O. Cables, Generally: Label each cable within 4 inches (100 mm) of each termination and elsewhere as indicated.
- P. Exposed Cables and Cables in Cable Trays: Label each cable at intervals not exceeding 15 feet (4.5 m).
- Q. Cable Schedule: Post at a prominent location in each IDF Room and equipment room. List incoming and outgoing cables and their designations, origins, and destinations. Protect with a rigid frame and clear plastic cover. Provide a diskette copy of final comprehensive schedules for the project in the software and format as indicated in section 1.6.4.

### 3.9 SYSTEM ACCEPTANCE TESTING

- A. The Cable System Installer shall document the cable system testing methodologies in detail, including the scope, procedures and acceptance criteria for testing. The testing process shall be comprised of the test cycles outlined below. All test results (e.g.; cable lengths, test result values, etc.) shall be documented in both hard copy and electronic format for the Owner's review and approval. Electronic format shall be provided using one of the products available in the Microsoft Office Suite (Word, Excel, etc.), and shall be provided in format acceptable to BCPS.
- B. The Cable System Installer shall provide all necessary diagnostic tools (i.e.; Time Domain Reflectometer (TDR), cable scanner, meters, logging equipment, etc.) The Cable System Installer shall describe any testing tools that are used, along with the capabilities and limitations of these tools.

- C. Cable System testing shall be conducted before, during and after installation. Upon completion of all prerequisite tasks to the corresponding test, the Cable System Installer shall notify the Owner in writing that the relevant portion of the cabling system is complete and ready for testing.
- D. Acceptance Test Failure: Failure of any portion of the Cabling System to successfully complete an Acceptance Test shall be deemed a failure of the entire cabling system. Such events shall be cause for Vendor obligation to execute the Retesting procedure outline below:
  - 1. If the Cabling System, or any part thereof, fails an Acceptance test, the Cabling Installer shall either:
    - Modify or adjust the Cabling System to satisfy the necessary specifications and discrepancies;
      -OR-
    - b. Replace or add such components as may be necessary to make the Cabling System satisfy the specifications.
  - 2. The cabling System installer shall notify the Owner in writing of the diagnosed problem, proposed method for correction, and then once the corrections have been completed of the readiness of the Cabling System for re-execution of the Acceptance test.
  - 3. Once all Acceptance Tests have been successfully completed, the Cabling System Installer shall provide for the Owner's signature, a document indicating that the system has passed all acceptance tests and certifying the installation. This document will then be signed by the Owner as acceptance of the Cabling Installation and Acceptance Testing methodology and results.
- E. Cable Systems Acceptance Tests:
  - 1. All copper cabling and terminations shall be tested, characterized and documented. At a minimum, the following tests must be performed:
    - a. Continuity Testing shall be performed to determine that the copper conductors are continuous with no opens or shorts.
    - b. Cable Characteristic Testing shall be performed to measure the intrinsic characteristics of a copper cable segment. Information derived from this test shall include the cables near end crosstalk (NEXT), capacitance, and characteristic impedance. This test shall be conducted on all installed end-to-end cable sections.
    - c. Time Domain Reflectometer (TDR) shall be used to evaluate copper loss per unit length (Db/ft) to measure both the quality and length of copper cable. The TDR information shall be used to verify that the cable meets required IEEE 802.3 specifications for 1000BaseT connections over unshielded twisted pair cable.
    - d. Termination Testing shall be performed after the cable has been installed to verify that all cable pairs have been properly terminated. This testing shall assure

that the pin-outs are correct and that there have been no flipped or unterminated pairs.

- e. Link Confidence Testing shall measure the copper cables ability to support 100 Mb/s (Fast Ethernet) and 1000 Mb/s (Gig Ethernet) (250Mhz or greater) transmissions. Link Confidence Testing shall measure the fiber cables ability to support 100 Mb/s (Fast Ethernet), 1000 Mb/s (Gig Ethernet) (250Mhz or greater), and 10 gig Ethernet transmissions.
- f. Certification reports for all data wiring run shall be emailed to gvukov@bcps.org Test results shall be provided in Fluke Linkware format, or cvs format for import into the Baltimore County Public Schools DOT Information Services tracking system. In addition, hard copies of each test report and a CD-ROM with all reports shall be included in the project Operation and Maintenance Manual.
- g. Frequency tests must exceed 250MHz and up to 500MHz for future capability. All cabling, horizontal and backbone, must be tested and certified by the installer, with electronic test results provided to Greg Vukov within 10 days of job completion, certifying to at least CAT6/250MHZ/1000Mbps on all copper CAT6 cabling.
  - The matrix below defines when each of the above tests shall be

h

Copper Cable Test Requirements					
Unit Test Name	On-Reel	After Install	Post Term.	Final Test	
Continuity Test		!	!		
Cable Characteristic Test				!	
Time Domain Reflectometer (TDR)			!	!	
Termination Testing			!	!	
Link Confidence Test @100 Mb/s			!	!	
Link Confidence Test @1000 Mb/s			!	!	
Link Confidence Test @10000 Mb/s (fiber only)			!	!	

performed:

- F. CATV System Acceptance Tests:
  - 1. Coaxial Cable Plant Testing shall consist of a sweep test of the cable plant provided under this Contract to verify installed cable bandwidth and distortions.

- 2. A Cumulative Leakage Index (CLI) survey shall be made to verify system integrity. Section 76.605(a)(h) of the FCC states that signal leakage must not exceed 20 micro-volts/meter from 54 MHz to 216 MHz at 3 meters and 15 micro-volts/meter at all other frequencies.
- 3. The Contractor shall test and for the following:
  - a. Test all specialty video cables for open, short, and ground.
  - b. Test all specialty video cables for end to end signal performance.
  - c. Test picture quality at each specialty outlet.
  - d. Test cables for frequency response and insertion loss at 5-1000 MHZ.

# 3.10 CLEANING

A. On completion of system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions from all areas worked in.

# 3.11 DOCUMENTATION:

- A. The conditions of the General Provisions (General, Supplementary, and other Conditions) and the General Requirements are hereby made a part of this Section.
- B. A comprehensive installation, operation, programming and instruction manual shall be supplied as part of the system. The manual shall provide complete service information, including schematics, layout drawings, and interconnecting diagrams showing the location of all the outlets, cable taps, cable routes, and other installed components. Include final revised one-line system drawings. Include for this particular project parts lists to permit quick and efficient maintenance and repair of the equipment by qualified technicians. Manuals shall include 8 2" x 11" device location/cabling route drawings provided in CADD format Autodesk -AutoCadd Release 2005 or later (.dwg/.dxf) on CD disk. Manuals shall include a copy of the operations manuals listed below. Manuals shall be indexed and placed in a hard-cover three ring binder. Three (3) copies of this manual shall be provided to the Owner upon project completion. Contractor shall retain a minimum of one (1) copy for their permanent records. Provide one copy of Manual and disk(s) in the Main Equipment Rack. Refer to "General Provisions" in the contract for additional or documentation requirements.

### 3.12 DRAWINGS

- A. As-built drawing shall be provided by the Contractor, in compliance with EIA ANSI/TIA/EIA-606, showing the locations of and identifiers for all:
  - 1. Horizontal cable routing and terminations.
  - 2. Telecommunications outlets/connectors, Telco System interfaces.
  - 3. Backbone cable routing and terminations and outlets.
  - 4. Video cable routing and terminations and outlets.
  - 5. Data cable routing and terminations and outlets.
  - 6. Electrical power cable routing and terminations, power outlet locations.
  - 7. Network cabling plans identifying type, number, and location of equipment and outlet.
  - 8. Cable penetration details, schematic riser diagrams, and equipment closet layouts.

- B. Provide as-built drawings to include cabling routing, details of station and hardware locations, etc. The Contractor shall provide as-built drawings on CD disk in AutoCAD (.dwg/.dxf) file format. Contractor will have access to drawings provided with this specification where they are in electronic form.
- C. Provide a set of "As-Built" Drawings encased in a plastic sheet protector at backboard, in each wiring closet.
- D. At the completion of the project, the Contractor shall bring the system wiring diagrams fully up to date with the actual field installation, showing all field-made changes for deviations from the approved shop drawings. Accurately record location of service entrance conduit, termination backboards and cabinets, outlet boxes, messenger cable raceways and cable trays, pull boxes and equipment. Room names and numbers shall be updated to indicate actual field-assigned room numbers. They may not necessarily be the room names and numbers shown on the Contract Drawings.

# 3.13 RECORDS

- A. All records shall be created by the installation contractor and turned over at the completion of work. The format shall be computer based and both soft copies and hard copies shall be part of the As-built package. The minimum requirements include:
- B. Cable records shall contain a complete listing of the identifier, cable type, length, pair status, pair assignment, termination positions at both ends, manufacturer, and part number.
- C. Connecting hardware records shall contain the identifier, type of hardware and the amount of positions.
- D. Connecting hardware positions records shall contain the identifier, type of position, and the cable identifier attached to it.
- E. Test documentation on all cable types shall be included as part of the As-built package. Only signed copies of test reports shall be acceptable.
- F. Outlet Records: Provide a database of outlet designations capable of being exported to a cable management software system (xls format). The Contractor shall provide a complete database indicating the location of each outlet and corresponding port on wire closet equipment.
- G. Provide a complete Owner's Manual including full documentation of system paths and components to allow for plug and play operating cable management, cable maintenance, and cable modifications. Commercial off-the-shelf manuals shall be furnished for operation, installation, configuration, and maintenance for all products provided as a part of this section.

### 3.14 TRAINING:

A. The Contractor shall include (4) four-hour on-site training sessions, or as required, of startup and training assistance during cutover and Owner installation of equipment to ensure a fully

functional system. This training may also be used for system configuration during initial system startup or other services as required at the Owner's request.

- B. Training shall include a "walk-through" of the system for location and labeling orientation, a discussion of overall system concepts and configuration, specific instruction in system reconfiguration using patch cords in the wiring closets, a review of the as-built drawings, a review of the system testing and acceptance documentation, and guidelines for basic trouble-shooting of the structured cabling system. The contractor shall supply personnel who are thoroughly familiar with the installation to present the instruction in an organized and professional manner. BCPS shall supply personnel to physically inspect the installation to assure that all equipment and cable is installed in a neat and workmanlike manner as called for by the plans and specifications. Contractor to schedule the inspection and walk-through BCPS at a mutually agreeable time.
- C. The Contractor shall provide key personnel at each training session, as required by the Owner, at no additional cost to the Owner. Key personnel include Contractor's site-foreman, project manager and service manager.

# END OF SECTION

# SECTION 27 51 23 - INTEGRATED TELECOMMUNICATIONS SYSTEM

#### PART 1 - GENERAL REQUIREMENTS

### 1.1 GENERAL

- A. The conditions of the General Contract (General, Supplementary, and other Conditions) and the General Requirements are hereby made a part of this Section.
- B. All bids shall be based on the performance of the system as specified herein. All systems must be approved by the specifying authority.
- C. This section covers the public address, intercommunication and master clock system.
- D. Integrated Telecommunications System (Public Address System) wiring shall be plenum-rated and shall be installed identical to the voice/data/video cabling as specified in Specification Section 271500. Provide all labor, material, equipment and services necessary for and incidental to the complete installation of the intercommunication, public address and master clock system as described herein. The entire system shall be hereinafter referred to as Integrated Telecommunications System (ITS) system or simply System. Complete system shall include all handsets and station wiring.
- E. The installation shall conform to all rules, regulations and codes of local, state and federal authorities having jurisdiction including the National Electrical Code, National Fire Protection Association and NECA Standards of Installation.
- F. Coordinate the installation with the local telephone company and verify with the Owner that the planned telephone system and capacity has not changed or is not changing from the initial design.
- G. Arrange conduit, raceways, backboards and equipment generally as shown. The Contract Drawings are diagrammatic and do not show all fittings, elbows, junction boxes, etc., required for a complete installation. Provide all such devices as needed or as required to present a neat and fully functional system.
- H. Where variances occur between drawings and Specifications or within either document itself, provide the item or arrangement of better quality, higher cost and/or neater installation. The Engineer will make all final decisions required.
- I. Cabling shall be installed in cable tray, where practicable. All cabling shall be in conduit from cable tray to devices.
- 1.2 SCOPE OF WORK
- A. Furnish and install all equipment, accessories, and materials in accordance with these specifications and drawings to provide a complete and operating integrated Communication

System consisting of integrated Telephone, Intercommunication, Public Address System, Audio Retrieval, Video Retrieval and Time Control System as specified herein.

- B. Telephone service with public utilities shall be arranged by the owner, in conjunction with the equipment supplier.
- C. Where applicable, visit the site, verify all items shown on the plans, or specified, and be familiar with the working conditions, hazards, and local requirements involved; submission of bids shall be deemed evidence of such visit. All proposals shall take these conditions into consideration and the lack of specific information on the drawings shall not relieve the Contractor of any responsibility.
- D. All materials, unless otherwise specified, shall be new, free from any defects, and of the best quality of their respective kinds. All like materials used shall be of the same manufacture, model, and quality, unless otherwise specified.
- E. All manufactured articles, material, and equipment shall be applied, installed connected, erected, used, cleaned, adjusted, and conditioned as recommended by the manufacturers, or as indicated in their published literature, unless specifically herein specified to the contrary.
- F. All work shall be performed by competent workmen and executed in a neat and workmanlike manner providing a thorough and complete installation. Work shall be properly protected during construction, including the shielding of soft or fragile materials. At completion, the installation shall be thoroughly cleaned and all tools, equipment, obstructions, or debris present as a result of this portion of work shall be removed from the premises.
- 1.3 RELATED WORK SPECIFIED ELSEWHERE
- A. All work under this section is subject to the General Conditions and any Special Requirements for the entire Contract.
- B. The work in this section is related to work in Section 271500 Voice/Data/Video Systems.

# 1.4 SUBMITTALS

- A. Original Specification Sheets shall be submitted on all items. Extensive use of photo copies shall not be acceptable. Manufacturers name, make and model number shall appear on each sheet. Submittals shall be indexed and presented in a neat and logical order. Submittals shall contain installation, operation and programming manuals as required to provide the Owner information as to system features, functions and capabilities.
- B. Submit outline drawing of system control cabinets showing relative position and size of all major components. Submittal shall contain quantities of all supplied components. Detail equipment assemblies, rack elevations, indicate dimensions, weights, required clearances, and locations of each field location.

- C. Submit FCC registration number on separate documentation with the ringer equivalency of the proposed integrated telecommunication system. This documentation is mandatory: All submittals without FCC registration information will automatically be rejected. The entire telecommunication system shall be FCC listed. Partial listing of system shall be considered unacceptable.
- D. Submit wiring diagrams showing typical connections for all equipment. Detail wiring for power, signal, and control systems and differentiate between manufacturer's installed and field-installed wiring. Identify terminals to facility installation, operation, and maintenance. Include a single-line diagram showing cabling interconnection of components.
- E. Shop Drawings: Submit layout drawings of integrated Communication System, components, and accessories. List all rooms and areas connected to the system.
- F. Specification sheets shall be submitted on all items including cable types.
- G. Submit a certificate of completion of installation and service training from the system manufacturer. The supplying contractor shall have attended the manufacturer's installation and service school. A certificate of this training shall be provided with the Contractor's submittal.
- H. Submittals not containing these documents shall be automatically rejected.
- I. Product Certificates: Signed by Manufacturers of equipment certifying that products furnished comply with specified requirements.
  - 1. Installer Certificates: Signed by Manufacturer certifying that installers comply with requirements.
  - 2. Manufacturer Certificates: Signed by Manufacturers certifying that they comply with requirements.
  - 3. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Include record of final matching transformer-tap settings, and signal ground-resistance measurement certified by the Installer.
- J. Maintenance Data: For equipment to include in maintenance manuals specified in Division. Include record of Owner's equipment-programming option decisions.
  - 1. Submit a copy of the UL listing card for the proposed system.
- K. Specification sheets shall be submitted on all items including cable types.
- L. Submit outline drawing of system control cabinet showing relative position of all major components.
- M. Submit wiring diagrams showing typical connections for all equipment.
- N. Submit a certificate of completion of installation and service training from the system manufacturer.
- O. Submit a statement of assurance that the system will be compatible with any standard off the

shelf DTMF telephone that the owner may wish to supply.

- P. Submit a copy of the supervising electrician's Baltimore County license.
- Q. Submit a copy of the approving RCDD's registration and the CTS registration.

### 1.5 SERVICE AND MAINTENANCE

- A. Provide a <u>two</u> (2) year warranty of the entire installed system against defects in material and workmanship. All labor and materials shall be provided at no expense to the owner during normal working hours. The warranty period shall begin on the date of acceptance by the owner/engineer. If this project is to be completed in phases, the supplier shall document acceptance dates of each area and turn over at each stage a copy of the acceptance letter acknowledging the starting and ending date of t he warranty of each area.
- B. At the Owner's request, make available a service contract offering continuing factory authorized service of this system after the initial warranty period.
- C. The system manufacturer shall maintain engineering and service departments capable of rendering advice regarding installation and final adjustment of the system.
- 1.6 QUALITY ASSURANCE
- A. All items of equipment including wire and cable shall be designed by the manufacturer to function as a complete system and shall be accompanied by the manufacturer's complete service notes and drawings detailing all interconnections.
- B. The Contractor shall be an established Communications and Electronics Contractor that has had, and currently maintains, a locally run and operated business for at least five years. The contractor shall be a duly authorized distributor of the equipment supplied with full manufacturer's warranty privileges.
- C. Contractor: Show satisfactory evidence of maintaining a fully equipped service organization capable of furnishing adequate inspection and service to the system. Maintain at facility the necessary spare parts in the proper proportion as recommended by the manufacturer to maintain and service the equipment being supplied. Provide a portable computer in order to record the programming required for the operation of the system. A separate disk shall be kept in the Contractor's file that includes all of the programming information for this particular school installation.
- D. Installer Qualifications: An experienced installer who is an authorized representative of the equipment manufacturer for both installation and maintenance of equipment required for this Section. Firms with at least ten years of successful installation experience with projects utilizing integrated communications systems and equipment similar to that required for this project. This experience must be by the firm itself and not any individual employee. Installers shall include with their submittal proof from the manufacturer that they are certified to install the system.

- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
  - 1. Comply with NFPA 70, National Electrical Code.
  - 2. Comply with UL 50, Enclosures for Electrical Equipment.
- F. Comply with EIA-160-51, Sound Systems
- G. Comply with ANSI EIA-310-D-92 Cabinet, Racks, Panels, and Associated Equipment.
- H. Comply with EIA-SE-101-A-49 *Amplifiers for Sound Equipment*.
- I. Comply with EIA-SE-103-49 Speakers for Sound Equipment.

J. The contractor must have a BiCSi Registered Communications Distribution Designer (RCDD) on its regular staff. The use of a sub-contracted RCDD shall not be acceptable. The headquarters records of the BiCSi organization shall determine the employment status of the RCDD. All submittals and drawing must carry the official seal of the RCDD.

K. The contractor must have an Infocomm Certified Technology Specialist (CTS) on its regular full time staff.

- 1.7 SINGLE SOURCE RESPONSIBILITY
- A. Except where specifically noted otherwise, all equipment supplied shall be the standard product of a single manufacturer of known reputation and experience in the industry. Integration of various Manufacturers' products in an attempt to meet the specifications shall be deemed in direct conflict with the specifications and shall be rejected. The Contractor shall have attended the Manufacturer's installation and service school and upon request must show proof of attending such a school.
- 1.8 SAFETY / COMPLIANCE TESTING
- A. The communication system supplied shall be listed by Underwriter's Laboratories
- B. All equipment normally used by staff or other personnel, either on a daily basis or for instructional needs, shall meet ADA accessibility requirements. This includes intercom and paging functions, master clock, VCR's and LDP's, remote controls, dining area and gymnasium public address systems, etc.
- 1.9 IN-SERVICE TRAINING
- A. The Contractor shall provide a minimum of sixteen (16) hours of in-service training with this system. These sessions shall be broken into segments which will facilitate the training of individuals in the operation of this system. Operators' Manuals and Users' Guides shall be provided at the time of this training. Additional eight (8) hour training segments shall, as a minimum, consist of the following periods:

- 1. Upon completion of the installation.
- 2. After six weeks of use of the system.
- 3. During the last month of the warranty period.
- B. Separate demonstrations shall be given to the office staff, administrative staff (Principal, etc.), and teaching staff; and each demonstration shall be oriented for their particular requirements. Demonstrations shall be scheduled at the Owner's preference with three days' minimum advance notification to the Contractor.
- 1.10 WIRING
- A. System wiring and equipment installation shall be in accordance with good engineering practices as established by the EIA and the NEC. Wiring shall meet all state and local electrical codes. All wiring shall test free from all grounds and shorts.
- 1.11 PROTECTION
  - A. Provide all necessary transient protection on the AC power feed and on all station/central office lines leaving or entering the building.
  - B. Note in system drawings, the type and location of these protection devices as well as all wiring information.

### PART 2 - PRODUCTS

- 2.1 ACCEPTABLE MANUFACTURERS
- A. Only Manufacturer's system by Telecor 21, Rauland-Borg Telecenter 21 or Bogen 2100 shall be submitted provided that every operational function contained herein is provided. It is understood that the two manufacturers may provide different means of providing a feature, function or operation. The Owner reserves the right to determine if these alternate means of operations meets the requirements of the facility and the intent of these specifications. Items and quantities are critical to the operation of the facility and must be provided exactly as specified, no substitutions are allowed. Manufacturer and contractor shall also fully comply with the provisions outlined in these specifications.
  - 1. The documents were prepared using as a basis of design the Rauland-Borg Telecenter 21.
- B. The intent is to establish a standard of quality, function and features. It is the responsibility of the bidder to insure that the proposed product meets or exceeds every standard set forth in these specifications.
- C. The functions and features specified are vital to the operation of this facility; therefore, the Contractor must provide full compliance with the requirements of this specification. Listing of a Manufacturer does not release the Manufacturer from providing all features and functions described herein.

D. All bids shall be based on the equipment as specified herein. Any alternate system must be pre-approved by the specifying authority. Bidders wishing to submit alternate equipment shall submit to the specifying authority, at least 10 days prior to bid opening, the equipment proposed to provide a precise functional equivalent system to meet specifications. Bidder shall provide adequate information prior to bid date such as Specification sheets, working drawings, shop drawings, and a demonstration of the system. The bidder shall also provide the FCC registration number of the proposed system. The local contractor shall provide proof of the installation and operation of at least five (5) similar systems with full interconnection to Media Center retrieval equipment and Central Office telephone service. These systems shall be installed within the State of Maryland. Alternate supplier-contractor must also provide a list to include at least five (5) installations of the identical system proposed which have been in operation for a period of two (2) years.

# 2.2 GLOBAL SWITCHING

- A. The system shall be a global switching system; that is, there shall be no linking within the system that would restrict or block telephone communications.
- B. The system being proposed shall have no limitations within the switch that restrict the ability of a system telephone to access any available link at any time. Systems that contain such restrictions shall not be considered as a "global" switch and will not be accepted under this specification.
- C. Providing two (2) consoles or telephones at attendant and administrative positions shall be considered in direct conflict with the intent of this specification and therefore shall be deemed not acceptable. If a compatible administrative telephone exists at these locations, the use of a second instrument shall be deemed unacceptable.

### 2.3 CENTRAL SWITCHING EXCHANGE

- A. School's Telephone System:
  - The system shall be integrated with the BCPS supplied Meridian Norstar Electronic Key System allowing any phone on the system, if so desired, to page and conduct hands-free open voice intercom with any speaker in the system, and handset to handset with any administrative control console and classroom telephone. The intercom system will be supplied with the equipment required to provide three (3) intercom to Norstar station connections and one (1) intercom to Norstar central office line connection. All of the above connections must be capable of being accessed and used simultaneously. Any other type of interconnection between the intercom and the Meridian Norstar will not be accepted due to the risk of performance degradation in the BCPS supplied Meridian Norstar.
  - 2. The system shall also be equipped with a wall-mounted display, located in the main office, which will show the room number of incoming intercom calls. The school's Norstar telephones shall be used to answer these calls.
- B. The Contractor shall provide all Classroom telephone handsets as well as all power, cabling and provisions to serve the Owner-provided telephone switch.

# 2.4 CLASSROOM EQUIPMENT

- A. Classrooms shall be equipped with the following minimum equipment as indicated on the drawings:
  - 1. Ceiling loudspeaker, baffle, support and backbox.
  - 2. Staff/Classroom Telephone: Shall be furnished by Contractor
- B. Classroom Equipment:
  - 1. Classroom telephones shall be furnished by Contractor.
    - These telephones must be standard "off the shelf" telephones. The customer shall be able to bring in any DTMF phone of their choice and plug it into the system to demonstrate this capability as part of the acceptance of the system. If the system is not capable of all functions with a standard off the shelf DTMF telephone, including ringing, the contractor shall replace the electronics to provide this capability at the contractor's cost. Staff telephones shall be carbon type with built-in networks. Systems which modify a standard DTMF telephone in order to function with their system thus not permitting BCPS to purchase a telephone from the local phone store and use it on the system or use dynamic handsets shall not be acceptable.
  - 2. Provide two-wire balanced audio transmission with dial tone, ringing, and busy signal capability to all administrative and classroom telephones.
  - 3. Classrooms shall be equipped with the following minimum telecommunication equipment or as indicated on the drawings.
  - 4. Loudspeaker, baffle, backbox. Wall-mounted Staff Telephone with wall-mounted stainless steel phone jack.

### 2.5 ADMINISTRATIVE OFFICE EQUIPMENT

- A. Administrative Office areas shall be equipped with the following equipment or as indicated on the drawings: Electronic Key Telephone (provided by Owner).
- B. Provide administrative telephone outlets at locations indicated on the drawings. These outlets shall serve instruments (furnished by Owner) that shall operate as administrative telephones and shall be used as secondary answering points for incoming telephone calls.
- C. Call control consoles with telephone and fax/modem jacks and faceplates. Administrative telephones with telephone and fax/modem jacks and faceplates. Wall-mounted digital display with date and time indication of master clock.
- D. The system shall provide for Personal identification Number (PIN) Codes for all staff members and administrators. By dialing their PIN Code at any system telephone, the staff member/administrator shall have access to the same capabilities assigned to their office telephone or authorization level, regardless of the restrictions on the phone on which they are dialing. System shall be capable of supporting a minimum of two-hundred and fifty (250) individual PIN codes of four (4) digits in length.

### 2.6 TELEPHONE COMMUNICATION OPERATION

- A. The system shall provide telephone service to classrooms at all locations as indicated on the drawings.
- B. The integrated telecommunication system shall provide for direct connection to central office telephone lines (CO Trunks). Initially the system shall be equipped for twenty-five (25) or sixteen (16) trunks and wired for twenty-five (25) or sixteen (16) trunk(s).
- C. The system shall offer routing of inbound trunks for:
  - 1. Attendant Answer Incoming (AAI)
  - 2. Direct Inward Dialing (DID)
  - 3. Direct Inward Line (DIL)
  - 4. Private Direct Inward Line (PDIL)
  - 5. Direct Inward System Access (DISA)
- D. It shall also provide all standard Telco signaling to interface with other special services such as off-premise extensions (OPX), WATS, and CENTREX. Incoming Caller ID (ICLID) shall also be supported on all inbound trunks.
- E. The system shall be capable of operating with either loop start or ground start trunks for compatibility with future utility services. The system shall also be capable of operating with E&M Tie Trunks (2 / 4 wire audio, Type I / II, IV & V signaling). The specified interface shall be Type I with 2 wire control signaling with 2 wire audio.
- F. The system shall provide direct interface to Owner supplied Electronic Key System Units (EKSU). At a minimum, the System shall be compatible with, but not limited to, Toshiba DK280, Merlin, Meridian, Spirit, AT&T Dimension and other Owner supplied systems.
- G. The system shall be capable of direct connection to Central Office trunk ports. Provide a minimum of (1) trunk port interface circuits.
- H. System shall provide a minimum of (4) E & M ports capable of direct connection to E & M ports of the Owner's EKSU System.
- I. Provide adjustable gain repeaters for each E & M circuit and C. O. trunk to maintain unity (or better) gain between systems.
- J. The system shall offer full flexibility of software restrictions to station lines for external calling capability. Each station may be programmed as:
  - 1. Totally unrestricted
  - 2. Restricted access
    - a. Long Distance Access
    - b. Area Code Access
    - c. Local Exchange Access
  - 3. No Access to Outside Trunks

- K. The installed system must maintain toll restriction at the station level even when installed in CENTREX or other nested applications.
- L. The system shall provide for Personal Identification Number (PIN) Codes for selected administrators. By dialing their PIN code at any system telephone, the administrator shall have access to the same capabilities assigned to their office telephone, regardless of the restrictions on the phone on which they are dialing. System shall be capable of supporting a minimum of 256 individual PIN codes
  - 1. The system shall provide discriminating ringing to enable the party receiving a call to distinguish between an internal call (long ring) and an outside call (two short rings).
  - 2. The system shall provide automatic hunting for the first available trunk for an outside line request. Both Rotary and Linear hunting shall be supported. The system shall be capable of partitioning to provide complete control over access to outside trunks.
- M. The system shall provide a "re-order signal" to unauthorized telephones attempting to select an outside trunk.
- N. The system shall provide trunk queuing to allow a station to queue on a group of lines. When a line becomes available, the system will automatically ring the queued phone, and then re-transmit the dialed number. It shall not be necessary for the user to re-dial the desired number.
- O. The system shall provide a minimum of eight (8) trunk groups for administrative telephones and four (4) trunk groups for staff (classroom) telephones for the selection of outgoing lines.
- P. It shall probe possible to connect a CO trunk to the system which will directly ring a designated phone without the assistance of an operator, as for private line service. This call may be automatically routed to the attendant if it is not answered within a pre-determined time.
- Q. The system shall provide circular hunting for outgoing trunks. This shall distribute outside traffic evenly and prevent any one trunk from experiencing excess usage.
- R. The system shall provide "Call Park" with remote pickup. This shall enable attendant to park call and permit paged party to remotely pick-up outside call from any telephone.
- S. Provide conference calling and call transfer capability between all telephones.
- T. Transferred calls to busy extensions shall automatically return to the party which originated the transfer.
- U. Provide executive override permitting assigned telephones to break into ongoing conversations.
- V. The system shall allow any staff telephone to remotely pick-up a call from any other ringing staff telephone.
- W. The system shall enable any administrative telephone to remotely answer any outside call on an AAI programmed trunk by dialing a pre-determined code.

- X. The system shall be capable of providing "night answer". When placing the system in "night answer" mode, it shall be possible for an incoming call on any trunk to be directed to a pre-determined extension. Night mode shall also provide a tone over system speakers signaling key personnel to answer the incoming call at any telephone. This shall provide the ability to answer calls throughout the facility.
- Y. The system shall provide "Flexible Class of Service" to allow changes in system features and functions during selected hours. The following program changes in Class of Service shall be possible:
  - 1. Trunk type assignments (DISA, DIL, AAI).
  - 2. Trunk routing assignments.
  - 3. Restrictions on individual telephones including:
    - a. Outside line access
    - b. Toll restrictions
    - c. Paging access restrictions
    - d. Speaker first / phone first selection
- Z. It shall be possible to initiate Class of Service Changes either manually or automatically using the system's internal time base. Unless a request to the contrary is made by the owner, the system shall automatically make the Class of Service change each day at (4:30) PM and (6:30) AM.
- AA. A minimum of four (4) independent program memory sets shall be provided. The choice of time of service change and active memory set selected shall be completely programmable. A memory set includes all system functions and programming parameters except master clock time. Memory set #1 shall be automatically selected for normal daytime operation. Memory set #2 shall be automatically selected for night answer operation. Memory set #3 shall be automatically selected via a signal (contact closure) from the security/intrusion system upon arming and shall provide system programming suitable to enhance security. Memory set #4 shall be left available for the Owner.
- BB. The system shall provide Direct Inward System Access (DISA). It shall be possible to access central switch functions (i.e., all page, zone page, direct room dialing, monitoring, etc.) from any off-site touch tone telephone via an incoming CO Trunk. Only authorized individuals may use this feature by dialing the dedicated trunk number and then dialing the system function. It shall also be possible to restrict access to this function by means of a password/PIN code. This DISA function shall not be compromised by the use of duration timers.
- CC. The system shall provide Supervised Disconnect capability. When the Central Office sends a disconnect signal (wink pulse), the system shall automatically terminate the speaker connection.
- DD. The system shall be compatible with standard in-band PBX signaling for direct connection to any future PBX or Electronic Key Service Unit provided by the Owner.

# 2.7 CALL EQUIPMENT

A. Provide Call Control Consoles at locations indicated on the Drawings. The Call Control Console shall provide the following features and functions.

- 1. The ability to identify, answer, and route the incoming outside calls.
- 2. The ability to directly access any outside trunk.
- 3. All incoming calls shall be annunciated and rung to the Call Control Console. The console shall mute incoming call tones while calls are being processed. Calls may be held, parked or released.
- 4. Serve as a fast, efficient answering instrument capable of processing calls at a rate of up to 360 calls per hour.
- 5. Any transferred call shall Recall to the Console after a predetermined period of time if the call is unanswered. An indication shall be given to the Attendant that this is a Recall.
- 6. Provide a Hold Reminder feature. A reminder tone shall be transmitted every thirty seconds while a call is on hold.
- 7. Transferred calls to busy extensions shall automatically return to the Console. A Busy message shall appear on the display.
- 8. The console shall have the ability to pre-screen outside calls.
- 9. The Call Control Console shall provide an alpha-numeric display. Display shall provide prompting messages to assist and simplify operation of the system.
- 10. All internal operator calls shall appear on designated operator key(s).
- 11. The Console shall provide the ability to direct calls to selected extensions using dedicated pre-programmed direct select keys.
- 12. The Call Control Console shall provide a minimum of forty-eight (48) keys programmable as trunk lines, operator lines, direct select speakers. Each key shall provide multi-status LED's or LCD's to indicate ringing, busy, incoming call and answered call.
- 13. Additional features available at all administrative telephones and Call Control Consoles shall include:
- 14. Call Announce Intercom.
- 15. Call Forward, All Calls, When Busy and No Answer.
- 16. Call Pick-Up Group and Directed.
- 17. Provisions for Caller ID Integration Optional.
- 18. Camp-On and Call Transfer.
- 19. Conferencing, Multi-Line & Add-Ons.
- 20. Do Not Disturb Mode.
- 21. Head Set Compatible.
- 22. Interactive Digital Display.
- 23. Intercom Receive Mode Selector.
- 24. Message Waiting.
- 25. Off Net Call Forwarding.
- 26. Preset Text Messages.
- 27. Speaker Phone.
- 28. Station Speed Dial-20 Numbers Minimum.
- 29. System Speed Dialing 80 Numbers Minimum.
- 30. True DTMF Tone Dialing.
- 31. Universal Night Answer.
- 32. User Programmable Name in Display.
- 33. Least Cost Routing/Automatic Route Selection.
- 34. Separate Day and Night Class of Service.
- 35. SMDR Output for Call Accounting.

- 36. Toll Restriction by Station and CO Line.
- 37. Preset Call Forwarding/Overflow Ringing.
- 38. Full Privacy, Programmable By Station and CO Line.
- 39. Provisions for Voice Mail and Auto Attendant Optional.
- 40. Attendant Disable Outgoing Calls.
- 41. Attendant Override/Barge-In.
- 42. Multiple Attendant Capability.
- 43. Call Transfer and Busy Station Indication.
- 44. Recall for Transferred Calls and Calls on Hold.
- B. The system shall provide a selectable Siren sound from any or all loudspeakers. The siren shall be automatically activated from a signal (contact closure) from the security/intrusion system or fire alarm system. The siren volume shall be independently adjustable from other paging and time tone functions.
- C. The system shall provide a Uniform Dialing Plan within the system's programming; that is, identical access codes shall be used at all telephones within the system. Systems requiring a different access code or dialing sequence at staff and administrative telephones shall be unacceptable. The system's dialing plan shall include, but not be limited to the following:
  - 1. The telephone/intercoms system's internal dialing codes (station to station, outside line access, feature access, etc.)
  - 2. All Owner supplied EKSU internal dialing codes.
  - 3. All Applicable County Centrex extensions (when nested).
  - 4. Numbers requested by the Owner.
- D. When an extension dials a entry programmed into the Uniform Dialing Plan, the system shall provide whatever prefix dialing, pauses, senderized operation, line selection, etc., required to provide the automated connection. This operation shall be totally transparent to the user.
- E. The system shall provide facilities for Emergency 911 Service Dial-through. The user of a staff telephone located in a classroom or elsewhere shall be able to lift the telephone and dial 911 to access emergency police and fire service (where available). It shall not be necessary to dial an access code prior to dialing 911 so that untrained operators may use the system in an emergency. If all outbound telephone trunks are in use when 911 is dialed, the system shall be capable of automatically terminating the conversation on a pre-specified trunk and making the 911 connection via that trunk.
- F. Provide a built-in, auto-answer 9600 baud modem allowing off-premise troubleshooting and off-premise programming. Provide necessary outside line port for off-premise troubleshooting. Provide to the Owner two (2) copies of a DOS/IBM compatible shell diagnostics program on 3 & 1/2" H.D. diskettes, capable of providing on-site programming of all system parameters via a laptop/notebook type computer and off-site programming via modem. These disks shall also contain the layout drawings as specified. Provide a separate copy of the disk in a protective sleeve in the system cabinet containing the shell program along with the site content-specific files.

# 2.8 INTERCOMMUNICATION SYSTEM OPERATION

- A. The central switching exchange shall be supplied with at least two (2) simultaneous loudspeaking intercom conversations without blocking of any kind. Systems that are restricted to a single conversation within any group of stations shall not be acceptable.
- B. The system shall be equipped with bi-directional intercom amplifiers that shall be capable of delivering at least twelve (12) watts RMS per channel and shall contain an automatic level control.
- C. The system shall provide facilities for calling a classroom telephone station by dialing the assigned classroom number. Predetermination as to whether to ring the telephone or to permit talking over the speaker shall be user-selectable when dialing. Systems which do not provide this selectable feature or which require that separate numbers be dialed for the speaker and telephone shall not be acceptable. Telephone ringers shall be fully operable signals via a classroom loudspeaker to simulate telephone ringing shall be considered non-industry standard and shall not be acceptable.
- D. The system shall provide automatic switching of the talk path from loudspeaking intercom mode to a telephone mode, during the course of a call, should the telephone associated with the speaker be lifted from its cradle.
  - 1. Systems which do not allow for the automatic switching of the conversation from the speaker to the telephone shall not be considered acceptable.
  - 2. System shall provide a minimum of two simultaneous communication paths to each classroom equipped with a loudspeaker and staff telephone. A separate two-way intercom call shall be possible to the classroom when the staff telephone is in use. Conversely, if the loudspeaker is engaged in a two-way conversation, the staff telephone shall be capable of receiving a call.
- E. The system shall provide facilities for up to twelve (12) independent digital readout displays upon which incoming intercom calls are identified by their designated numbers. The display shall show visually, in the order received, three (3) calls at a time. Emergency calls shall override normal calls and shall annunciate with the letters "EMER" and the calling station number. An intercom call switch shall be provided at locations indicated on the drawings. The call switch shall be equipped with dedicated Call and optional Emergency buttons. Normal calls shall be placed by pressing the "Call" button. Emergency calls shall be placed by pressing the "Emergency" button. System shall provide dial-tone at each call switch location, enabling the Owner to install telephones in the future without additional wiring or installing additional system circuitry or telephone cards.
- F. The system shall allow the classroom telephones to place intercom call-in's from the telephone keypad. This function shall operate exactly as if the call switch had been used. It shall be possible to place a normal call by pressing the "\*" key. It shall be possible to place an emergency call by pressing the "\*" key twice. System shall provide emergency calls to be placed automatically if a staff telephone is removed from the hookswitch for a selected period of time. This function shall allow the handset cord to be used as a duress call cord.

G. Provide facilities for answering calls registered in the main office display by pressing a single "response" button on the administrative (EKSU) telephone. This capability shall not prevent other calls from being placed or answered by dialing their numbers.

### 2.9 PUBLIC ADDRESS / EMERGENCY TONE SIGNALING OPERATION

- A. The system shall provide for the distribution of paging announcements from any authorized telephone. It shall be possible to distribute announcements to the entire facility or to selected areas or zones. If the staff telephone originating a paging announcement is associated with a loudspeaker, the system shall automatically mute the speaker to avoid feedback.
- B. The system shall provide the capability of assigning speaker locations to any one or more of the eight (8) software programmable zones for zone paging. The paging zones shall be separate from time signal zones.
- C. Through programming, it shall be possible to exclude selected speakers from the reception of paging announcements. Speakers may be permanently excluded or they may be temporarily excluded so that student testing or other functions may take place without interruption. Speakers that have been temporarily excluded shall be automatically reinstated by the system at midnight each night.
- D. Provide a Priority Paging Microphone for use by administrative personnel. The microphone shall be a desk type with a locking Push-to-Talk bar. When the Push-to-Talk bar is pressed, the system shall automatically initiate an all-page from the microphone.
- E. The system shall provide for the distribution of emergency tone signals to all locations with speakers to alert school personnel to emergency situations. It shall be possible to initiate tone signals from any authorized telephone. When tones are initiated from a system telephone, it shall also be possible to make a voice announcement in conjunction with the tone. The system shall automatically mix the tone and voice signals.
- F. The system shall provide for Personal Identification Numbers (PIN) for selected administrators. By dialing their PIN at any staff system telephone, the administrator shall have access to the same capabilities assigned to their office telephone including paging and tone distribution, regardless of the restrictions on the staff telephone they are currently using.

### 2.10 AUDIO PROGRAM RETRIEVAL OPERATION

- A. The system shall provide for the distribution and retrieval of audio programs. The system shall support up to one simultaneous audio program sources.
- B. The system shall be equipped program sources as follows: AM/FM/Auto-Reverse CD with Monitor Loudspeaker. The AM/FM/CD Player shall be equipped with an LED tuning display, front panel indicators, internal clock, base, treble, and volume controls. The AM section shall be tunable over a range of 525 to 1620 kHz. The FM section shall be tunable over a range of 88 to 108 MHz. System shall be supplied with omni-directional AM and FM antennae.

C. The system shall provide facilities for the distribution of program material from administrative locations in the following manner: Authorized administrative telephones may select a program source for distribution and then initiate the distribution to selected rooms, or zones or to all zones simultaneously.

# 2.11 MASTER CLOCK SYSTEM FUNCTIONS / OPERATION

- A. The Master Clock System shall be a Rauland Model 2524 or approved equal. The system shall provide a master clock system which shall provide class change signaling and shall serve as a controller to ensure that a consistent time base in maintained throughout the school.
- B. Time Control:
  - 1. 512 events and 8 schedules.
  - 2. 8 building zones totally independent from page zones and program zones.
  - 3. Automatic Spring Ahead/Fall Back
  - 4. Correct both analog and digital clocks.
  - 5. Create 8 distinct tones from a combination of over 500 possibilities.
  - 6. Display alpha on classroom digital clocks either manually or automatically; i.e., "FIRE".
- C. Provide a Time Control System as an integral part of the Communications System. The time control system shall be capable of operating and correcting both digital and analog secondary clocks, as well as controlling class change signals to all speakers and/or bells.
- D. The system shall utilize a Remote Clock Driver as the interface device between digital secondary clocks. It shall be specifically designed for use with the digital clocks and can also correct analog secondary clocks. Providing an independent master clock in conjunction with the built in time clock provided within the Communications System shall be considered an unnecessary redundancy and deemed in direct conflict with intent of the specification and therefore deemed unacceptable.
- E The Remote Clock Driver shall be capable of driving both digital and analog secondary clocks. The unit shall provide the required digital signals to assure synchronization of all system digital clocks.
- F. Battery back-up shall be provided by the System, insuring correct time-keeping of the internal master clock during failure. Once power is restored, the Remote Clock Driver shall instantaneously update all digital clocks with the correct time.
- G. The Remote Clock Driver shall provide capabilities to correct Synchronous Wired Analog Secondary Clocks. The necessary 8 second signal required to set the minute and second hands to HH:59:00 shall be provided to correct the analog clocks. In addition a 14 second signal, to initiate the 12 hour correction cycle shall also be provided.
- H. The system shall provide for automatic clock correction for Daylight Savings Time.
- I. The system shall provide alpha display on the classroom digital clocks. The words "FIRE" and "BELL" shall either manually or automatically be displayed.

- J. Digital Secondary Clocks
  - The secondary clocks shall be approved. It shall be specifically designed for use with a Remote Clock Driver and associated Administrative Communications System. Provide the following Digital Secondary clocks as indicated in these specifications: 4.0" FLUSH MOUNT DIGITAL CLOCK 4.0" SURFACE MOUNT DIGITAL CLOCK – DOUBLE SIDED
  - 2. Clock synchronization shall be controlled by a Remote Clock Driver. All secondary clocks shall be continuously synchronized with the Master. No hourly clock corrections are required. All clocks shall consistently maintain identical time.
  - 3. The clock shall operate on 24 volt or 120 volt AC power
  - 4. The Digital Clock shall provide display characters no less than 4" high; numerals shall be legible at distances up to 60 feet. The Digital Clock shall provide display characters no less than 4.0" high; numerals shall be legible at distances up to 120 feet.
  - 5. Both the units shall be finished in matte black, semi gloss enamel. The displays shall use A1GaAs "Super-Bright" LEDs exclusively, offering exceptional illumination and visibility.
- K. Analog Secondary Clocks
  - 1. Provide remote Analog Secondary Clocks in locations as indicated in these specifications. The clock shall be a synchronous wired 12 hour, 12 inch, semi-flush mounted unit with a sweep second hand.
  - 2. Gymnasium clocks shall be 15 inch similar to above, complete with wire guards.
  - 3. The clocks shall be synchronous motor driven and operate on 24 volt or 120 volt AC power.
  - 4. The clocks shall have a high impact shatterproof acrylic lens.

### 2.12 SPARE CAPACITY/SYSTEM EXPANSION

A. Include extra circuits for staff telephones and loudspeakers built into the system for future expansion. Provide and install 20% extra circuitry (line cards, expanders, etc.) for these devices. The Owner shall add only field instruments (telephones and loudspeakers), cabling, and programming to make these extra capacity circuits fully operational.

## 2.13 REMOTE SOUND SYSTEMS INTERLOCK

A. Provide circuits, as required, to include loudspeakers connected to remote sound systems in the telecommunication system. Remote loudspeakers shall be temporarily seized during paging,

two-way intercom, any transmitted tonesets and program distribution which includes the remote system(s) area. After completion of the transmission the remote sound system shall be returned to normal local operation.

## 2.14 LOUDSPEAKERS

- A. Provide loudspeaker assemblies at locations indicated on the drawings. Ceiling loudspeakers shall be 8" diameter with a minimum 5 oz. magnet and industry standard 25 volt multi-tap transformer. Provide Rauland ACC1400 loudspeaker, or approved equal. Assembly to include a round white steel baffle, a steel backbox with an approved lining, conduit and connectors as required and an "H" or "T" type grid support mechanism. Provide Lowell LBS8-R1 support or approved equal. In no case shall loudspeakers be solely supported by the ceiling grid.
- B. Provide outdoor loudspeaker assemblies at locations indicated on the drawings. Manufacturer and type of loudspeaker may vary depending on architectural considerations. Loudspeaker shall contain a high compression horn, 25 volt multi-tap transformer, and be water, dust, wind, vandal and insect resistant in design. Loudspeaker shall be capable of flush, semi-flush or surface mounting as required and indicated on the drawings. Loudspeaker shall be constructed of epoxy painted aluminum or zinc. Provide Soundolier VTF Series horn or approved equal.
- C. Provide outdoor call-station and loudspeaker assembly at locations indicated on drawing. Assembly shall contain a waterproof 25 volt loudspeaker with multi-tap transformer, an integral call-in switch and be vandal resistant in design. Assembly shall be constructed of 11 gauge stainless steel and be capable of flush or surface mounting as indicated on the drawings. Provide Rauland HSS-1 intercom station or approved equal.
- D. Provide indoor horn type loudspeaker assemblies at locations indicated on the drawings. Loudspeaker shall contain a high efficiency 30 watt horn, 25 volt multi-tap transformer, and be water, dust, wind and insect resistant in design. Loudspeaker shall be capable of surface mounting as required. Loudspeaker shall be constructed of painted aluminum, steel, or reinforced fiberglass. Provide Rauland 3601 horn or approved equal.

### 2.15 BUS PAGING FACILITIES

- A. Provide a locking surface-mounted telephone box at the location indicated on the drawings, on wall of the Principal's Office. Box shall be supplied with dual (two) locks with keys and a trim ring suitable for masonry mounting. Box shall be constructed of carbon fiber or glass fiber polymer. Box shall not be constructed of metal components. Provide identification label on the exterior of the box. Provide a stainless steel wall mount RJ11 type telephone jack in the box and connect to Communication System. The bus paging telephone shall receive operating power from the telecommunication system UPS. Telephone box shall be 16" high by 12" wide by 6" deep. Telephone box shall be Carlon Model #HM1612-A or approved equal.
- B. Provide a 2.4 GHz digital spread-spectrum, cordless telephone mounted in the telephone box. Telephone shall employ digitally encrypted transmissions with a minimum of 32 channel capacity. Provide a protective belt-holster for the hand-held telephone unit. Program as required

by Owner for bus paging use. Cordless telephone shall be Panasonic Model KX-200B, Engenious Ultra 920-1, or approved equal.

## 2.16 MISCELLANEOUS

- A. Connectors: Cabling shall be terminated neatly and logically on split 50 pair Type 66 termination blocks. All connectors shall be as recommended by the manufacturer or as indicated on the drawings. Provide a service access point in the form of bridging clips for all station, loudspeaker and systems' interface connections. Provide hinged covers on all connector blocks and label covers for circuits contained within. All blocks and cabling connections and terminations shall be installed on fire-treated plywood backboard, minimum of 3/4" thick and painted to match the surrounding wall finish, size and located shall be as shown on the drawings. Provide under Alternate #14.
  - 1. Wall-mounted staff (classroom) telephone jacks shall be metal and suitable for secure mounting of staff telephones. Jack shall be rated for Category 3 applications and shall be supplied with USOC RJ-11 type connectors. Cable pairs one and two shall be terminated on the jacks with pairs three and four left un-terminated and insulated.
- B. Amplifiers: System audio amplifiers selected by the Contractor shall be loaded no more than 80% of rated capacity. Amplifiers shall be rated for continuous commercial duty operation and as recommended by the Manufacturer of the telecommunication system. System shall deliver a minimum of 93 dB at 1 meter at each and every indoor loudspeaker in the system.
  - 1. Equipment Rack: Equipment rack(s) shall be provided for the telecommunication system. The rack shall be upright, floor standing, steel, with a locking rear door. Finish shall be textured black. All unused rack space shall be blanked off with matching steel panels. All central switching equipment, amplifiers, program sources, etc., shall be mounted in a distribution/media retrieval rack.
  - 2. Power amplifiers shall be employ silicon transistors. The amplifiers shall be capable of producing an audio output of 60, 120 or 250 watts RMS at less than 1% distortion and shall have a peak power output of over full wattage. They shall be designed to operate on a line voltage of 115 AC. These amplifiers shall be industry standard and the customer shall be able to have them serviced or replaced by any vendor of their choice.
- C. Cabling:
  - 1. Cabling for all new loudspeaker circuits shall be two (2) conductor 20 22 AWG shielded with gray-colored overall jacket.
  - 2. Cabling for all new telephone jack locations shall be four (4) pair, unshielded, Category 5E type gray-colored overall jacket.
  - 3. New Category 5E cabling system shall be installed for all administrative telephones/fax/modem lines and Call Control consoles. Provide cabling as recommended by the Manufacturer to interconnect the telecommunication system rack and the media retrieval/video headend system rack. Twenty-five (25) pair Category 5 cable shall be installed from the M-POP to the telecom headend for outside line service.

# PART 3 - EXECUTION

## 3.1 GENERAL

- A. The conditions of the General Contract (General, Supplementary, and other Conditions) and the General Requirements are hereby made a part of this Section.
- B. Install and connect all appliances and equipment as specified and shown on the contract drawings in accordance with the manufacturer's instructions and recommendations. Furnish and install complete electrical service and electrical connections as recommended by the manufacturer and as required for proper operation. Prior to roughing in outlets, verify locations, voltages, phase, current rating and type of outlet required from approved shop drawings.
- C. Mark switches, connectors, jacks, receptacles, conduits, outlets, cables, and cable terminations, clearly, logically, and permanently.
- D. Program system per instructions of the Owner.
- E. Execute, without claim for payment, moderate moves or changes necessary to accommodate other equipment to assure symmetry and pleasing appearance.
- F. The system must be matched. All major electronic equipment must be assembled, tested and furnished by one equipment supplier.
- G. Final appearance and finishes are subject to the Owner's approval.
- H. System amplifiers shall be loaded no more than 80% of rated capacity. System shall deliver a minimum of 93db at 1 meter at each and every loudspeaker in the system. Articulation shall be a minimum of 86% in all areas.
- I. Cabling types shall be installed per manufacturer's recommendations in plenum, non-plenum or conduit as required or as indicated on the drawings.
- J. Cabling shall be marked and terminated neatly and logically as specified in 2.15.

### 3.2 INSTALLATION

- A. Install equipment to comply with manufacturer's written instructions.
- B. Wiring Method: Install wiring in raceway except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum-board partitions where cable wiring method may be used. Use plenum cable in environmental air spaces, including plenum ceilings. Conceal cable and raceway except in unfinished spaces.
- C. Install exposed cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings so designed and installed to avoid damage to cables. Secure cable at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, or fittings.

- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess. Use lacing bars in cabinets.
- E. Control-Circuit Wiring: Install number and size of conductors as recommended by system manufacturer for control functions indicated.
- F. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) for speaker microphones and adjacent parallel power and telephone wiring. Separate other school intercom and program equipment conductors as recommended by equipment manufacturer.
- G. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- H. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- I. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables to identify media in coordination with system wiring diagrams.
- J. Cut and patch walls, ceilings, floors, or other building finishes for installation. Repair, restore, and refinish surfaces to original appearance.
- 3.3 GROUNDING
  - A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
  - B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
  - C. Install grounding electrodes as specified in Section "Grounding."
- 3.4 FIELD QUALITY CONTROL
- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installations, including connections and initial system programming. Report results in writing.
- B. Programming: Fully brief Owner on available programming options. Record Owners decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

- C. Operational Test: Test originating station-to-station, all-call, and page messages at each intercom station. Verify proper routing and volume levels and freedom from noise and distortion. Test each available message path from each station on system.
- D. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.
- E. Signal-to-Noise Ratio Test: Measure the ratio of signal to noise of complete system at normal gain settings, using the following procedure:
  - 1. Disconnect a speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure the ratio of signal to noise at paging speakers.
  - 2. Repeat test for three speaker microphones, one master station microphone, and for each separately controlled zone of paging loudspeakers.
  - 3. Minimum acceptable ratio is 45 dB.
- F. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each intercom, paging, and all-call amplifier. For each frequency, measure the distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.
- G. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use a sound-level meter with octave-band filters to measure level at five locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB, and in levels between adjacent zones is plus or minus 5 dB.
- H. Power Output Test: Measure electrical power output of each paging amplifier at normal gain setting at 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.
- I. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Section "Grounding."
- J. Retesting: Correct deficiencies and retest. Prepare written record of tests.
- K. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging and independent room speaker-line matching transformers.
- L. Schedule tests with at least seven days advance notice of test performance.
- M. Contractor shall test all cables and equipment before any demonstrations to the Owner.

### 3.5 DEMONSTRATION

A. Following the installation and tests of the equipment and cables, the system shall be demonstrated to the Owner's representative at a time acceptable to the Owner.

- B. Training of the Owner's personnel shall only start after the system has been accepted by the Owner's representative.
- C. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain equipment as specified below:
  - 1. Train Owners maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining equipment.
  - 2. Review data in maintenance manuals.

3. Schedule training with Owner, through Engineer, with at least seven days' advance notice.

- D. Provide, without additional expense to the Owner, the services of a competent instructor who will give full instruction in the care, adjustment, and operation of all parts of the electronic equipment to the Owner's representatives who are to be in charge of the equipment.
- E. The Instructor shall be familiar with all parts of the system on which instruction is to be given, and shall be trained in operating theory as well as in practical operation and maintenance work.
- F. Separate demonstrations shall be given to the office staff, administrative staff (principal, etc.), and teaching staff; and each demonstration shall be oriented for their particular requirements.

# 3.6 DOCUMENTATION

- A. The conditions of the General Contract (General, Supplementary, and other Conditions) and the General Requirements are hereby made a part of this Section.
- B. A comprehensive installation, operation, programming and instruction manual shall be supplied as part of the system. The manual shall provide complete service information, including schematics, layout drawings, interconnecting diagrams for this particular project and parts lists to permit quick and efficient maintenance and repair of the equipment by a qualified technician. Manuals shall include 8 2" x 11" device location drawings provided in CADD format (Autodesk AutoCadd Release 12 or higher). Manuals shall be neatly bound and indexed. Three (3) copies of the manual shall be provided.
- C. A simplified operation guide, suitable for use by the school staff, shall be provided. This guide shall provide step-by-step instructions for all available functions, an orderly directory for all system stations, telephone numbers and addresses for operational and service assistance from the telecommunications contractor. Provide one manual for each staff telephone; specific to staff telephone functions plus ten (10) spares. Provide fifteen (15) manuals, specific to applicable administrative (EKSU) telephone functions.
- D. The Contractor shall furnish four (4) copies of all plans, drawings, and schematics to the Owner after the acceptance test. The drawings shall show all terminal designation, location of all Junction boxes, terminal cabinets, devices, wiring and conduit routings.

- E. All tests are to be documented and a copy of these tests placed in the O & M Manuals. Prior to insertion in the O & M Manual, supplier shall submit test results to the Engineer for acceptance.
- F. Provide record drawings and floor plans identifying all room outlet numbers and locations.

# 3.7 OCCUPANCY ADJUSTMENTS

- A. On-site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions. Provide up to three on-site assistance visits within one year of Substantial Completion.
- 3.8 LOOSE EQUIPMENT
- A. Deliver to the Owner at the end of the project, all loose equipment including microphones, stands, etc. Obtain signed delivery receipt and include copy of receipt in O&M Manual for the system.

# END OF SECTION

# SECTION 27 52 00 - LOCAL SOUND SYSTEMS

## PART 1 - GENERAL REQUIREMENTS

## 1.1 SCOPE

- A. The intent of this specification is to provide complete and satisfactory operating systems for the pickup, amplification, distribution, and reproduction of audio program material. This specification may also make certain provisions to incorporate pickup and reproduction in the future.
- B. This specification is based on equipment manufactured by JBL, Crown, Rane, TOA, Peavey, and other manufacturers of like reputation and quality. Equipment substitutions will be accepted only if submitted at least ten (10) days prior to bid date. The Engineer shall review any requests and recommend action to the Architect and Owner. Equipment that is judged as inferior, insufficient, or discontinued models shall not be acceptable. The contractor shall provide the required number of complete sets of the following: submittals, shop drawings, rack layouts, patch bay assignments, as-built drawings, instruction manuals for all equipment, and service manuals for all equipment.
- C. The system shall be guaranteed for a period of one (1) year from the date of acceptance against defective materials, workmanship and improper adjustment. Any defective material shall be replaced with no charge to the owner, provided it does not show abuse.

Provide one year of maintenance to consist of at least two (2) semi-annual visits to the site. The maintenance shall consist of, but not be limited to:

- a. level changes to optimize system operation
- b. re-equalization if feedback problems are prevalent
- c. cleaning of all tape heads and transports
- d. routine adjustment and calibration of any equipment
- e. any malfunctions reported by the owner

Notify the owner at least 48 hours prior to a maintenance visit.

- D. It should be noted that this project will take place in an OCCUPIED school building. This may require the installing contractor to take additional precautions for the security of material and equipment, as well as additional precautions to insure the absolute safety of the school's students, faculty and administration.
- E. The specifying authority retains the absolute right to immediately remove from the project any individual or contractor whose work habits, in the specifying authority's sole judgment, are endangering others, or who is acting in an unprofessional manner towards members of the student body and/or others.
- F. To assure compliance with all governmental codes, regulations, and laws, the installing contractor shall have on its staff a Master Electrician licensed within the State of Maryland. Proof of such licensing shall be included with the contractor's submittal.

- G. To assure compliance with all industry and governmental standards and policies, the installing contractor shall have on its staff a BiCSi Registered Communications Distribution Designer. Proof of such registration shall be included with the contractor's submittal.
- H. The contractor shall have an ICIA Certified Technical Specialist (CTS) on staff.
- I. All equipment, except portable equipment, shall be held firmly in place. This shall include loudspeakers, projection equipment, cables, rack enclosures, etc. All switches, connectors, cable, etc. shall be clearly, logically and permanently marked during installation. Markings shall be engraved directly on the required surface, or on "grav-o-ply" plastic, or hot-stamped on heatshrink. Cabling inside equipment racks and large surface raceway shall be secured at six (6)- inch intervals. Wiring shall be carried out according to the standards found in Sound System Engineering by Don & Carolyn Davis (Howard W.Sams and Co., catalog #21857).
- J. Carefully examine the contract documents, the blue prints, and/or the installation site for omissions, existing conditions and general hands-on knowledge. The Contractor shall provide a complete system that fully meets all conditions defined throughout this specification. The contractor must interface with the Electrical Engineer, the Electrical Contractor, the Mechanical Contractor, the Drywall/Finishing Contractor(s), and the General Contractor to: coordinate schedules, define device locations, separate conduit groups, install equipment mounts, and generally coordinate all other aspects of the project. The contractor shall be responsible to insure that the supplied equipment and it's installation meet the requirements set forth herein.
- K. Bid submittals shall include the following:
  - 1. Equipment list
  - 2. Drawings or cuts of all wall plates to coordinate with box types.
  - 3. Block diagram of system
  - 4. Rack drawings
  - 5. Test equipment list (see section 3.2)
  - 6. Statement attesting bidder's experience in sound system design and installation for a period of five (5) years or more. This statement shall point out a job foreman and include detailed personal experience.
  - A list of three (3) similar sound system installations performed within the last two
    (2) years. Include owner/representative names and telephone numbers.
  - 8. Copy of staff Electrician's Liscense and staff BiCSi Designers certification.

All of the above drawings must be CAD generated in a format usable by AutoCAD. All Shop Drawings must be approved by a BiCSi Registered Communications Distribution Designer whose Official Seal and Registration Number must be affixed to each drawing. At the specifying authority's request, 3.5" HD diskettes containing the required drawings must be provided.

# 1.2 FUNCTIONS AND OBJECTIVES

A. Provide sound reinforcement of speech in the areas described. Provide reproduction of program audio in these areas. This reinforcement and reproduction shall be in the form of

actual sound from loudspeakers.

- B. Provide for microphone pickup, both wired and wireless, of "live" program material from locations as shown on the drawings. Provide microphone-level input circuits to accommodate the above. Provide at least one (1) spare microphone input channels in each system.
- C. Provide for program playback, both permanent and temporary, of pre-recorded audio and/or video material from the Equipment Cabinets as shown on the drawings. Provide input circuits to accommodate the playback sources specified herein. Also provide an input, for portable sources, on the front panel of the cabinet. Each input shall have a dedicated volume control as integral features of the mixer(s).
- H. Provide even distribution of the reinforced sound throughout the listening area, typically □3dB front to back and side to side for the one-octave band centered at 4000 Hz. Total variation from the "worst" to the "best" seat shall not exceed □4dB.
- J. Provide uniform frequency response throughout the audience area. Typically, □3dB from 100Hz-10KHz as measured with broadband pink noise and a 1/3-octave real-time analyzer.
- K. Provide adequate dynamic range to reproduce program peaks without distortion. The sound systems shall be capable of delivering 85dBA SPL (95dB SPL for the Gymnasium) average program level with an additional 10dB peaking margin to any audience position.

## 1.3 SYSTEM TYPES

A. Gymnasium Sound Reinforcement System. Wall-mounted speakers will provide for a stand alone system in the Gym, with the capability to combine with the Cafeteria system when the partition is open, with the Cafeteria as the master. A "Combine/Separate" switch shall be provided at the equipment cabinet. This switch shall bridge the two mixers and designate the Cafeteria as the master mixer to feed both rooms Clearly label the master volume control for all functions. The DSP shall have presets configured for the "separate" and "combined" modes, delaying the gymnasium speakers to the cafeteria speakers, and adjusting the output levels so that all sound appears to emanate from the Cafeteria system. When rooms are combined, the three speakers facing the Cafeteria shall be turned off and the remaining three shall be delayed to the Cafeteria speakers.

The system shall consist of a mixer, power amplifier, digital signal processor, wireless microphones and microphone jacks.

- B. Cafeteria Sound Reinforcement System -Wall-mounted speakers will provide for a stand alone system in the Cafeteria, with the capability to combine with the Gymnasium system when the partition is open, with the Cafeteria as the master. The system shall consist of a mixer, power amplifier, digital signal processor, wireless microphones and microphone jacks.
- C. Hearing Assistance System Provide a reinforcement system for the hearing impaired in both the Gymnasium and Cafeteria. The hearing assistance system shall be an FM radio system
that shall not limit operation to certain seats or areas of the room(s). Provide approximately 20-40 milliseconds of high-quality digital signal delay to help in the localization of the sound source. Contractor is to ensure that each system will work without interference when the systems are in "separate" mode. Each hearing assistance system shall receive the same signal when the rooms are in "combined" mode.

# PART 2 - PRODUCTS

# 2.1 GYMNASIUM SOUND EQUIPMENT

- A. FM Wireless Microphone System:
  - 1. The Wireless Microphone shall be a miniature battery-operated FM transmitter and matching AC powered receiver incorporating compander circuitry to increase dynamic range and signal-to-noise ratio. The systemshall operate in the UHF band, utilizing dual diversity antennae for reducing multipath problems. A backlit LCD display shall show the operating frequency, antenna signal strength and transmitter battery life. An auto-detect mode shall allow the receiver to synchronize with the matng transmitter.
  - 2. Each system shall incorporate agile frequency tuning and shall be able to operate with up to 12 wireless systems simultaneously.
  - 3. Minimum Overall Performance Requirements:
    - a. Frequency Response:  $45-15,000 \text{ Hz}, \pm 2 \text{ dB}$  (without mic).
    - b. Distortion: 0.5% THD.
    - c. Dynamic Range: >100dB, A weighted.
    - d. RF Carrier Frequency: 518-752 MHz.
    - e. Frequency Sensitivity: -105dBm for 12dB SINAD
  - 4. Hand-Held Transmitter, provide one:
    - a. Hand-held microphone with built-in transmitter, batteries, and antenna.
    - b. LCD display showing frequency and battery life.
    - c. Power Output: 30mW RF using 2 AA batteries.
    - d. Acceptable Products:
      - 1) Sennheiser SKM135G2 with mating swivel stand adapter.
      - 2) Shure SLX2/SM58 with mating swivel stand adapter.
  - 5. Receiver, provide one:
    - a. AC powered receiver in  $\frac{1}{2}$  rack package with dual antennas.
    - b. A backlit LCD displaying frequency, RF signal and transmitter battery life. .
    - c. Balanced microphone and line-level output on rear panel.
    - d. Provide two remote 1/4 wave antennas and mounts per receiver
    - e. Acceptable Products:
      - 1) Sennheiser EM100G2/NT with rack mount.
      - 2) Shure SLX4 with rack mount.
- B. General Purpose Microphone:
  - 1. Usable in floor or desk stand using included clip.
  - 2. Hyper-cardioid or Super-cardioid directional characteristic.
  - 3. 15 dB or greater front-to-back discrimination from 100-8000 Hz.
  - 4. Frequency response  $\pm 3 \text{ dB from } 120-12 \text{ kHz}$ .
  - 5. Provide with two 25' braided shield mic cable with cast zinc alloy connectors per

microphone.

- 6. Acceptable products, provide two:
  - a. Shure Beta 58M.
  - b. Sennheiser e845.
  - c. EV RE16.
- C. Microphone Stands
  - 1. Floor stand with 10" diameter cast iron base. Two-section extendible tube of 7/8" and 5/8" seamless steel tubing. Standard 5/8"-27 thread, adjustable from 37-60 inches in height. Black tube and base. Provide two Atlas MS-12CE microphone stand.
  - 3. Desk stand with small footprint base and short mounting tube. Tube to be 4-8" in height and finished in black. Base to be isolating type, black in color weighing at least 1.5lb. Provide two Atlas DS-2E.
- D. Microphone Mixer:
  - 1. The mixer shall be a high quality modular design with at least eight configurable inputs. Each input shall have a dedicated front panel level control. Input modules shall be available for microphone, line level and other various inputs.
  - 2. A master level control, bass and treble tone controls and level indicator LED shall be provided. A mute function shall be provided. Remote volume control capability must be provided.
  - 3. The rear panel shall feature preamp output connections, a bridging input/output jack low cut switch and external mute jack shall be provided.
  - 4. The output section shall deliver +20dBm at less than 0.1% THD. Provide output terminals for 150 ohm and 600 ohm transformer-balanced main output as well as an aux out jack.
  - 6. Acceptable product, provide one:

a. TOA M-900MK2 with rack mount and M-11S microphone and B-01S line input modules.

b. Peavey A/A MMA800T with rack mount, MPT-S2 microphone modules and BTM-S line input modules.

- c. Equal with the above stated features.
- E. CD Changer
  - a) Provide a rack-mount stereo 5 CD changer with infrared remote control.
  - b) Integrated balanced, unbalanced and digital outputs. Wire balanced line to stereo line input channel strip of the mixing console.
  - c) Acceptable products, provide one:
    - 1. Denon DCM-290P
    - 2. Tascam CD-355
- F. Programmable Dual DSP Processor:
  - 1. Tamper-resistant unit without front panel controls, with on-board non-volatile memory for multiple presets, field programmable internally with security code lockout, or by external device.
  - 2. Minimum requirements are: two input channels; four output channels; 1/3 octaveband analog cut/boost filters on ANSI preferred 31.5-16,000 Hz center frequencies; input

signal delays; output signal delays; compressor/limiters; and programmable gain settings.

- 3. Programming of settings using personal computer running Windows 98 minimum.
- 4. Dimensions: 1-3/4" high for standard 19" rack-mounting.
- 5. Minimum Performance Requirements:
  - a. Frequency Response:  $\pm 0.5$  dB, 20-20,000 Hz. with controls set for flat response.
  - b. Distortion: 0.05% THD at 0 dBm output, 20-20,000 Hz, with controls set for flat response.
  - c. Dynamic Range: >96dB.
  - d. 1/3 Octave Filter Control Range:  $\pm 12$  dB in 1/2 dB steps.
  - e. Infra-Sonic Filter: 12 or 18 dB/octave slope, 16-20 Hz.
  - f. Gain: -20 to +20dB.
  - g. Input: max. +18 dBu. balanced bridging min. 10k ohms.
  - h. Output: max. +18 dBu, balanced for min. 600 ohm load.
  - i. Memory: EEPROM non-volatile memory with at least 8 memory locations, battery-backed memory shall not be acceptable.
  - Programmable Dual DSP Processor-Acceptable Products:
  - 1. Rane RPM26z.
  - 2. dbx Drive Rack 220i may be acceptable if 2 units are provided.
  - 3. Shure DFR22 may be acceptable if 2 units are provided.
- G. Power Amplifier:

- 1. Solid-state, two channel amplifier. Capable of withstanding +22dBu input.
- 2. Front panel indication of clipping.
- 3. All inputs via barrier type terminal strips, Phoenix or XLR-type connectors. All outputs via barrier type terminal strips or 5-way binding posts.
- 4. Minimum Performance Requirements:
  - a. Frequency Response:  $\pm 0.1$  dB, 20-20,000 Hz.
  - b. Distortion: 0.1W THD, 20-20.000 Hz at full rated output.
  - c. Signal to Noise Ratio: 100 dB below rated 8 ohm output at 1k Hz.
  - d. Inputs: min. 20k, balancedI
  - e. Minimum Rated Load Impedance: 4 ohms, able to operate safely into any load.
- 5. Output Power:
  - 500W per channel minimum into 4 ohms or 70 volt line.
- 6. Acceptable Products, provide one:
  - a. Crown CDi1000
  - b. Architectural Acoustics ICA 600 (must provide DSP listed above).
  - c. QSC ISA 450 (must provide DSP listed above)
- H. Loudspeakers
  - 1. The loudspeakers shall be two-way design with 12" low frequency drivers and 1" high frequency driver/horn combination.
  - 2. Each loudspeaker shall provide the following features:
    - a. Protection Steel ball gaurds over cone drivers
    - b. Frequency Response/Sensitivity 60Hz-15KHz, +3,-5dB/100dBSPL, 1W 1m
    - c. Power Rating 250W continuous pink noise
    - d. Dimensions 27" x 17" x 17.5"

- e. Weight 38 lbs.
- f. Dispersion 90 deg x 60 deg @ -6dB
- g. Mounting integral mounting points on cabinet rear for mounting brackets
- 3. Acceptable products, provide six in a central cluster:
  - a. Electro-Voice SX100+
  - b. Architectural Acoustics Quadra 12
  - c. JBL Eon 1500
- 4. When rooms are combined, the three speakers facing the Cafeteria shall be turned off and the remaining three shall be delayed to the Cafeteria speakers.
- I. Equipment Cabinet:

- 1. The rack shall be a section wall-mounted cabinet constructed of 16 gauge CRS throughout. The rear section and front door shall be hinged to the center section. The hinges shall be bolted not welded.
- 2. Each section shall be one-piece construction with M.I.G. welded joints and seams.
- 3. The rear section shall have concentric 1/2" and 3/4" knockouts at the top and bottom.
- 4. The equipment mounting rails shall be tapped with 10-32 holes at EIA 19" rack spacing.
- 5. The front door shall allow 2" of distance from the mounting rails when closed. A cylinder lock shall be provided. Provide six keys to the owner.
  - Acceptable products, provide one:
    - 1. Atlas/Soundolier 320-26B.
    - 2. Middle Atlantic SWR18-16 with WRD-10 door.
    - 3. Lowell L53-28.
- 7. Include one (1) Furman PL8 Pro Power Conditioner or comparable product by Surge X or Monster for each rack.
- 8. Provide one (1) Atlas SD7-145 Four Space Storage Drawer or comparable product by Middle Atlantic or Lowell.
- J. Hearing Assistance System:
  - 1. FM radio transmission system operating in the 72-76 MHz Auditory Assistance Band as set aside by the FCC.
  - 2. Digitally selectable operating frequency within the approved band.
  - 3. Input connections to include balanced XLR and unbalanced RCA selectable to mic level, line level and speaker level.
  - 4. Shaped frequency response with selectable high pass filter, compressor, peak limiter and enhancing circuit.
  - 5. Front panel monitor jack and level control.
  - 6. Minimum performance characteristics:
    - a. FM modulation transmission system
    - b. 50Hz-15KHz  $\pm$  3dB frequency response
    - c. 8000uV/m radiating power at 3m (~20mW)
    - d. Signal to noise ratio of 80 dB with SQ.
    - e. 50PPM transmitter stability
  - 7. Acceptable products, provide one transmitter, ten receivers and two neck loops:
    - a. Listen LT 800-072 transmitter with remote antenna and rack mount. Listen LR400-072 receiver with single earbud.

Listen LA-166 Neckloop.

b. Approved equal by Telex, Phonic Ear or Williams Sound with the same features and performance specifications.

# 2.2 CAFETERIA SOUND EQUIPMENT:

- A. FM Wireless Microphone System:
  - 1. The Wireless Microphone shall be a miniature battery-operated FM transmitter and matching AC powered receiver incorporating compander circuitry to increase dynamic range and signal-to-noise ratio. The systemshall operate in the UHF band, utilizing dual diversity antennae for reducing multipath problems. A backlit LCD display shall show the operating frequency, antenna signal strength and transmitter battery life. An auto-detect mode shall allow the receiver to synchronize with the matng transmitter.
  - 2. Each system shall incorporate agile frequency tuning and shall be able to operate with up to 12 wireless systems simultaneously.
  - 3. Minimum Overall Performance Requirements:
    - a. Frequency Response: 45-15,000 Hz,  $\pm 2 \text{ dB}$  (without mic).
    - b. Distortion: 0.5% THD.
    - c. Dynamic Range: >100dB, A weighted.
    - d. RF Carrier Frequency: 518-752 MHz.
    - e. Frequency Sensitivity: -105dBm for 12dB SINAD
    - Hand-Held Transmitter, provide one:
    - a. Hand-held microphone with built-in transmitter, batteries, and antenna.
    - b. LCD display showing frequency and battery life.
    - c. Power Output: 30mW RF using 2 AA batteries.
    - d. Acceptable Products:

- 1) Sennheiser SKM135G2 with mating swivel stand adapter.
- 2) Shure SLX2/SM58 with mating swivel stand adapter.
- 5. Receiver, provide one:
  - a. AC powered receiver in  $\frac{1}{2}$  rack package with dual antennae.
  - b. A backlit LCD displaying frequency, RF signal and transmitter battery life. .
  - c. Balanced microphone and line-level output on rear panel.
  - d. Provide two remote 1/4 wave antennas and mounts per receiver
  - e. Acceptable Products:
    - 1) Sennheiser EM100G2/NT with rack mount.
    - 2) Shure SLX4 with rack mount. 3)
- B. General Purpose Microphone:
  - 1. Usable in floor or desk stand using included clip.
  - 2. Hyper-cardioid or super-cardioid directional characteristic.
  - 3. 15 dB or greater front-to-back discrimination from 100-8000 Hz.
  - 4. Frequency response  $\pm 3 \text{ dB}$  from 120-12kHz.
  - 5. Provide with two 25' braided shield mic cable and cast zinc alloy connectors per microphone.
  - 6. Acceptable products, provide two:
    - a. Shure Beta 58M.

- b. Sennheiser e845..
- c. EV RE16.
- C. Microphone Stands:
  - 1. Floor stand with 10" diameter cast iron base. Two-section extendible tube of 7/8" and 5/8" seamless steel tubing. Standard 5/8"-27 thread, adjustable from 37-60 inches in height. Black tube and base. Provide two Atlas MS-12CE microphone stand.
- D. Microphone Mixer:
  - 1. The mixer shall be a high quality modular design with at least eight configurable inputs. Each input shall have a dedicated front panel level control. Input modules shall be available for microphone, line level and other various inputs.
  - 2. A master level control, bass and treble tone controls and level indicator LED shall be provided. A mute function shall be provided. Remote volume control capability must be provided.
  - 3. The rear panel shall feature preamp output connections, a bridging input/output jack low cut switch and external mute jack shall be provided.
  - 4. The output section shall deliver +20dBm at less than 0.1% THD. Provide output terminals for 150 ohm and 600 ohm transformer-balanced main output as well as an aux out jack.
    - Acceptable product, provide one:

a. TOA M-900MK2 with rack mount and M-11S microphone and B-01S line input modules.

b. Peavey A/A MMA800T with rack mount, MPE-S3 microphone modules and AUX 2 line input modules.

- c. Equal with the above stated features. modules.
- E. Power Amplifier:

- 1. Solid-state, two channel amplifier. Capable of withstanding +22dBu input.
- 2. Front panel indication of clipping.
- 3. All inputs via barrier type terminal strips, Phoenix or XLR-type connectors. All outputs via barrier type terminal strips or 5-way binding posts.
- 4. Minimum Performance Requirements:
  - a. Frequency Response:  $\pm 0.1$  dB, 20-20,000 Hz.
  - b. Distortion: 0.1W THD, 20-20.000 Hz at full rated output.
  - c. Signal to Noise Ratio: 100 dB below rated 8 ohm output at 1k Hz.
  - d. Inputs: min. 20k, balancedI
  - e. Minimum Rated Load Impedance: 4 ohms, able to operate safely into any load.
- 5. Output Power: 500W per channel minimum into 4 ohms or 70 volt line
- 500W per channel minimum into 4 ohms or 70 volt line.
- 6. Acceptable Products, provide one:
  - a. Crown CDi1000
  - b. Architectural Acoustics ICA 600.
  - c. QSC ISA 450 (must provide DSP listed above)
- F. CD Player
  - a. Provide a rack-mount stereo CD player with infrared remote control.

- b. Integrated balanced, unbalanced and digital outputs.
- c. Front panel  $\pm 8\%$  pitch control. Instant start on play and Cue features.
- d. Acceptable products, provide one:
  - 1. Denon DN-615.
    - 2. TASCAM CD-01U.
- G. Solid State Recorder
  - a. Records to compact flash and CD-R/RW.
  - b. Balanced XLR and unbalanced RCA line inputs and outputs
  - c. Auto track increment
  - d. Acceptable products, provide one:. Tascam SS-CDR1.
- H. Loudspeakers
  - 1. The loudspeakers shall be two-way design with 12" low frequency drivers and 1" high frequency driver/horn combination.
  - 2. Each loudspeaker shall provide the following features:
    - a. Protection Steel ball gaurds over cone drivers
    - b. Frequency Response/Sensitivity 60Hz-15KHz, +3,-5dB/100dBSPL, 1W 1m
    - c. Power Rating 250W continuous pink noise
    - d. Dimensions 27" x 17" x 17.5"
    - e. Weight 38 lbs.
    - f. Dispersion 90 deg x 60 deg @ -6dB
    - g. Mounting integral mounting points on cabinet rear for mounting brackets
  - 3. Acceptable products, provide two:
    - a. Electro-Voice SX100+
    - b. Architectural Acoustics Quadra 12
    - c. JBL Eon 1500
- I. Equipment Cabinet:
  - 1. The rack shall be a section wall-mounted cabinet constructed of 16 gauge CRS throughout. The rear section and front door shall be hinged to the center section. The hinges shall be bolted not welded.
  - 2. Each section shall be one-piece construction with M.I.G. welded joints and seams.
  - 3. The rear section shall have concentric 1/2" and 3/4" knockouts at the top and bottom.
  - 4. The equipment mounting rails shall be tapped with 10-32 holes at EIA 19" rack spacing.
  - 5. The front door shall allow 2" of distance from the mounting rails when closed. A cylinder lock shall be provided. Provide six keys to the owner.
  - 5. Acceptable products, provide one:
    - 1. Atlas/Soundolier 320-26B.
    - 2. Middle Atlantic SWR18-16 with WRD-10 door.
    - 3. Lowell L53-28.
- J. Hearing Assistance System:
  - 1. FM radio transmission system operating in the 72-76 MHz Auditory Assistance Band as set aside by the FCC.
  - 2. Digitally selectable operating frequency within the approved band.

- 3. Input connections to include balanced XLR and unbalanced RCA selectable to mic level, line level and speaker level.
- 4. Shaped frequency response with selectable high pass filter, compressor, peak limiter and enhancing circuit.
- 5. Front panel monitor jack and level control.
- 6. Minimum performance characteristics:
  - a. FM modulation transmission system
  - b. 50Hz-15KHz  $\pm$  3dB frequency response
  - c. 8000uV/m radiating power at 3m (~20mW)

# 2.3 WIRE

- A. Provide West Penn 291, or equal, for all microphone jack, line jacks and remote volume control locations, and for all line level wiring. Color code wires for separate functions (e.g. blue=microphone, violet=line level, green=volume).
- B. Provide West Penn 226, or equal, for the Gymnasium loudspeaker cluster circuits.
- C. Provide West Penn 225, or equal, for the Cafeteria loudspeaker circuits.

# 2.4 CONNECTORS

- A. Provide Neutrik NC3 series "XLR", Neutrik NP3C "TRS" or Canare F-09 "RCA" connectors for microphone and line level connections
- B. Provide Switchcraft N112B connectors for line inputs.
- C. Provide crimped or gas-tight terminals for all loudspeaker connections. Wirenuts are not acceptable.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. The Contractor shall be responsible for mounting and installing of all equipment specified herein. All conduit and hardware related to the conduit (i.e. boxes, supports, blank plates, etc.) shall be provided by others. All wire to support the Sound system, except AC power wire, shall be fully installed (pulled and terminated) by the Sound Contractor.
- B. The equipment racks shall be fully assembled and tested in the contractors shop prior to delivery to the site. All wires that come into the equipment rack shall be terminated on barrier strips or quick-connect termination blocks specifically designed for stranded wire. Telephone-type 66 blocks shall not be acceptable for termination of stranded wire. Wires entering the equipment racks shall not connect directly to any equipment.
- C. Install the wires entering the equipment racks in such a way as to allow re-adjustment of the rack location by the user. Use Cole-Flex XS100-type expandable braid sleeving around each bundle of signal wires and furnish six (6) foot loops that will rest off the floor when the rack is not pulled out into the room. Assure adequate strain relief of all wires.

- D. Install different signal types in separate conduits. Run and bundle wire types in groups allowing separation of at least 12 inches between types. Do not run any signal wires in parallel to AC power cabling. Signal and AC power wires shall only meet and cross at right angles to each other. Coordinate with the Electrical Contractor to have conduits of like signal types grouped at Sound junction boxes, or run signal types separately in divided surface raceway between Sound junction boxes and the equipment racks.
- E. Install the loudspeakers as depicted in the drawings. Follow the manufacturer's recommendations for rigging and support structures. The Contractor shall gasket each underbalcony baffle to prevent rattling and resonance between the ceiling and speaker assembly. Pull speaker circuits through separate conduit from microphone or line level circuits.
- F. Install microphone outlets as shown on the drawings. Wire all cables pin for pin with: shield on pin 1, hot or red on pin 2, and cold or black on pin 3. The outlet shall be a Soundolier S-501 with Switchcraft C3F, or equals. Pull microphone circuits through separate conduit from speaker or line level circuits. All microphone circuits shall be home run lines without splices.
- G. Install remote volume controls as shown on the drawings. Do not splice wires, parallel connections only on approved terminal strips in enclosures or by neat and orderly soldering on connectors.
- H. Fill all blank spaces in the equipment cabinet with panels of appropriate size. Provide security covers for all equalizers, delays, and other non-user preset controls.

## 3.2 SYSTEM PERFORMANCE TESTS

- A. Provide all required testing apparatus to complete the performance test of the system. Provide knowledgeable personnel to perform the testing.
- B. Provide the following minimum test equipment:
  - 1. Audio Toolbox or Audio Control SA-3050A with calibrated microphone and printer output options.
  - 2. TEF 12+ or TEF 20 TDS analyzer or Audio Precision P1A.
  - 3. Earthworks M30 microphone and preamplifier.
  - 4. Sennheiser ZP-3 or Goldline ZM1 AC impedance bridge
  - 5. HP 8903BDistortion analyzer
  - 6. Oscilloscope
  - 7. Sound level meter
  - 8. Digital Multimeter
- C. Measure and record the DC loop resistance of all microphone lines with a shorting plug installed in place of the microphone.
- D. Check and correct the phasing of all loudspeakers.
- E. Measure and record the impedance of all loudspeakers including the connecting wires. The

values may be checked with the impedance meter but, the measurements shall made and recorded with the TEF analyzer, as recommended by the manufacturer, from 20 Hz to 20,000 Hz.

- F. Measure and record the THD and noise level of each amplifier channel. Load the output with 8 ohm power resistors. Adjust controls for optimum signal-to-noise ratio and full amplifier output with a -50 dBm, 1 kHz sine wave at one microphone input. Measure and record the distortion level; the level shall be less than 1%. Substitute a 150 ohm resistor at the microphone input and measure and record the overall hum and noise at each amplifier output. The level shall be down at least 80 dB from the full output level from 20 Hz 20,000 Hz.
- G. Check for oscillation and radio frequency pickup. Set up system for intended usage, less any microphones. Use an oscilloscope on the speaker lines to monitor the output of the system. Insure that the system is free of spurious oscillation and RF pickup with no input signal and when driven to 75 dBA with a 500 Hz sine wave.
- H. Check for and correct any rattles or buzzes. Apply a full range music source adjusted so that peaks are at specified minimum sound pressure level. Apply a swept sine wave from 100 Hz
  2,000 Hz at the specified average sound pressure level. There shall be no irregularities.
- I. Adjust system levels so the limiter/compressor (or the mixer's integral limiter) activates just before clipping of any and all amplifiers. The limiter shall be turned "OFF" for all other tests. Reactivate and recheck the limiter after all other tests have been completed.
- J. Adjust the digital delay line to a setting that provides the best time coherence between the visual source, speaker systems and hearing assistance system.
- K. Measure and record, on the chart recorder, from at least three (3) representative positions, the "RAW" frequency response of the voice speaker system alone, without equalization. Repeat the above procedure for the program speaker system.
- L. Equalize, measure and record the "EQUALIZED" frequency response of just the speaker system from at least three positions. The response shall be □3 dB of the following:
  - 1. Flat and even between 100 and 5,000 Hz.
  - 2. Fast rolloff (about 12dB per octave) below 50 Hz.
  - 3. Slow rolloff (about 3dB per octave) between 5,000 and 10,000 Hz.
  - 4. Fast rolloff (about 6-12dB per octave) beyond 15,000 Hz.
- M. Measure the maximum output level of the system. Apply full range music adjusted so that peaks remain below the clipping level of the amplifiers. Measure the output level at peaks with the "fast" setting on the SLM. The audio system shall be able to deliver at least 105 dBA SPL to any audience position in the Gymnasium and 95dBA SPL in the Cafeteria.

## 3.7 OCCUPANCY ADJUSTMENTS

A. On-site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions. Provide up to three on-site assistance visits within one year of Substantial Completion.

## 3.8 LOOSE EQUIPMENT

A. Deliver to the Owner at the end of the project, all loose equipment including microphones, stands, etc. Obtain signed delivery receipt and include copy of receipt in O&M Manual for the system.

# **END OF SECTION**

# SECTION 27 52 50 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

#### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to the work of this Section.

#### 1.2 SUMMARY

- A. Provide all materials and labor for the installation of a grounding and bonding system for communications infrastructure. This section includes requirements for providing a permanent grounding and bonding infrastructure for communications circuits, raceways, and cable tray.
- B. Related Sections
  - 1. Division 27 Section "Conduit and Backboxes for Communications Systems"
  - 2. Division 27 Section "Inside Plant Communications Systems"

#### 1.3 REFERENCES

- A. The applicable portions of the following specifications, standards, codes and regulations shall be incorporated by reference into these specifications.
  - 1. General:
    - a. National Electrical Code (NEC)
    - b. National Electrical Safety Code (NESC)
    - c. Occupational Safety and Health Act (OSHA)
  - 2. Communications:
    - a. TIA/EIA 568: Commercial Building Telecommunications Cabling Standard
    - b. TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
    - c. TIA/EIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
    - d. TIA/EIA 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
    - e. ISO/IEC IS 11801: Generic Cabling for Customer Premises
    - f. BICSI: BICSI Telecommunications Cabling Installation Manual
    - g. BICSI: BICSI Telecommunications Distribution Methods Manual (TDMM)

h. BICSI: BICSI Customer-Owned Outside Plant Design Manual (CO-OSP)

#### 1.4 DEFINITIONS

- A. "TMGB" shall mean *Telecommunications Main Grounding Busbar*. There is typically one TMGB per building, located in the main telecommunications room. This busbar is directly bonded to the electrical service ground.
- B. "TGB" shall mean *Telecommunications Grounding Busbar*. There is typically one TGB per telecommunications room. The TGB is connected both to the TMGB and to building structural steel or other permanent metallic systems.
- C. "TBB" shall mean *Telecommunications Bonding Backbone*. The TBB is a conductor used to connect TMGBs to TGBs.

#### 1.5 SYSTEM DESCRIPTION

- A. Furnish, install, and place into satisfactory and successful operation all materials, devices, and necessary appurtenances to provide a complete, permanent Grounding and Bonding infrastructure for communications circuits, raceways, and cable trays as hereinafter specified and/or shown on the Contract Documents. The Grounding and Bonding system shall support an ANSI/TIA/EIA and ISO/IEC compliant communications Structured Cabling System (SCS).
- B. The work shall include materials, equipment and apparatus not specifically mentioned herein or noted on the plans but which are necessary to make a complete working ANSI/TIA/EIA and ISO/IEC compliant Grounding and Bonding system.

## 1.6 SUBMITTAL INFORMATION

- A. Product Data Submittals: Provide submittal information for review before materials are delivered to the job site. Provide product data submittals for all products at the same time.
  - 1. Submit a letter stating that the materials will be provided as specified, and specifically listing any items that will not be provided as specified. The letter shall also state that the Contractor has reviewed the specified items and agrees that they are applicable to this project in all respects.
  - 2. For those items noted as allowing "or equal," and which are not being provided as specifically named, submit standard manufacturer's cut sheets or other descriptive information, along with a written description detailing the reason for the substitution.
  - 3. Provide standard manufacturer's cut sheets and the operating and maintenance (O&M) instructions at the time of submittal review for each device in the system, regardless of whether it is submitted as specified or as an approved equal. These instructions shall detail how to install and service the equipment and shall include information necessary for rough-in and preparation of the building facilities to receive the materials.
- B. Closeout Submittals: Provide submittal information for review as follows:
  - 1. O&M Manual for Communications At the completion of the project, submit O&M information from product data submittals (above), updated to reflect any changes during

the course of construction, to the Designer in the telecommunications-specific O&M Manual for Communications binder labeled with the project name and description.

- 2. Records Maintain at the job site a minimum of one set of Record Drawings, Specification, and Addenda. Record Drawings shall consist of redline markups of drawings, specifications and spreadsheets.
  - a. Document changes to the system from that originally shown on the Contract Documents and clearly identify system component labels and identifiers on Record Drawings.
  - b. Keep Record Drawings at the job site and make available to the Owner and Designer at any time.
  - c. Keep Record Drawings current throughout the course of construction. ("Current" is defined as not more than one week behind actual construction).
  - d. Show identifiers for major infrastructure components on Record Drawings.

# 1.7 SEQUENCING

## 1.8 CONTRACTOR WARRANTY:

- A. Provide a Contractor-endorsed two-year service warranty against defects in materials and workmanship.
  - 1. Provide labor attributable to the fulfillment of this warranty at no cost to the Owner.
  - 2. The Contractor Warranty period shall commence upon Owner acceptance of the work.

# PART 2 - PRODUCTS

## 2.1 GENERAL

A. Materials shall consist of busbars, supports, bonding conductors and other incidentals and accessories as required.

## 2.2 MATERIALS

- A. Grounding/Bonding:
  - 1. Telecommunications Main Grounding Bus Bar (TMGB):
    - a. Large (20" x 4" x <sup>1</sup>/<sub>4</sub>"), Pre-drilled: CPI 10622-020, or equal
    - b. Small (10" x 4" x <sup>1</sup>/<sub>4</sub>"), Pre-drilled: CPI 10622-010, or equal
  - 2. Telecommunications Grounding Bus Bar (TGB):
    - a. Large (20" x 4" x ¼"), Pre-drilled: CPI 10622-020, or equal
    - b. Small (10" x 4" x <sup>1</sup>/<sub>4</sub>"), Pre-drilled: CPI 10622-010, or equal

- 3. Telecommunications Bonding Backbone: #6 AWG insulated (green in color) copper conductor.
- 4. Grounding Conductor: #6 AWG insulated (green in color) copper conductor.
- B. Firestopping material: Conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of the actual field conditions.
- C. Labels: As recommended in ANSI/TIA/EIA 606. Permanent (i.e. not subject to fading or erasure), permanently affixed, and created by a hand-carried label maker or a computer/software-based label making system. Handwritten labels are not acceptable.
  - 1. Hand-carried label maker:
    - a. Brady: ID Pro Plus (or approved equal).
  - 2. Labels:
    - a. Brady: Bradymaker Wire Marking Labels WML-511-292 (or approved equal)

## PART 3 - EXECUTION

- 3.1 GENERAL
  - A. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances.
  - B. All work shall comply with applicable safety rules and regulations including OSHA. All work shall comply with the requirements of the National Electrical Safety Code (NESC) and the NEC except where local codes and/or regulations are more stringent, in which case the local codes and/or regulations shall govern.
  - C. All work shall comply with the standards, references and codes listed in PART 1 --REFERENCES above. Where questions arise regarding which standards, references, or codes apply, the more stringent shall prevail.
  - D. All work shall comply with the requirements and recommendations of the product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.
  - E. Replace and/or repair to original (or better) condition any existing structures, materials, equipment, etc. inadvertently demolished or damaged by the Contractor during the course of construction at no additional cost to the Owner.
  - F. Install the grounding and bonding system in a manner ensuring that communications circuits, when installed, are able to fully comply with the ANSI/TIA/EIA and other references listed in Part 1 References, above.
  - G. Remove surplus material and debris from the job site and dispose of legally.

## 3.2 INSTALLATION

- A. The grounding and bonding infrastructure system shall not make use of the building plumbing system, unless required to do so by the NEC.
  - 1. Coordinate the installation of the grounding and bonding system with the electrical power distribution system grounding infrastructure.
- B. Ground/Bonding:
  - 1. TMGB: Provide a minimum of one TMGB per telecommunications entrance room for each building and as shown on the Contract Documents. Install TMGB(s) and directly bond TMGB(s) to electrical service ground and to associated TBB(s). Group protector, busbar bonding, and approved building grounding conductors toward one end of the TMGB and leave space for equipment grounding conductors on the other end.
  - 2. TGB: Provide a minimum of one TGB per telecommunications room for each building and as shown on the Contract Documents and as required by the standards, references and codes listed in PART 1 -- REFERENCES above. Directly bond each TGB to its associated TBB and to the nearest building structural steel or other permanent metallic system. Group protector, busbar bonding, and approved building grounding conductors toward one end and leave space for equipment grounding conductors on the opposite end.
  - 3. TBB(s) and Grounding Conductors: Provide TBB(s) and grounding conductors as shown on the Contract Documents and as required to bond all non-current carrying metal telecommunications equipment and materials to the nearest TGB. Use TBB(s) to connect the TMGB to each TGB. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. Insulate TBB(s) and conductors from their support. TBB(s) and grounding conductors shall be continuous (without splices).
    - a. Ensure that bonding breaks through paint to bare metallic surface of all painted metallic hardware.
- C. Firestopping
  - 1. Only employees trained/certified by the firestopping manufacturer shall apply firestopping materials.
  - 2. Maintain the fire rating of all penetrated fire barriers. Fire stop and seal all penetrations made during construction.
    - a. Provide firestopping material for through and membrane penetrations of fire-rated barriers.
    - b. Install firestops in strict accordance with manufacturer's detailed installation procedures.
    - c. Install firestops in accordance with fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and applicable codes and standards referenced in PART 1 REFERENCES. Apply of sealing material in a manner acceptable to the local fire and building authorities.

- d. For demolition work, apply firestopping to open penetrations in fire rated barriers where cable is removed. Apply firestopping regardless of whether or not the penetrations are used for new cable or left empty after construction is complete.
- e. Firestopping material used to seal open penetrations through which cable passes shall be re-usable/re-enterable.

D. Labels:

- 1. Label TMGB(s) with "TMGB"
- 2. Label TGB(s) with "TGB".
- 3. Label TBB(s) and bonding conductors "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

# **END OF SECTION**

# SECTION 27 58 00 - CONDUIT AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

#### PART 1 - GENERAL

- 1.1 RELATED DOCUMENTS
  - A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

#### 1.2 SUMMARY

- A. Provide all materials and labor for the installation of a pathway system for inside plant communications circuits. This section includes requirements for horizontal and building backbone raceways, fittings, and boxes specific to communications circuits (cabling) for voice and data.
- B. Related Sections:
  - 1. Division 27 Section "Grounding and Bonding for Communications Systems"
  - 2. Division 27 Section "Inside Plant Communications Systems"

#### 1.3 REFERENCES

- A. Incorporate by reference the applicable portions of the following specifications, standards, codes into this specification section.
  - 1. General:
    - a. National Electrical Code (NEC)
    - b. National Electrical Safety Code (NESC)
    - c. Occupational Safety and Health Act (OSHA)
  - 2. Communications:
    - a. ANSI/TIA/EIA 568: Commercial Building Telecommunications Cabling Standard
    - b. ANSI/TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
    - c. ANSI/TIA/EIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
    - d. ANSI/TIA/EIA 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
    - e. ISO/IEC IS 11801: Generic Cabling for Customer Premises
    - f. BICSI: BICSI Telecommunications Cabling Installation Manual

g. BICSI: BICSI Telecommunications Distribution Methods Manual (TDMM)

# 1.4 DEFINITIONS

- A. "EMT" shall mean Electrical Metallic Tubing.
- B. "RMC" shall mean Rigid Metal Conduit.
- C. "SMR" shall mean Surface Metal Raceway.
- D. "Raceway" shall mean any enclosed channel for routing wire, cable or busbars.
- E. "TMGB" shall mean *Telecommunications Main Grounding Busbar*. There is typically one TMGB per building, located in the main telecommunications room. This busbar is directly bonded to the electrical service ground.
- F. "TGB" shall mean *Telecommunications Grounding Busbar*. There is typically one TGB per telecommunications room. The TGB is connected both to the TMGB and to building structural steel or other permanent metallic systems.
- G. "TBB" shall mean *Telecommunications Bonding Backbone*. The TBB is a conductor used to connect TMGBs to the TGBs.
- H. "Pullbox" shall mean a metallic box with a removable cover, used to facilitate pulling cable through conduit runs longer than 100' or in which there are more than 180 degrees of bends.
- I. "Junction box" shall mean a pullbox wherein a feeder conduit transitions to multiple distribution conduits.

## 1.5 SYSTEM DESCRIPTION

- A. Furnish, install, and place into satisfactory and successful operation all materials, devices, and necessary appurtenances to provide a complete Raceway system as hereinafter specified and/or shown on the Contract Documents. The Raceway system shall support an ANSI/TIA/EIA and ISO/IEC compliant communications Structured Cabling System (SCS) as specified in 271500 -Inside Plant Communications Systems
- B. The work shall include materials, equipment and apparatus not specifically mentioned herein or noted on the Contract Documents but which are necessary to make a complete working Raceway system.

## 1.6 SUBMITTALS

- A. Product Data Submittals: Provide submittal information for review before materials are delivered to the job site. Provide product data submittals for all products at the same time.
  - 1. Submit a letter stating that the materials will be provided as specified, and specifically listing any items that will not be provided as specified. The letter shall also state that the Contractor has reviewed the specified items and agrees that they are applicable to this project in all respects.

- 2. For those items noted as allowing "or equal," and which are not being provided as specifically named, submit standard manufacturer's cut sheets or other descriptive information, along with a written description detailing the reason for the substitution.
- 3. Provide standard manufacturer's cut sheets and the operating and maintenance (O&M) instructions at the time of submittal review for each device in the system, regardless of whether it is submitted as specified or as an approved equal. These instructions shall detail how to install and service the equipment and shall include information necessary for rough-in and preparation of the building facilities to receive the materials.
- B. Closeout Submittals: Provide submittal information for review as follows:
  - 1. O&M Manual for Communications At the completion of the project, submit all O&M information from product data submittals (above), updated to reflect any changes during the course of construction, to the College in the telecommunications-specific O&M Manual for Communications binder labeled with the project name and description.
  - 2. Records Maintain at the job site a minimum of one set of Record Drawings, Specification, and Addenda. Record Drawings shall consist of redline markups of drawings, specifications and spreadsheets, including maintenance hole/handhole butterfly drawings.
    - a. Document changes to the system from that originally shown on the Contract Documents and clearly identify system component labels and identifiers on Record Drawings.
    - b. Keep Record Drawings at the job site and make available to the Owner and Designer at any time.
    - c. Keep Record Drawings current throughout the course of construction. ("Current" is defined as not more than one week behind actual construction).
    - d. Show identifiers for major infrastructure components on Record Drawings.

## 1.7 CONTRACTOR WARRANTY:

- A. Provide a Contractor-endorsed one-year service warranty against defects in materials and workmanship.
  - 1. Provide labor attributable to the fulfillment of this warranty at no cost to the Owner.
  - 2. The Contractor Warranty period shall commence upon Owner acceptance of the work.

# 1.8 QUALITY ASSURANCE

- A. Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled.
  - 1. The Terms "Listed" and "Labeled": As defined in NEC, Article 100.
  - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

- B. Comply with NECA's "Standard of Installation."
- C. Comply with NEC.

# 1.9 COORDINATION

A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS

## 2.1 GENERAL

- A. Materials shall consist of conduit, surface metal raceway, outlet boxes, fittings, enclosures, pull boxes, and other raceway incidentals and accessories as required for inside plant communications circuits.
- 2.2 MATERIALS
  - A. Conduit:
    - 1. EMT. 1" minimum conduit size. Flexible metal conduit (FMC) is not acceptable.
      - a. Conduit: Galvanized steel tubing meeting ANSI C80.3.
      - b. Couplings: Steel, cast iron, or malleable iron compression type employing a split, corrugated ring and tightening nut, with integral bushings and locknuts. Indent-type and setscrew-type couplings are not permitted.
    - 2. RMC. 1" minimum conduit size.
      - a. Conduit: Hot dipped galvanized steel with threaded ends meeting ANSI C80.1.
      - b. Couplings: Unsplit, NPT threaded steel cylinders with galvanizing equal to the conduit.
      - c. Nipples: Same as conduit, factory-made up to 8 inches in diameter, no running threads.
  - B. Sleeves: EMT conduit, with insulated throat bushings for each end
  - C. Surface Raceway: Wiremold V2400 series or equivalent Two piece, steel, single channel surface raceway.
  - D. Outlet boxes: Minimum 4"x4" size, 2 1/8" minimum depth, with extension rings (if needed) and single gang covers (i.e.; mud rings), unless otherwise noted on the Contract Documents. Combined interior depth of outlet box, extension ring and cover shall be a minimum 2-1/2". Stamped steel, deep drawn one piece (without welds or tab connections), galvanized, with knockouts for 1" trade size conduit or connector entrance, meeting NEMA OS 1.
    - 1. Acceptable manufacturers:
      - a. Appleton, Raco, Steel City, or equal

- 2. Wiremold Extra Deep Switch and Receptacle Box: V5744-2 (two gang), or equal
- E. Junction Boxes and Pull Boxes: Stamped steel, deep drawn one piece (without welds or tab connections), galvanized, with knockouts for conduit or connector entrance. Boxes 6"x6"x4" or larger may be code gauge fabricated steel continuously welded at seams and painted after fabrication.
  - 1. Dry locations: meeting NEMA OS 1.
  - 2. Wet locations: NEMA OS 3R.
- F. Miscellaneous Fittings:
  - 1. Locknuts and conduit bushings: Malleable iron
    - a. Appleton, Crouse Hinds, OZ Gedney, or equal
  - 2. Through wall seals and floor seals shall be:
    - a. OZ Gedney FS and WS series, or equal.
- G. Pull Strings: Plastic or nylon with a minimum test rating of 200 lb.
- 2.3 FIRESTOPPING
  - A. Material: Conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of the actual field conditions.
- 2.4 LABELING AND ADMINISTRATION
  - A. Labels: As recommended in ANSI/TIA/EIA 606. Permanent (i.e. not subject to fading or erasure), permanently affixed, typed, and created by a hand-carried label maker or an approved equivalent software-based label making system. Handwritten labels are not acceptable.
    - 1. Hand-carried label maker:
      - a. Brady: ID Pro Plus (or approved equal).
    - 2. Labels:
      - a. Brady: Bradymaker Wire Marking Labels WML-511-292 (or approved equal).

# PART 3 - EXECUTION

- 3.1 GENERAL
  - A. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances.
  - B. All work shall comply with applicable safety rules and regulations including OSHA. All work shall comply with the requirements of the National Electrical Safety Code (NESC) and the NEC except where local codes and/or regulations are more stringent, in which case the local codes and/or regulations shall govern.

- C. All work shall comply with the standards, references and codes listed in PART 1 --REFERENCES above. Where questions arise regarding which standards, references, or codes apply, the more stringent shall prevail.
- D. All work shall comply with the requirements and recommendations of the product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.
- E. Install the raceway system in a manner ensuring that communications circuits, when installed, are able to fully comply with the ANSI/TIA/EIA and other references listed in Part 1 References, above.
- F. Replace and/or repair to original (or better) condition any existing structures, materials, equipment, etc. inadvertently demolished or damaged by the Contractor during the course of construction at no additional cost to the Owner.
- G. Remove surplus material and debris from the job site and dispose of legally.

## 3.2 EXAMINATION

A. Examine surfaces and spaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

## 3.3 INSTALLATION

- A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions. Provide a raceway for each location indicated. Do not gang raceway into wireways, pullboxes, junction boxes, etc., without specific approval from the Designer.
- B. Conduit:
  - 1. Install EMT unless other conduit is shown on the Contract Documents or is required by Code.
  - 2. Install conduit as a complete, continuous system without wires, mechanically secured and electrically connected to metal boxes, fittings and equipment. Blank-off unused openings using factory-made knockout seals.
  - 3. Run conduit in the most direct route possible, parallel to building lines. Do not route conduit through areas in which flammable material may be stored.
  - 4. Keep conduit at least 6 inches away from parallel runs of flues and steam or hot-water pipes or other heat sources operating at temperatures above one-hundred degrees Fahrenheit. Install horizontal conduit runs above water piping.
  - 5. Keep conduit away from sources of electromagnetic interference as follows:
    - a. 5 inches from fluorescent lighting
    - b. 12 inches from conduit and cables used for electrical power distribution

- c. 48 inches from motors or transformers
- 6. Do not exceed 90 meters total length for a given conduit run to be used for distribution cabling (from outlet box to telecommunications room), including intermediate conduits and junction boxes.
- 7. Install conduit exposed, except in finished areas or unless shown otherwise on the drawings. Do not install conduit below grade/slab unless specifically shown on the Contract Documents as being installed below grade/slab.
- 8. Install exposed conduit in lines parallel or perpendicular to building lines or structural members except where the structure is not level. Follow the surface contours as much as practical. Do not install crossovers or offsets that can be avoided by installing the conduit in a different sequence or a uniform line.
  - a. Run parallel or banked conduits together, on common supports where practical.
  - b. Make bends in parallel or banked runs from same centerline to make bends parallel.
- 9. Conduits concealed above ceilings, furred spaces, etc., which are normally inaccessible may be run at angles not parallel to the building lines.
- 10. Wherever practical, route conduit with adjacent ductwork or piping and support on common racks. Base required strength of racks, hangers, and anchors on combined weights of conduit and piping.
- 11. Where conduits cross building expansion joints, use suitable sliding or offsetting expansion fittings. Unless specifically approved for bonding, use a suitable bonding jumper.
- 12. Support conduits as specified in Section "Basic Electrical Materials and Methods."
  - a. Provide anchors, hangers, supports, clamps, etc. to support the conduits from the structures in or on which they are installed. Do not space supports farther apart than five feet.
  - b. Provide sufficient clearance to allow conduit to be added to racks, hangers, etc. in the future.
  - c. Support conduit within three feet of each outlet box, junction box, gutter, panel, fitting, etc.
- 13. Ream conduits to eliminate sharp edges and terminate with metallic insulated grounded throat bushings. Seal each conduit after installation (until cable is installed) with a removable mechanical-type seal to keep conduits clean, dry and prevent foreign matter from entering conduits.
- 14. Install a pull string in each conduit.
- 15. For conduits entering through the floor of a telecommunications room, terminate conduits 6" above the finished floor.
- 16. Do not install communications conduits in wet, hazardous or corrosive locations.

- 17. Where conduit is shown embedded in masonry, embed conduit in the hollow core of the masonry. Horizontal runs in the joint between masonry units are not permitted.
- 18. Where conduit is shown embedded in concrete, embed conduit a minimum of two inches from the exterior of the concrete. Do not place conduit in concrete less than 4 inches thick.
  - a. One inch trade size conduit shall be used. Conduits sized smaller than one inch trade size conduit are not permitted embedded in concrete without approval from the College.
  - b. Run conduit parallel to main reinforcement.
  - c. Conduit crossovers in concrete are not permitted.
- 19. Where conduit exits from grade or concrete, provide a rigid steel elbow and adapter.
- 20. Where conduit enters a space through the floor and terminates in that space, terminate the conduit at 6" above the finished floor.
- 21. Where conduits terminate at a cable tray, the conduits shall be consistently terminated no more than 8" from the cable tray, and have a visually uniform appearance.
- 22. Where several circuits follow a common route, stagger pullboxes or fittings.
- 23. Where several circuits are shown grouped in one box, individually fireproof each conduit.
- 24. Bend and offset metal conduit with standard factory sweeps or conduit fittings. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
  - a. Conduit sweeps:
    - 1) Sweeps shall not exceed 90 degrees.
    - 2) Do not exceed 180 degrees for the sum total of conduit sweeps for a section of conduit (between conduit termination points).
    - 3) Sweep radius shall be at least 10 times the internal diameter of the conduit.
    - 4) 90-degree condulets (LB's) and electrical elbows are not acceptable.
  - b. Factory-manufactured sweeps are required for bends in conduit larger than  $1-\frac{1}{4}$ " trade size.
  - c. For bends in 1 <sup>1</sup>/<sub>4</sub>" trade size conduit and larger, field-manufactured bends (using a hydraulic bender with a 1 <sup>1</sup>/<sub>4</sub>" boot) are permitted only when factory-manufactured sweeps are not suitable for the conditions. In all other cases, factory-manufactured sweeps are required. "Hickey-bender" use is prohibited.
- 25. Connect conduit to hubless enclosures, cabinets and boxes with double locknuts and with insulating type bushings. Use grounding type bushings where connecting to concentric or eccentric knockouts. Make conduit connections to enclosures at the nearest

practicable point of entry to the enclosure area where the devices are located to which the circuits contained in the conduit will connect.

- 26. Penetrations for raceways:
  - a. Do not bore holes in floor and ceiling joists outside center third of member depth or within two feet of bearing points. Holes shall be  $1-\frac{1}{4}$ " diameter maximum.
  - b. Penetrate finished walls and finished surfaces with a PVC or sheet metal sleeve with an interior diameter (ID) at least 1/4" greater than the outer diameter (OD) of the conduit, set flush with walls, pack with fiberglass, seal with silicone sealant.
  - c. Penetrate poured-in-place walls and free slabs with a cast iron sleeve (or Schedule 40 PVC black pipe sleeve for above-grade only) with retaining ring or washer. Set sleeves flush with forms or edges of slab. Pack around conduit with fiberglass and seal with silicone sealant.
- 27. Raceway terminations and connections:
  - a. Join conduits with fittings designed and approved for the purpose and make joints tight. Do not use set indent-type or screw-type couplings.
  - b. Make threaded connections waterproof and rustproof by applying a watertight, conductive thread compound. Clean threads of cutting oil before applying thread compound.
  - c. Make conduit terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
  - d. Cut ends of conduit square using a hand saw, power saw or pipe cutter. Ream cut ends to remove burrs and sharp ends. Where conduit threads are cut in the field, cut threads to have same effective length, same thread dimensions and same taper as specified for factory-cut threads.
  - e. Provide double locknuts and insulating bushings at conduit connections to boxes and cabinets. Align raceways to enter squarely and install locknuts with dished part against the box. Use grounding type bushings where connecting to concentric or eccentric knockouts.
  - f. Where conduits are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.
- 28. Install conduit sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed conduits, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

- a. Where conduits pass from warm to cold locations, such as the boundaries of air conditioned or refrigerated spaces and where conduits enter or exit buildings from outdoor areas, including underground ducts or conduit runs.
- b. Where otherwise required by the NEC.
- 29. Conduit shall be clean and dry.
- C. Sleeves:
  - 1. Provide sleeves where required, sized as noted on the Contract Documents. Where not noted, sleeve sizing shall be determined by the type and quantity of cable to be routed through the sleeve per TIA/EIA 569A cable capacity standards, plus an additional 20% for future expansion.
  - 2. Provide roto-hammering or core drilling where required for installation.
  - 3. Seal between sleeve and wall or floor in which the sleeve is installed. Firestop all penetrations to restore wall or floor to pre-penetration fire-rating.
- D. Surface Raceway:
  - 1. Provide surface raceway for all surface mounted telecommunications outlet boxes and as shown on the Contract Documents.
  - 2. Surface raceway shall be routed parallel to and perpendicular to surfaces or exposed structural members, and follow surface contours.
  - 3. Surface raceway color shall match as closely as possible the existing wall finish. Do not paint Surface Raceway.
  - 4. Surface raceway systems shall be completely installed, including insulating bushings and inserts as required by manufacturer's installation requirements. Unused openings in the surface raceway shall be closed using manufactured fittings.
  - 5. Surface raceway shall have a minimum two inch radius control at all bend points.
  - 6. Surface raceway shall be securely supported by screws or other anchor-type devices at intervals not exceeding 10 feet and with no less than two supports per straight raceway section. Surface raceway shall be securely supported in accordance with the manufacturer's requirements. Tape and glue are not acceptable support methods.
  - 7. Mechanically and electrically continuous surface raceway shall be bonded and grounded to the Telecommunications Grounding system.
- E. Outlet Boxes:
  - 1. Provide outlet boxes and covers as shown on the Contract Documents and as needed. Verify that the appropriate cover type and depth is provided for each type of wall and finish. Provide extension rings as needed.
  - 2. Coordinate box locations with building surfaces and finishes to avoid bridging wainscots, joints, finish changes, etc.

- 3. Install boxes in dry locations (not wet, corrosive, or hazardous).
- 4. Attach boxes securely to building structure with a minimum of two fasteners. Provide attachments to withstand a force of one hundred pounds minimum, applied vertically or horizontally.
- 5. Install boxes at the following heights to the bottom of the box, except where noted otherwise:
  - a. Wall mounted telephones: 48" above finished floor.
  - b. Workstation outlets: 18" above finished floor.
  - c. Place boxes for outlets on cabinets, countertops, shelves, and similar boxes located above countertops two inches above the finished surface or two inches above the back splash. Coordinate and verify size, style, and location with the supplier or installer of these items prior to outlet box installation.
- 6. Recessed mounted outlet boxes:
  - a. Recess boxes in the wall, floor, and ceiling surfaces in finished areas. Set boxes plumb, level, square and flush with finished building surfaces within one-sixteenth inch for each condition. Set boxes so that box openings in building surfaces are within one-eighth inch of edge of material cut-out and fill tight to box with building materials. Single gang opening shall extend at least to the finished wall surface and extend not more than 1/8 inch beyond the finished wall surface. Provide backing for boxes using structural material to prevent rotation on studs or joists.
  - b. Install floor boxes level and adjust to finished floor surface.
- 7. Surface-mounted outlet boxes:
  - a. For boxes surface-mounted on finished walls, provide Wiremold outlet box or equivalent. Cut box as necessary to accept conduit.
  - b. For boxes surface-mounted on unfinished walls (i.e. electrical rooms, mechanical rooms), provide 4"x4" (minimum) outlet box with single gang cover.
- F. Floor Boxes:
  - 1. Provide floor boxes as shown on the Contract Documents.
  - 2. Set device boxes plumb, level, square and flush with floor, within 1/16" tolerance for each condition.
  - 3. For floor boxes with combined power and telecommunications circuits, provide metal dividers to separate power from telecommunications circuits.
- G. Junction Boxes:
  - 1. Provide junction boxes as shown on the Contract Documents and as required.

Feeder	Box	Box Depth
Conduit Size	Length	
1"	12"	4"
1-1/4"	12"	4"
1-1/2"	12"	4"
2"	24"	4"
2-1/2"	24"	6"
3	36"	6"
3-1/2"	48"	6"
4"	60"	6"

a. Where sizing is not shown on the Contract Documents, size junction box length and depth according to the size of the feeder conduit in the following table:

- b. Where sizing is not shown on the Contract Documents, size junction box width according to the following formula:
  - 1) From the table below, select the width associated with the largest conduit on the distribution side of the box. For each additional distribution conduit, add the "Increase Width" value associated with the size of that distribution conduit to the box width for the largest distribution conduit.
    - a) For example, if the distribution side of the junction box has one  $1-\frac{1}{4}$ " distribution conduit and three 1" distribution conduits, the total distribution-side width would be 6"+2"+2"+2"=10".
  - 2) Repeat the above process for the feeder side of the junction box. Junction boxes are typically fed by a single conduit, therefore unless the box has more than one feeder conduit, the "Increase Width" part of the formula is unnecessary.
    - a) For example, if the feeder side of the junction box has two 2" feeder conduits the total feeder-side width would be 8"+5"=13".
  - 3) The larger of the two width calculations (distribution side vs. feeder side) shall be the width of the junction box to be provided.
    - a) For example, if the distribution-side width were 10" and the feederside width were 13", provide a 13" wide junction box.

Conduit Size	Box Width	For each additional conduit Increase Width
1"	4"	2"
1-1/4"	6"	3"
1-1/2"	8"	4"
2"	8"	5"
2-1/2"	10"	6"
3	12"	6"
3-1/2"	12"	6"
4"	15"	8"

- 2. A junction box may not be substituted for a 90-degree bend. 90 degree condulets (LB's) are not acceptable.
- 3. Install junction boxes in a location readily accessible both at time of construction and after building occupation. Do not install junction boxes in inaccessible interstitial building spaces.
- 4. Where junction boxes are to be mounted on ceiling structure above ceiling grid, do not mount higher than 4' above grid.
- 5. Install hinged-cover enclosures and cabinets plumb, and supported at each corner.
- 6. Install junction boxes so that the access door opens from the side where the cable installer will normally work typically from the bottom (floor side) of the box.
  - a. Where a junction box is installed in a ceiling space, coordinate with other trades to provide full access to the junction box door and adequate working room for both the installation personnel and for proper looping of cable during installation.
  - b. Provide a lockable access cover (or junction box door if junction box is exposed) in hard lid ceilings.
- 7. Install junction boxes such that conduits enter and exit at opposite ends of the box as follows:



- H. Pull Boxes:
  - 1. Provide pull boxes as shown on the Contract Documents and as required.

Size of Largest	Box Width	Box Length	Box Depth
1"	4"	12"	4"
1-1/4"	6"	12"	4"
1-1/2"	8"	12"	4"
2"	8"	24"	4"
2-1/2"	10"	24"	6"
3	12"	36"	6"
3-1/2"	12"	48"	6"
4"	15"	60"	6"

a. Where sizing is not shown on the Contract Documents, size pull boxes as follows:

- b. Where a pull box is required with conduits 1" trade size or smaller, an outlet box may be used as a pull box. Where outlet boxes are used as pull boxes, the outlet boxes shall be dedicated for use as a pull box and shall not host cable termination hardware.
- 2. A pull box may not be substituted for a 90-degree bend. 90 degree condulets (LB's) are not acceptable.
- 3. Install pull boxes in an accessible location, readily accessible both at time of construction and after building occupation. Do not install pull boxes in inaccessible interstitial building space.
- 4. Where pull boxes are to be mounted on ceiling structure above ceiling grid, do not mount higher than 4' above grid (mount on wall instead).
- 5. Install hinged-cover enclosures and cabinets plumb, and supported at each corner.
- 6. Install pull boxes so that the access door opens from the side where the cable installer will normally work (typically from the bottom, or floor side, of the box).

- a. Where a pull box is installed in a ceiling space, provide full access to the junction box door and adequate working room for both the installation personnel and for proper looping of cable during installation.
- b. Provide a lockable access cover (or pull box door if pull box is exposed) in hard lid ceilings.
- 7. Install pull boxes such that conduits enter and exit at opposite ends of the box as follows:



- I. Firestopping:
  - 1. Only employees trained/certified by the firestopping manufacturer shall apply firestopping materials.
  - 2. Maintain fire rating of penetrated fire-rated walls. Firestop and seal each penetration made during construction.
    - a. Provide firestopping material for through and membrane penetrations of fire-rated barriers.
    - b. Installation shall be performed in strict accordance with manufacturer's detailed installation procedures.
    - c. Install firestops in accordance with fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and applicable codes and standards referenced in PART 1 REFERENCES. Apply all sealing material in a manner acceptable to the local fire and building authorities.
- J. Grounding/Bonding: Grounding and bonding work shall comply with the Virginia Uniform Statewide Building Code, Uniform Fire Code, National Electrical Code, and UL 467, ANSI/TIA/EIA standards and the references listed in PART 1 REFERENCES above, as well as local codes which may specify additional grounding and/or bonding requirements.
  - 1. Bond metallic raceway together and to the nearest TGB (as provided under Division 27 Section "Grounding and Bonding for Communications Systems"). Ensure that bonding breaks through paint to bare metallic surface of painted metallic hardware.
- 3.4 LABELS:
  - A. Conduits: For any conduit extending beyond the space or room in which it starts, label each such conduit end in a clear manner by designating the location of the other end of the conduit (i.e. room name, telecommunications room name, pull box identifier, outlet identifier (use the

label of the first port of the outlet as the outlet identifier), etc.). Indicate conduit length on the label.

- 1. Where a conduit is intended for future cabling use outside of the Contract, the conduit shall be labeled in a clear manner by designating the location of the other end of the conduit (i.e. room name, telecommunications room name, pull box identifier, etc.) along with a sequential number for each spare conduit terminated into a single room. Indicate conduit length on the label.
  - a. Suggestion: The second spare conduit (whether spare or in use) between Room 100 and telecommunications room 1A might be labeled in the telecommunications room as "Room 100 #2, \_\_\_\_\_ feet." In Room 100 the same conduit might be labeled "1A #2, \_\_\_\_\_ feet."
- B. Pull Boxes: Label each pullbox with a unique identifier. Identifiers shall be of the form "RN-Y" where "RN" is the room name of the room closest to (or containing) the pull box, and "Y" is the sequential number of the pull box for each "RN".
  - 1. Example: The second pull box in the vicinity of room "100" would have the label "100-2".
- C. Pull Strings: For any conduit extending beyond the space or room in which it starts, label its pull string in a clear manner by designating the location of the other end of the pull string (i.e. room name, telecommunications room name, pull box identifier, outlet identifier (use the label of the first port of the outlet as the outlet identifier), etc.).
  - 1. Where a pull string is installed in a conduit intended for future cabling use outside of the Contract, the pull string shall be labeled similar to the spare conduit in which it is installed.

# 3.5 PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and in accordance with accepted industry practice, that ensure coatings, finishes, and cabinets are without damage or deterioration at the time of Substantial Completion.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

# 3.6 CLEANING

1. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

# **END OF SECTION**

# SECTION 27 60 00 - TELEPHONE AND CATV UTILITY - INCOMING SERVICE PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract, including the General Requirements, apply to the work specified in this section.

B. Division 16, Basic Materials and Methods sections apply to work of this section.

1.2 DESCRIPTION OF WORK

A. The Contractor shall provide all materials and labor required by the utility for service provisions.

B. The Contractor shall provide all materials and labor for complete empty conduit power, telephone and CATV distribution systems as shown on the drawings and as specified herein.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. General Electrical Requirements: Div 16010

B. Basic Electrical Materials and Methods: Div 16.

C. Raceways and Boxes: Div 16130.

E. Underground Ductbanks: Div 16300.

G. Grounding: Div 16452.

1.4 UTILITY COMPANY COORDINATION

A. Contact "Miss Utility" (1-800-257-7777) prior to any excavation or underground work. The Contractor shall verify the location and depth of all utilities. Provide test pits to verify location and depth of all existing utilities crossing new incoming services.

B. Contact serving utility companies immediately upon award of Contract. Do not install related equipment until fully coordinated with appropriate utilities.

C. Provide all Construction Schedules, dates of requested services, outage windows, equipment locations, etc., necessary for utility work.

D. The Contractor shall coordinate the electric and telephone services points of entry to be within twenty (20) feet (7.0 m), or as required to comply with NEC 800-11.

\_

E. The Contractor shall ascertain, from the utility companies, the exact amount of work required in connection of the utilities. Work required which is not provided by the utility companies shall be provided by the Contractor.

- F. Provide and coordinate all temporary services with utility companies.
- G. The Contractor shall coordinate the required separation distances for all utilities.
- H. The Contractor shall obtain al permits and permissions required.

# 1.5 SUBMITTALS

A. Certificate of Compliance: Contractor shall submit a documentation certifying that work complies with all utility company requirements including the following:

- 1. Construction Standards of each Utility Company.
- 2. Trench and cover Depth.
- 3. Spacing and Support of Utilities.
- 4. Installation of underground marking tape.
- 5. Pull cords and Mandrels.

B. Photographs: Contractor shall submit photographs of each utility installation at each of the above described levels of completion and attach photographs to Certificate of Compliance for verification. Submit a minimum of six (6) color 4" x 6" photographs for each utility service.

C. Submit Certificate of Compliance and photographs to each utility company for verification and approval.

D. Include Certificate of Compliance, photographs, and utility company approvals in O&M Manual.

E. The Contractor shall provide and submit all required documentation to each utility company, including service application, site plan and coordination drawings.

1.6 QUALITY ASSURANCE

A. Comply with the requirements of Power Company *Customer Requirements for Electric Service.* 

B. Comply with the requirements of NFPA 70 National Electrical Code.

- C. Comply with the NECA *Standards of Installation*.
- D. Comply with National Electrical Safety Code.

E. Contractor shall have experience with not less than 5 comparable projects for which the Contractor completed service provisions with each utility. Contractor shall be familiar with all current utility requirements and guidelines.

- F. Comply with the recommendations and guidelines of *the BICSI Outside Plant Design Reference Manual 5<sup>th</sup> Edition.*
- G. Obtain utility company inspector's approval for all work.

# PART 2 - PRODUCTS

# 2.1 TELEPHONE COMPANY PROVISIONS

A. The telephone utility is Verizon.

B. Telephone Service Wall Space: Provide a wall-mounted 3/4" fire-retardant painted plywood backboard, 8 feet high x 4 feet wide, as shown at location indicated on the drawings.

C. Provide adjacent to backboard two duplex convenience NEMA 5-20R receptacles connected to the [emergency] power system. Provide 2 #12 and 1 #12 ground in 3/4" conduit from receptacles to nearest 120 volt emergency power panel.

D. Provide adjacent to the backboard, one No. 8 copper ground conductor extended from the building's service ground point.

E. Provide one 50 pair telephone cable, plenum rated, (Belden or approved equal by West Penn) run concealed to the Owner's telephone system. Terminate cable in exact location and manner as required.

F. Provide conduit sleeves where cable is extended through partitions, walls, or floor slabs. Fire seal all openings after cable is installed.

- G. Incoming Telephone service:
  - 1. Coordinate incoming telephone service requirements with area public telephone system utility. Provide two (2) 4" Schedule 40 PVC underground telephone service conduits from the telephone service equipment backboard to the vicinity of the power company's pad-mounted transformers or as indicated on the Drawings and terminate ducts in the exact location and manner as directed by the telephone company.
  - 2. Provide pre-cast pulling handholes in duct run in location(s) as directed if deemed necessary by the telephone utility. Size of handholes (L x W x H) shall be as required by the utility. Handholes installed in roadways shall be H20 roadway type.
  - 3. Extend two (2) 4" PVC Schedule 40 underground service conduits along with primary electrical feeder from power company transformer location to 5'-0" beyond property line, or as indicated on the Drawings, then capped and stubbed.

\_
4. In addition to the above requirements, install raceways in maximum lengths of 300 feet (90m) or as required by telephone company and a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.

H. Coordinate incoming raceway with telephone utility company. Provide required conduit size as determined by the telephone company.

I. Coordinate for installation of pay telephones. Provide sufficient notice for telephone procurement and installation. Provide all necessary pay telephone rough-in provisions including 1" empty conduit from pay telephone location to main TTB and 120 volt power for ADA-required TTY unit.

J. Contractor shall be responsible for contacting and coordinating with the telephone company prior to ordering or installing any telephone entrance equipment and provisions.

## 2.2 CABLE TELEVISION COMPANY PROVISIONS

A. The Cable Television Company is Comcast.

B. Incoming CATV Service: Coordinate incoming CATV service requirements with the cable company. Provide two -4" Schedule 40 PVC underground from the telephone service equipment backboard to the cablevision pedestal in the vicinity of the power company's pad-mounted transformers as directed by the Cable Company. Extend 2 - 4" Schedule 40 underground service conduit along with primary electrical feeder to 5'-0" beyond the property line, then cap and stub.

## 2.3 TYPICAL INCOMING SERVICE PROVISIONS

A. Pull Wire: 1/4" nylon pull cord with 500 lb. minimum tensile strength in each conduit.

B. Conduit, Elbows, and Couplings: UL Schedule 40, EB-35, DB-60, DB-120, or ANSI/ASTM F-512 as required by utility for the specific application.

C. Spacers: Every 4 feet of conduit.

D. Splice Boxes: Purchase from utility company. Provide as required.

- E. Manholes: Purchase from utility company. Provide as required.
- F. Underground Marking: Provide detectable warning tape over all conduits.
- G. Bends: Minimum 5 foot radius (horizontal) and 36" radius (vertical).

H. Concrete for encasement: Minimum 3,000 psi or as noted on Drawing or as specified in Section 16300 "Underground Ductbank", with air entrainment and pea gravel.

I. Backfill: Virgin soil/select backfill only. Backfill shall be stone dust, rock-free earth, or top soil with no stones larger than 1-1/2" in diameter permitted.

J. Miscellaneous Materials: Provide bushings, bell ends, conduit plugs and other miscellaneous materials as required by utility companies.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Mandrel: Contractor shall pull a mandrel (1/2'') smaller in diameter than the conduit, and six inches long) through each conduit.

B. Pull Wires: Pull wires shall be left in all conduits, after mandrel pull.

C. Coordination: Coordinate location of telephone and CATV wall spaces, raceways, and boxes, as necessary, to interface installation of telephone and CATV systems with other work.

D. Bushings: Provide conduit bushing at each end of all conduits.

E. Bell Ends & Plugs: Provide Bell ends and plugs for each conduit.

F. Sealing Conduits: Provide duct sealant in each conduit after utility cable is installed.

## 3.2 PREPARATION

A. Contractor shall provide conduits at all street or road crossings for all utility facilities.

B. Provide a level area at final grade for all transformer, pedestal, and utility equipment locations.

C. Coordinate utility line separation requirements between electric, water, sewer, gas, telephone and CATV.

D. Contractor shall clear area for all utility cables of rubble, debris, stumps, and other obstructions.

## END OF SECTION

\_

### SECTION 28 01 01 - ELECTRONIC SAFETY AND SECURITY GENERAL PROVISIONS

### PART 1 - GENERAL

### 1.11 SECTION INCLUDES

- A. General provisions and requirements for electronic safety and security.
- 1.14 RELATED SECTIONS
  - A. Requirements of this section generally supplement requirements of Division 01.
  - B. Division 01 includes sections specifying requirements for LEED rating, commissioning, and construction waste management.

### 1.20 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.
- 1.24 SYSTEM DESCRIPTION
  - A. The full set of Contract Documents applies to work of Division 28.
  - B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
  - C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
  - D. Except as required otherwise in Division 01, promptly obtain and pay for, all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Owner.
  - E. Electronic safety and security work of this project includes, as a brief general description, the following:
    - 1. Provide a complete electrical power distribution and lighting system for a new elementary school.
    - 2. Provide a complete fire detection and alarm system for a new elementary school building.
    - 3. The project includes commissioning under the direction of a Commissioning Agent (CxA).
    - 4. The project will be LEED certified.
  - F. See Division 01 for requirements related to LEED certification, commissioning, Owner's occupancy of the premises, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

### 1.26 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 28 specifications.
- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in article "Substitutions" below for substitutions.
- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance.
  - 1. Where other acceptable manufacturers are named, Contractor may provide products of those named manufacturers only, which meet the specifications.
  - 2. Where specification permits "equal" products, without naming other acceptable manufacturers, Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

### 1.27 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 28 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
  - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
  - 2. Will provide the same warranty for the substitution as for the specified product.
  - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to Owner.
  - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
  - 5. Will reimburse Owner for review or redesign services associated with re-approval by authorities.

- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

## 1.28 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project, and of representative manufacture. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.
- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
  - 1. Furnish: Supply item
  - 2. Install: Mount and connect item
  - 3. Provide: Furnish and install
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturer's instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the Architect.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the Architect will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the Architect of said uncertainty, doubt, or conflict and obtain a decision as to the intent prior to initiating any work which may be affected by this decision.

### 1.29 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the Architect and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with the project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate electronic safety and security work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.
- D. Coordinate location and elevation of all conduit, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the Architect prior to initiation of work. Correct improperly coordinated installation at no additional cost.
- E. The Contractor's assistants shall include a competent foreman, who shall be on the premises at all times to check, lay out, coordinate and superintend the installation of work. The foreman shall establish all basic requirements relative to the work before starting, and be responsible for the accuracy thereof.

### 1.30 SUBMITTALS

- A. Manufacturers' and subcontractors' lists:
  - 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.
- B. Shop drawings and product data:
  - 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of Shop Drawings and Product Data for every item of equipment. Shop drawings or product data will not be considered until Manufacturers' Lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
  - 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.

28 01 01 - 4

- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electronic safety and security items furnished as items associated with mechanical items but not specifically described in the mechanical item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the mechanical item by identified specification paragraph.
- 5. Product data sheets shall be 8.5-inch by 11-inch cut sheets for operating and maintenance manual.
- C. Submit at least three copies of the results of every test required under any section in this division.
- D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.
  - 1. Include project name, address, name and phone number of owner's representative, and project type and size.
- E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Architect prior to final acceptance of the work.

### 1.34 SPECIALIST

A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

### 1.35 CONTRACT CLOSEOUT SUBMITTALS

- A. Project record documents:
  - 1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:
    - a. Contract Drawings.
    - b. Specifications.
    - c. Addenda.
    - d. Change Orders and other Modifications to the Contract.
    - e. Reviewed shop drawings, product data, and samples.

- 2. Maintain record documents separate from documents used for construction.
- 3. Record information concurrent with construction progress.
- 4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:
  - a. Manufacturer's name and product model and number.
  - b. Product options, substitutions, or alternates utilized.
  - c. Changes made by addenda and modifications.
- 5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:
  - a. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
  - b. Field changes of dimension and detail.
  - c. Details not on original Contract Drawings.
- 6. Submit documents as specified in Division 01.
- B. Operation and maintenance data:
  - 1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
  - 2. Binders: Three-ring binders with vinyl-covered hard covers. Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
  - 3. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", and title of project. Print on spine of binder "O & M INSTRUCTIONS". If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
  - 4. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
  - 5. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
  - 6. Part 1: Directory, listing names, addresses, and telephone numbers of engineers; contractor; subcontractor; and major electrical equipment suppliers.
  - 7. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
    - a. Significant design criteria.
    - b. List of equipment.
    - c. Parts list for each component, including recommended spare parts list.
    - d. Operating instructions.
    - e. Maintenance instructions for equipment and systems.
    - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

- 8. Part 3: Project documents and certificates, including the following:
  - a. Shop drawings and product data.
  - b. Photocopies of certificates.
  - c. Photocopies of warranties, guarantees, and bonds.
  - d. Test reports: Copies of the results of all tests required under all sections of specifications.
- 9. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
- 10. Submit final volumes revised, within ten days after final inspection.
- 11. Submit DVD optical disc storage media specified in Section 28 05 00.

## 1.42 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.
- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
  - 1. The electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
  - 2. The National Electric Code, NFPA 70 (NEC).
  - 3. The National Fire Protection Association Code. (NFPA)
  - 4. International Building Code (IBC).
  - 5. International Energy Conservation, Fire, and Electrical Codes (ICC).

### 1.43 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply.
  - 1. Factory Mutual (FM)
  - 2. American National Standards Institute (ANSI)
  - 3. American Society for Testing and Materials (ASTM)
  - 4. International Code Council (ICC)
  - 5. Institute of Electrical and Electronics Engineers (IEEE)
  - 6. National Electrical Code (NEC) (NFPA 70)
  - 7. National Electrical Manufacturer's Association (NEMA)
  - 8. National Fire Protection Association (NFPA)

- 9. The Occupational Safety and Health Act (OSHA)
- 10. Underwriters Laboratory Inc. (UL)
- 11. American Association of State Highway and Transportation Officials (AASHTO)
- 12. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
- 13. Maryland Occupational Safety and Health Act (MOSHA)
- 14. Illuminating Engineering Society of North America (IESNA)

### 1.53 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.
- B. Area shall be maintained and shall be returned to original condition at the completion of the project.
- C. Store electronic safety and security construction materials such as wire, raceways and boxes, devices, and equipment in buildings, enclosed trailers, or portable enclosed warehouses.
  - 1. Materials and products subject to damage from moisture: Store in dry locations. If necessary, protect with protective wraps or covers.
  - 2. Plastics and other materials and products subject to damage from heat or cold: Store at manufacturer's recommended temperatures.
  - 3. Plastics and other materials and products subject to damage from sunlight: Protect from sunlight.
- D. Sensitive electronics equipment and components stored before installation and installed during construction: Provide clean, dry locations at manufacturer's recommended temperatures, and cover or wrap if required to protect from incidental damage.

### 1.54 **PROTECTION**

- A. Control dust resulting from construction work to prevent its spread beyond the immediate work area, and to avoid creation of a nuisance.
  - 1. Do not use water to control dust. Use drop cloths or other suitable barriers.
  - 2. In areas where dirt or dust is produced as a result of the work, sweep daily, or more often as required.
  - 3. Provide walk-off mats at entries and replace them at regular intervals.
  - 4. Construct dust partitions, where indicated on the drawings or as required.
  - 5. Seal off all return air registers and other mechanical systems to prevent dust from entering.
- B. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
  - 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
  - 2. Protect finished work from damage, defacement, staining, or scratching.
  - 3. Protect finishes from cleaning agents, or grinding and finishing equipment.

- 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
- 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- C. Repair all damage or soiling to the complete satisfaction of the Architect; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract sum.
- D. Protect work stored in place and supplies stored in the building.
  - 1. Store materials and products subject to damage from moisture in dry locations. If necessary, protect in wraps or covers.
  - 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- E. Protect materials and products from weather events and accidents of construction.
- F. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

## 1.55 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

### 1.60 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.
- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
  - 1. Promptly notify the Owner and Architect in writing.
  - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

### 1.80 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties as specified in individual sections.
- B. During the correction period, the Contractor shall promptly correct any work found to be defective or otherwise not in accordance with the requirements of the Contract Documents, on

receipt of written notice from the Owner. Except as otherwise required in General Conditions and Division 01, the correction period is two years after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.

- C. When use of the permanent equipment has been permitted for temporary services during construction of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Owner.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

## 1.85 COMMISSIONING

- A. This project includes commissioning under the direction of a Commissioning Agent (CxA). Contractor's and subcontractors' responsibilities are described in Division 01.
- B. Cooperate with the CxA to accomplish the requirements of the Commissioning Plan during the construction and correction periods.

### PART 2 - PRODUCTS

Not used.

## PART 3 - EXECUTION

### 3.11 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of conduits. Close superfluous openings and remove all debris caused by work of this division.
- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the Architect.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.

E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

## 3.14 TEMPORARY FACILITIES

- A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.
- 3.40 PROGRESS MEETINGS
  - A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or Architect finds them necessary or advantageous to progress of work.
  - B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, Architect and Owner shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

### 3.82 COMMISSIONING

A. Comply with requirements of "Commissioning" in Part 1 above.

## **END OF SECTION**

# SECTION 28 05 00 - COMMON WORK FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

### A. Section Includes:

- 1. Communications equipment coordination and installation.
- 2. Common communications installation requirements.
- 3. Demolition
- 4. Waterproofing.
- 5. Weatherproofing locations.
- 6. Cutting and Patching.
- 7. Painting.
- 8. Equipment Foundations, Supports, Piers and Attachments.
- 9. Equipment Guards and Rails.
- 10. Cleaning, Protecting and Adjusting.
- 11. Welding.
- 12. Sleeves for raceways and cables.
- 13. Sleeve seals.
- 14. Grout.

### 1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.
- C. Wiring: Cable and/or wire installed in Raceway.

## 1.4 SUBMITTALS

A. Product Data: For sleeve seals.

### 1.5 WATERPROOFING

A. Where work pierces waterproofing, including waterproof concrete, the method of installation shall be approved by the Architect prior to performing the work. Furnish necessary sleeves, caulking and flashing required to make openings absolutely watertight.

### 1.6 WEATHERPROOFING LOCATIONS (WP)

- A. Communication apparatus, such as outlet boxes, switches, connection panels, speakers, cameras, and other devices shall be weatherproof gasketed type, NEMA Types 3 or 4 in the following instances:
  - 1. On surface of exterior face of building, including areas where not under canopies, cast boxes with threaded hubs must be used and under canopies steel boxes with gasket connections to devices.
  - 2. In any areas where specifically noted "WP" or required by the NEC or Regulations mentioned herein.
  - 3. Within air conditioning enclosures.
  - 4. In underground splice boxes.
  - 5. On building roof.
  - 6. Within vivarium locations.
  - 7. In unconditioned spaces subject to exterior ambient conditions such as loading docks and parking garages.

## 1.7 CUTTING AND PATCHING

- A. Provide cutting and patching necessary to install the work specified herein. Patching shall match adjacent surfaces. Refer to Division 1, Cutting and Patching for specific directions.
- B. No structural members shall be cut without prior approval of the Architect; such cutting shall be done in a manner directed by him.
- C. Provide ceiling removal and replacement where work above ceilings is required. Replace ceiling components damaged in the process.
- D. Provide patching where communications devices are removed from walls, ceilings or floors.

### 1.8 ACCESSIBILITY

- A. Coordinate to ensure the sufficiency of the size of shafts, and chases, and the adequacy of clearances in hung ceilings and other areas required for the proper installation of this work.
- B. Locate equipment which must be serviced, operated or maintained in fully accessible positions. Locations in ceilings requiring access shall be coordinated with, but not limited to lights, curtain tracks, and speakers. Equipment requiring access shall include, but is not necessarily limited to, motors, junction boxes, fire dampers, controllers, switchgear, etc.

- C. Indicate the locations of access doors for each concealed device, concealed behind finished construction and requiring service on the coordination drawings. Equipment below floor slab or finished grade shall also be indicated on the coordination drawings.
- D. Furnish access doors under this division for installation by General Contractor. Coordinate during bidding phase with General Contractor. Locations of access doors in finished construction shall be submitted in sufficient time to be installed in the normal course of the work.
  - 1. Manufacturers: Subject to compliance with requirements, furnish access doors by one of the following:
    - a. Bar-Co., Inc.
    - b. J. L. Industries
    - c. Karp Associates, Inc.
    - d. Nystrom, Inc.
  - 2. Materials and Fabrication:
    - a. General: Furnish each access door assembly manufactured as an integral unit, complete with all parts and ready for installation.
    - b. Steel Access Doors and Frames: Fabricate units of continuous welded steel construction, unless otherwise indicated. Grind welds smooth and flush with adjacent surfaces. Furnish attachment devices and fasteners of type required to secure access panels to types of support shown.
    - c. Frames: Fabricate from 16-gauge steel.
      - 1) Fabricate frame with exposed flange nominal 1 inch wide around perimeter of frame for units installed in the following construction:
        - a) Exposed Masonry
      - 2) For gypsum drywall or veneer gypsum plaster, furnish perforated frames with drywall bead.
      - 3) For installation in masonry construction, furnish frames with adjustable metal masonry anchors.
      - 4) For full-bed plaster applications, furnish frames with galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.
    - d. Flush Panel Doors: Fabricate from not less than 14-gauge sheet steel, with concealed spring hinges or concealed continuous piano hinge set to open 175°. Finish with manufacturer's factory-applied prime paint.
      - 1) For fire-rated units, provide manufacturer's standard insulated flush panel/doors, with continuous piano hinge and self-closing mechanism.
    - e. Locking Devices: Furnish flush, screwdriver-operated cam locks of number required to hold door in flush, smooth plane when closed.

### 1.9 PAINTING

- A. Painting requirements of this section shall conform to Division 9.
- B. Provide surface preparation, priming, and final coat application in strict accordance with manufacturer's recommendations.
- C. Provide prime coat painting for the following:
  - 1. Indoor miscellaneous steel and iron provided under this Division of the specifications.
  - 2. Indoor hangers and supports provided under this Division of the specifications.

## 1.10 EQUIPMENT FOUNDATIONS, SUPPORTS, PIERS AND ATTACHMENTS

- A. Provide necessary foundations, auxiliary steel, supports, pads, bases and piers required for equipment specified in this division; submit drawings in accordance with Shop Drawing Submittal requirements prior to the purchase, fabrication or construction of same.
- B. Construction of foundations, supports, and pads where mounted on the floor, shall be of the same materials and same quality of finish as the adjacent and surrounding floor material.
- C. Equipment shall be securely attached to the building structure in an approved manner. Attachments shall be of a strong and durable nature and any attachments that are, in the opinion of the Architect, not strong enough shall be replaced as directed, with no additional cost to the Owner.

## 1.11 CLEANING, PROTECTING AND ADJUSTING

- A. Cleaning
  - 1. General cleaning requirements are specified in Division 1.
  - 2. Upon completion of the work, clean the exterior surface of equipment, accessories, and trim installed. Clean, polish, and leave equipment, accessories, and trim in first-class condition.
- B. Protection of Surfaces
  - 1. Protect new and existing surfaces from damage during the construction period.
  - 2. Provide plywood or similar material under equipment or materials stored on floors or roofs. Provide protection in areas where construction may damage surfaces.
  - 3. Surfaces damaged during the construction shall be repaired or replaced at the cost of the Contractor at fault. The method or repairing or replacing the surface shall be approved by the Owner and Architect.
- C. Protection of Services
  - 1. Protect new and existing services from damage during the construction period.

- 2. Repair, replace, and maintain in service any new or existing utilities, facilities, or services (underground, overground, interior, or exterior) damaged, broken, or otherwise rendered inoperative during the course of construction.
- 3. Services damaged during the construction shall be replaced at the cost of the Contractor at fault. The method used in repairing, replacing, or maintain the services shall be approved by the Owner and Architect.
- D. Protection of Equipment and Materials
  - 1. Equipment and materials shall be stored in a manner that shall maintain an orderly, clean appearance. If stored on-site in open or unprotected areas, equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.
  - 2. Equipment and material, if left unprotected and damaged, shall be repainted or otherwise refurbished at the discretion of the Owner. Equipment and material is subject to rejection and replacement if, in the opinion of the Architect or the manufacturer's engineering department, the equipment has deteriorated or been damaged to the extent that its immediate use or performance is questionable, or that its normal life expectancy has been curtailed.
  - 3. During the construction period, protect equipment from damage and dirt.
- E. Adjusting
  - 1. After the entire installation has been completed, make required adjustments to all systems until performance requirements are met.

### 1.12 SPECIAL TOOLS

A. Provide the Owner's representative with two (2) sets of special tools required for operation and maintenance of equipment provided.

### 1.13 WELDING

- A. General Requirements
  - 1. This paragraph covers the welding of systems. Deviations from applicable codes, approved procedures and approved shop drawings shall not be permitted. Materials or components with welds made off the site shall not be accepted if the welding does not conform to the requirements of this specification. Develop and qualify procedures for welding metals included in the work. Certification testing shall be performed by an approved independent testing laboratory. Bear costs of such testing.
  - 2. Certified welders, previously certified by test, may be accepted for the work without recertification provided that all of the following conditions are fulfilled:
    - a. Submit copies of welder certification test records in accordance with this Division and Division 1 requirements.
    - b. Testing was performed by an independent testing laboratory.
    - c. The welding procedures and welders are certified in accordance with the "ASME Boiler and Pressure Vessel Code," and base materials, filler materials, electrodes,

equipment, and processes conform to the applicable requirements of this specification.

- d. Certification has been within a one (1) year period from the start of the project.
- 3. Filler metals, electrodes, fluxes and other welding materials shall be delivered to the site in manufacturers' original packages and stored in a dry space until used. Packages shall be properly labeled and designed to give maximum protection from moisture and to assure safe handling.
- 4. Submit welding certificates for review. Each welder assigned to work covered by this specification shall be certified by performance tests using equipment, positions, procedures, base metals, and electrodes or bare filler wires.
- 5. Before assigning welders to the work, provide the architect with their names, together with certification that each individual is certified as specified. No welding work shall start prior to submissions. The certification shall state the type of welding and positions for which each is certified, the code and procedure under which each is certified, date certified, and the firm and individual certifying the certified tests.
- 6. Each welder shall be assigned an identifying number, letter, or symbol that shall be used to identify his welds. A list of the welders' names and symbol for each shall be submitted. To identify welds, either written records indicating the location of welds made by each welder shall be submitted, or each welder shall apply his mark adjacent to his weld using an approved rubber stamp or felt-tipped marker with permanent, weatherproof ink or other approved methods that do not deform the metal. For seam welds, identification marks shall be placed adjacent to the welds at 3 foot intervals. Identification by die stamps or electric etchers shall be confined to the weld reinforcing crown, preferably in the finished crater.

## PART 2 - PRODUCTS

## 2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
  - 1. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
    - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

### 2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Advance Products & Systems, Inc.
    - b. Calpico, Inc.
    - c. Metraflex Co.
    - d. Pipeline Seal and Insulator, Inc.
  - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - 3. Pressure Plates: Stainless steel. Include two for each sealing element.
  - 4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

### 2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

## PART 3 - EXECUTION

- 3.1 COMMON REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS INSTALLATION
  - A. Comply with NECA 1.
  - B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
  - C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
  - D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
  - E. Right of Way: Coordinate piping systems installed at a required slope.
  - F. Apply for detailed and specific information regarding the location of equipment as the final location may differ from that indicated on the drawings. Outlets, equipment or wiring improperly placed because of failure to obtain this information shall be relocated and

re-installed without additional expense to the Owner. Determine the actual direction of door swings, so that local switches and other controls shall be installed at the lockside of doors, unless otherwise noted. Improperly located switches shall be relocated without additional expense to the Owner.

- G. The design shall be subject to such revisions as may be necessary to overcome building obstructions. No changes shall be made in location of outlets or equipment without written consent of the Architect and Owner.
- H. Unless otherwise mentioned or indicated, mounting heights of outlets are shown on the drawings or in the specification. Dimensions given shall be considered to be from center of outlet to finished floor.
- I. Coordinate the location and elevation of all communications devices and fixtures with the architectural interior elevation plan and reflective ceiling plan prior to installation.
- J. Properly rough in for the communications raceways and equipment under this contract and modify as required for coordination during the construction period.
- K. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- L. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- M. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

### 3.2 WELDING

- A. Perform welding in accordance with qualified procedures using certified welders. Welding shall not be done when the quality of the completed weld could be impaired by the prevailing working or weather conditions. Welding of hangers, supports, and plates to structural members shall conform to AWS specifications.
- B. Field bevels and shop bevels shall be by mechanical means or by flame cutting. Where beveling is by flame cutting, thoroughly clean surfaces of scale and oxidation just prior to welding. Beveling shall conform to ANSI B31.1 and AWS B3.0.
- C. Replace and reinspect defective welds. Repairing defective welds by adding weld material over the defect or by peening shall not be permitted. Welders responsible for defective welds must be re-certified.
- D. Store electrodes in a dry heated area, keep free of moisture and dampness during fabrication operations. Discard electrodes that have lost part of their coating.

## 3.3 SLEEVE INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS PENETRATIONS

- A. Electronic Safety and Security Systems penetrations occur when raceways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, fire-rated floor, or wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry
  - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- J. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- K. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- L. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

### 3.4 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### 3.5 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 firestopping section.

### 3.6 DUST, DIRT AND NOISE

- A. Carry out new work and make changes, relocations, and installations with a minimum of noise. Site areas and new equipment, floors and walls, shall be adequately protected from dust and dirt caused by the work. Protection shall include suitable temporary barriers or coverings. The exterior and interior premises of each building shall be kept clean as possible during construction. Damages to surfaces or equipment as a result of negligence shall be replaced or corrected as required.
- B. School activities may be under way during much of the construction period. It is imperative that school functions and activities are given priority and the highest level of respect. Contractor functions which may be excessively noisy or disruptive shall be scheduled for times when school functions will not be interrupted or disturbed.

### 3.7 ENVIRONMENTAL AIR PLENUMS

A. In spaces over hung ceiling which are used for environmental air handling purposes as defined by Article 300.22C of the National Electric Code, power data and communications cable must be in conduit or of the type cable rated for air plenum use. Cable type and/or raceway is generally indicated on the drawings and specifications although the Contractor shall be responsible to clearly define ceiling space used for environmental air purposes.

## 3.8 SPECIAL ENGINEERING SERVICES

A. In the instance of complex or specialized telecommunications, security, and audiovisual systems that are included in Division 27; the installation, final connections, and testing of such systems shall be made under the direct supervision of competent authorized service engineers who shall be in the employ of the respective equipment manufacturer. Provide the Owner with copies of instruction manuals and booklets for each system and piece of equipment installed. Provide any additional instruction to the Owner over and above the listed above in the care, adjustment, and operation of all parts of the communications systems.

## END OF SECTION

### SECTION 28 13 00 - ACCESS CONTROL

### PART 1 - GENERAL

### 1.1 SUMMARY

A. This Section includes a security access system consisting of Request-to-Exit sensors, proximity card readers, entry-level controllers, and controllers, connected to each other by a high-speed electronic data transmission network. Controllers are connected to the BCPS Central Station over the BCPS WAN. Entry-level controllers monitor and control door strikes, magnetic locks, and door contacts specified in Division 08.

### 1.2 DEFINITIONS

- A. BCPS: Baltimore County Public Schools (Owner).
- B. Central Station: The existing BCPS computers hosting the BCPS software that controls access systems at BCPS buildings.
- C. Controller: An intelligent peripheral control unit that uses a computer for controlling its operation. Where this term is presented with an initial capital letter, this definition applies.
- D. LAN: Local area network.
- E. PC: Personal computer. This acronym applies to the Central Station, workstations, and file servers.
- F. PDF: (Portable Document Format.) The file format used by the Acrobat document exchange system software from Adobe.
- G. RS-232: A TIA/EIA standard for asynchronous serial data communications between terminal devices. This standard defines a 25-pin connector and certain signal characteristics for interfacing computer equipment.
- H. RS-485: A TIA/EIA standard for multipoint communications.
- I. WAN: Wide area network.
- J. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- K. Windows: Operating system by Microsoft Corporation.

### 1.3 SYSTEM DESCRIPTION

- A. System shall consist of field-installed controllers, entry-level controllers, and sensors connected to each other by a high-speed electronic data transmission network and connected to the BCPS Central Station over the BCPS WAN.
- B. Network connecting the Central Station and controllers shall be the BCPS WAN.

- C. Network(s) connecting controllers shall consist of one or more of the following:
  - 1. BCPS LAN to connect controllers at different locations.
  - 2. RS-485 to interconnect controllers at one location.

### 1.4 PERFORMANCE REQUIREMENTS

- A. Security access system shall use the BCPS database for access-control and credential-creation functions.
- B. System network requirements: Interconnect system components and provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
- C. Field equipment shall include controllers, entry-level controllers, sensors, and controls. Controllers shall serve as an interface between the BCPS Central Station and sensors and controls. Data exchange between the BCPS Central Station and the controllers shall include down-line transmission of commands, software, and databases to controllers. The up-line data exchange from the controller to the Central Station shall include status data such as intrusion alarms, status reports, and entry-control records.
- D. Door Hardware Interface: Coordinate with Division 08 Sections that specify door hardware required to be monitored or controlled by the security access system. The controllers in this Section shall have electrical characteristics that match the signal and power requirements of door hardware. Integrate door hardware specified in Division 08 Sections to function with the e controls and PC-based software and hardware in this Section.

### 1.5 SUBMITTALS

- A. Product Data: For each type of product indicated. Include operating characteristics, furnished specialties, and accessories. Reference each product to a location on Drawings.
- B. Shop Drawings:
  - 1. Diagrams for cable management system.
  - 2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
- C. Project planning documents as specified in Part 3.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data" include the following:
  - 1. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.

2. System installation and setup guides, with data forms to plan and record options and setup decisions.

### 1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
  - 1. Cable installer must have on staff a registered communication distribution designer certified by Building Industry Consulting Service International.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- C. Source Limitations: Obtain controllers, and all software through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NFPA 70, "National Electrical Code."
- 1.7 DELIVERY, STORAGE, AND HANDLING
  - A. Controllers:
    - 1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F (10 and 30 deg C), and not more than 80 percent relative humidity, noncondensing.
    - 2. Open each container; verify contents against packing list, and file copy of packing list, complete with container identification for inclusion in operation and maintenance data.
    - 3. Mark packing list with designations that have been assigned to materials and equipment for recording in the system labeling schedules that are generated by cable and asset management system specified in Part 2.

### PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
- 2.2 SECURITY ACCESS SYSTEM
  - A. Manufacturers:
    - 1. General Electric.

## 2.3 APPLICATION SOFTWARE

A. System Software: General Electric Secure Perfect Version 6 or higher.

## 2.4 TAMPER PROTECTION

A. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations.

## 2.5 CONTROLLERS

- A. Controllers: GE Security, M5, M2000 and M3000 PXNplus series as appropriate. The control panels shall be intelligent and fully stand-alone processor capable, making all local access control and alarm monitoring decisions without host server dependency. Control panels shall support the following:
  - 1. UL listed under UL 294 and UL 1076; FCC Part 15 and CE compliant.
  - 2. Direct on-board support for industry standard RS232, RS422, Dial-up modem AT command set, and 10/100Mb Ethernet communications interfaces to ISMS host.
  - 3. The 10/100Mb Ethernet NIC shall be onboard and support IT standard methods of communications with ISMS host including configuration support for static IP addressing, dynamic DNS, DHCP and DES encryption. PCMCIA Adapters or external terminal server devices will not be acceptable.
  - 4. Support redundant communications to ISMS host; primary communications via 10/100Mb Ethernet with automatic switchover to secondary communications via dial-up modem when detecting network failure.
  - 5. RS232 and RS422 communications ports for cascading/clustering multiple control panels via a single communications port interface to ISMS host.
  - 6. Flashable memory support for facilitating remote firmware updates from ISMS host server and operator workstations; control panels shall remain on-line and operational during firmware update process.
  - 7. The control panel shall be able to be configured & diagnosed remotely through a standard browser interface, independently of the ISMS host application.
  - 8. The control panel shall support local database retention in the event of power failure, without the use of batteries that have to be replaced. Minimum retention without primary power source shall be 20 days. When primary power is restored, the control panel shall automatically attempt to establish communications with the ISMS host, in the event communications to ISMS host is not available, the control panel shall automatically return to operation with its last local database configuration.
  - 9. Control panel cabinets shall be an industrial grade enclosure with knockouts outs for field wiring and have a key-locked and tamper protected door.
  - 10. Low voltage power supply with uninterruptible battery backup allowing continued operations for a minimum of 4 hours at full load.
- B. Provide one controller for every four controlled doors.
- C. Entry-Control Controller: Provide General Electric Model WIU-4 with General Electric "Micro/Junction" cabinet.

## 2.6 CARD READERS

- A. Provide HID Corporation "Mini-Prox Reader" Model No. 5365 Proximity Reader.
- 2.7 REQUEST-TO-EXIT SENSORS
  - A. Available Manufacturers: Bosch
  - B. Provide Bosche Model number DS150i

## 2.8 DOOR AND GATE HARDWARE INTERFACE

- A. Exit Device with Alarm: Operation of the exit device shall generate an alarm and annunciate a local alarm. Exit device and alarm contacts are specified in Division 08 Section "Door Hardware."
- B. Exit Alarm: Operation of a monitored door shall generate an alarm. Exit devices and alarm contacts are specified in Division 08.
- C. Electric Door Strikes: Use end-of-line resistors to provide power line supervision. Signal switches shall transmit data to Controller to indicate when the bolt is not engaged and the strike mechanism is unlocked, and shall report a forced entry. Power and signal shall be from the Controller. Electric strikes are specified in Division 08 "Door Hardware."
- D. Electromagnetic Locks: End-of-line resistors shall provide power line supervision. Lock status sensing signal shall positively indicate door is secure. Power and signal shall be from the Controller. Electromagnetic locks are specified in Division 08 Section "Door Hardware."

### 2.9 CABLES

- A. Available Manufacturers:
  - 1. Belden Inc.; Electronics Division.
  - 2. Berk-Tek; a Nexans Company.
  - 3. General Cable Technologies Corporation.
  - 4. Mohawk/CDT; a division of Cable Design Technologies.
  - 5. West Penn Wire/CDT; a division of Cable Design Technologies.
- B. Plenum-Type, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
  - 1. NFPA 70, Type CMP.
  - 2. Flame Resistance: NFPA 262 Flame Test.
- C. RS-485 communications require 2 twisted pairs, with a distance limitation of 4000 feet (1220 m).

- D. Plenum-Type, RS-485 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket.
  - 1. NFPA 70, Type CMP.
  - 2. Flame Resistance: NFPA 262 Flame Test.
- E. Plenum-Type, Paired, Readers Cable: Paired, 3 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, individual aluminum foil-polypropylene tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and fluorinated-ethylene-propylene jacket.
  - 1. NFPA 70, Type CMP.
  - 2. Flame Resistance: NFPA 262 Flame Test.
- F. Plenum-Type, Paired Lock Cable: 1 pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
  - 1. NFPA 70, Type CMP.
  - 2. Flame Resistance: NFPA 262 Flame Test.
- G. Plenum-Type, Paired Input Cable: 1 pair, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, aluminum foil-polyester tape shield (foil side out), with No. 22 AWG drain wire, 100 percent shield coverage, and plastic jacket.
  - 1. NFPA 70, Type CMP.
  - 2. Flame Resistance: NFPA 262 Flame Test.
- H. Plenum-Type, Paired AC Transformer Cable: 1 pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
  - 1. NFPA 70, Type CMP.
  - 2. Flame Resistance: NFPA 262 Flame Test.
- I. LAN Cabling: Comply with Division 16 Section "Wires and Cables."
  - 1. NFPA 262.

### 2.10 TRANSFORMERS

A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

## 2.11 CABLE AND ASSET MANAGEMENT

- A. Available Manufacturers:
  - 1. IMAP Textron; Division of Greenlee Textron.
  - 2. Total Wire Software Company, Inc.

- 3. Brady Corporation
- B. Computer-based cable and asset management system, with fully integrated database and graphic capabilities, complying with requirements in TIA/EIA-606.
  - 1. Document physical characteristics by recording the network, asset, user, TIA/EAI details, device configurations, and exact connections between equipment and cabling.
    - a. Manage the physical layer of security system.
    - b. List device configurations.
    - c. List and display circuit connections.
    - d. Record firestopping data.
    - e. Record grounding and bonding connections and test data.
  - 2. Information shall be presented in database view, schematic plans, or technical drawings.
  - 3. System shall interface with the following testing and recording devices:
    - a. Direct upload tests from circuit testing instrument into the PC.
    - b. Direct download circuit labeling into labeling printer.
- C. Software shall be designed for Microsoft Windows of same version as security access system's workstations and shall be installed on the designated PC, using a hard drive dedicated only to this management function. Hard-drive capacity shall be not less than 50 GB.

### PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN and control cable conduit systems to PCs, Controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with EIA/TIA-606, "Administration Standard for the Telecommunications Infrastructure of Commercial Buildings."
- C. Obtain detailed Project planning forms from manufacturer of access-control system; develop custom forms to suit Project. Coordinate with Owner's requirements. Fill in all data available from Project plans and specifications and publish as Project planning documents for review and approval.

- 1. Record setup data for control station and workstations.
- 2. For each Location, record setup of Controller features and access requirements.
- 3. Propose start and stop times for time zones and holidays, and match up access levels for doors.
- 4. Set up groups, facility codes, linking, and list inputs and outputs for each Controller.
- 5. Assign action message names and compose messages.
- 6. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
- 7. Develop user-defined fields.
- 8. Develop screen layout formats.
- 9. Complete system diagnostics and operation verification.
- 10. Prepare a specific plan for system testing, startup, and demonstration.
- 11. Develop acceptance test concept and, on approval, develop specifics of the test.
- 12. Develop cable and asset management system details; input data from construction documents. Include system schematics.
- D. In meetings with Architect and Owner, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

## 3.3 CABLING

- A. Comply with NECA 1, "Good Workmanship in Electrical Contracting."
- B. Install cables and wiring according to requirements in Specifications.
- C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
- D. Install LAN cables using techniques, practices, and methods that are consistent with Category 6 rating of components and that ensure Category 6 performance of completed and linked signal paths, end to end.
- E. Install cables without damaging conductors, shield, or jacket.
- F. Boxes and enclosures containing security system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered to be accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
- G. Install end-of-line resistors at the field device location and not at the Controller or panel location.

### 3.4 CABLE APPLICATION

- A. Comply with EIA/TIA-569, "Commercial Building Standard for Telecommunications Pathways and Spaces."
- B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.

- C. RS-232 Cabling: Install at a maximum distance of 50 feet (15 m).
- D. RS-485 Cabling: Install at a maximum distance of 4000 feet (1220 m).
- E. Card Readers:
  - 1. Install number of conductor pairs recommended by manufacturer for the functions specified.
  - 2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from Controller to the reader is 250 feet (75 m), and install No. 20 AWG wire if maximum distance is 500 feet (150 m).
  - 3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the Controller.
  - 4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
- F. Install minimum No. 16 AWG cable from Controller to electrically powered locks. Do not exceed 500 feet (150 m).
- G. Install minimum No. 18 AWG ac power wire from transformer to Controller, with a maximum distance of 25 feet (8 m).

### 3.5 GROUNDING

- A. Comply with Division 16 Section "Grounding."
- B. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Bond shields and drain conductors to ground at only one point in each circuit.
- E. Signal Ground:
  - 1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
  - 2. Bus: Mount on wall of main equipment room with standoff insulators.
  - 3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

## 3.6 INSTALLATION

- A. Install card readers and Request-to-Exit sensors.
- 3.7 IDENTIFICATION
  - A. In addition to requirements in this Article, comply with applicable requirements in Division 16 Section "Basic Electrical Materials and Methods" and with TIA/EIA-606.

- B. Using cable and asset management software specified in Part 2, develop Cable Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with same designation. Use logical and systematic designations for facility's architectural arrangement.
- C. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
  - 1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
  - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.
- D. At completion, cable and asset management software shall reflect as-built conditions.

## 3.8 SYSTEM SOFTWARE

- A. Owner will install databases for the complete and proper operation of systems involved.
- 3.9 FIELD QUALITY CONTROL
  - A. Perform the following field tests and inspections and prepare test reports:
    - 1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2, bidirectional, Category 5 tester. Test for faulty connectors, splices, and terminations. Test according to TIA/EIA-568-1, "Commercial Building Telecommunications Cabling Standards Part 1 General Requirements." Link performance for UTP cables must comply with minimum criteria in TIA/EIA-568-B.
    - 2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
    - 3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.
  - B. Remove and replace malfunctioning devices and circuits and retest as specified above.

### 3.10 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.

### 3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain security access system.
- B. Develop separate training modules for the following:
  - 1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
  - 2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
  - 3. Security personnel.
  - 4. Hardware maintenance personnel.
  - 5. BCPS management.
- C. Upon completion and demonstration of the system, provide BCPS Safety and Security Department a typed list of all System Administrative Passwords, user ID's and Panel Locations

### END OF SECTION

### SECTION 28 16 00 - INTRUSION ALARM

### PART 1 - GENERAL

### 1.1 SECTION INCLUDES

A. Provide a complete security system as specified and as shown on the drawings, including the following:

Control Panel Motion Detectors Door Contact Switches Temperature Sensors Keypads Local Sirens Digital Communicator Battery Back-up Accessories and Appurtenances

- 1.2 RELATED SECTIONS
  - A. Electrical requirements are specified in Division 26.
- 1.3 SYSTEM DESCRIPTION
  - A. System shall be centrally controlled and include alarm control panel, digital communicator, keypads detectors, switches, thermostats, local sirens, light controls, raceways, and complete wiring as specified and shown on drawings.
  - B. System shall detect intruders, identify zone where intrusion occurred, activate local sirens, detect building temperature below 45 degrees F, and above 110 degrees F, detect fire alarm signal, and send alarm signal(s) to Board of Education central receiving station, and maintain itself in operable condition for four hours upon failure of 120 volt 60 hertz supply.
  - C. Areas protected shall be all entry areas, administrative areas, and other specially designated areas. System shall be installed so that additional areas may be protected in the future.
  - D. Zones shall be arranged to include an individual zone for each device. Zone controls shall be tamper proof so that tampering with a zone control will activate the alarm. Arming keypad, control/communicator cabinet(s), and wiring shall be supervised so that any tampering will activate the alarm. After each alarm, the system shall automatically reset to be ready for any subsequent alarm detection.
  - E. Provide subcontrol keypads to allow use of the Parks and Recreation, custodial, and administration areas (zones), and allow full security of remaining school areas. A special subzone code will be sent whenever the subzone is disarmed or armed by any authorized user or group of users. An entry/exit delay loop and instant loop will be a part of this subzone control.
  - F. Provide entry/exit delay where indicated on drawings or specifications.

- G. Provide one 0.75-inch conduit and cable from the security alarm control panel to main fire alarm control panel and make connections for fire alarm to activate security alarm control panel.
- H. All motion detectors, door contact switches, and temperature sensors are to have individual popits and must indicate a single point per device on the master keypad's display.

## 1.4 SUBMITTALS

- A. Shop drawings: Schematic wiring diagram of the complete system. Maintain an approved copy of this diagram as the basis for the project record diagram. Provide a complete project record drawing showing the locations of all cable runs, cable routes, equipment and all components installed. Drawing shall become part of the O & M Manuals.
- B. Project record documents: Provide for the security system, in addition to documents required, three record and information booklets containing a description of the system, operating and maintenance instructions on each piece of equipment, including descriptive bulletin and parts lists. Booklet shall be a three-ring looseleaf binder on 8-1/2-inch by 11-inch sheets and shall contain name, address, and telephone number of the local representative of the equipment.

## 1.5 QUALITY ASSURANCE

- A. Qualified subcontractor shall have a satisfactory record of providing adequate service and maintaining a stock of replacement parts, for systems of similar type and size which have been operating for at least five years.
- B. Equipment shall be Underwriters' Laboratory listed.
- C. All equipment shall be installed in accordance with the manufacturer's instructions, National Electrical Code and other contract requirements.
- D. The equipment supplier's technician shall supervise location and actual installation of all equipment and final wiring connections, and shall perform all final testing, tuning and adjusting to make the system operable.
- E. Qualified subcontractor shall have the capability to program and control the installed system remotely from their local service center via the Radionics computer software.

### 1.6 MAINTENANCE

A. At the end of the general project correction period, offer the Owner a service contract covering the entire system.

### PART 2 - PRODUCTS

## 2.1 CONTROL PANEL
- A. Alarm control panel and digital communicator shall be Bosch, Model D9412G with eight programmable areas (zones), eight on-board points, and up to 238 off-board points for a total of 246. Include a tamper switch for the panel. Communicator shall be equipped with programmable phone line monitor, and include one D928 dual phone line switcher for use with two separate phone jacks and lightning arrestor protection and including but not limited to the following accessories:
  - 1. One D-126 lead-acid Battery, or a 12 volt 6 A.H. lead-acid type.
  - 2. One D-161 Telephone Cord
  - 3. One or more D-1255 Alpha IV Command Centers
  - 4. Two D-110 Tamper Switches
  - 5. One or more D-8129 Octo-Relay Modules
  - 6. One or more D-8125 Popex Module for Zonex system. One to 126 D8127 Popit Modules as may be necessary for Zonex System
  - 7. Four D1255 Independent Zone Control Keypads
  - 8. One dual phone line switcher D928
  - 9. Two RJ31 telephone jacks with individual cables terminated at telephone service equipment
- B. Digital communicator must be compatible with the Radionics Model 6600 Receiving unit existing at the Owner's central receiving station.
- C. Coordinate with the Owner for the installation of Owner's telephone interface equipment required to transmit security signals back to the Owner's central receiving station.
- D. The above equipment shall have the ability to:
  - 1. Visibly annunciate all zones and subzones. Alpha IV Command Center shall be capable of a minimum of 16 characters, alphanumeric display.
  - 2. Report each device to the Owner's central receiving station.
  - 3. Zone in and force arm any zone without affecting the security of remaining zones.
  - 4. Respond to interrogation from central receiving station.

## 2.2 DETECTION, SIGNALING DEVICES

- A. Provide intrusion detector types as listed and in the necessary quantities for a complete system as shown and specified.
  - 1. Recessed contact switches: Sentrol No. 1078CW, 0.75-inch diameter, for doors.
  - 2. Surface-mounted door contacts: Sentrol No. 2505A wide gap with three feet of armored cable protecting wires.
  - 3. Passive infared detectors: Equal to Bosch ZX935Z and OMLR 93-3 Long Range Series, or Owner approved equal, and adapted for use in all areas. Exact locations of devices shall be as directed by Owner.
- B. Building temperature sensors: Intellitemp T-1000 or Owner approved equal. Set for contact to open when temperature reaches 45 degrees F. (low) or 110 degrees F (high). These will occupy one zone or subzone on the control unit.

- C. Local Sirens: Equal to Ademco Model No. 740 high intensity sounder.
- D. Provide 8-1/2-inch by 11-inch building room layout based on the contract drawings in a suitable frame with glass panel, indicating intrusion zones and all intrusion detectors including identification numbers. Install adjacent to the intrusion alarm control panel.

#### 2.3 POWER REQUIREMENTS

- A. The control panel shall receive 120 VAC power as noted on the drawings.
- B. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of 24 hours. The system shall automatically transfer to the standby batteries upon power failure. All battery charging and recharging operations shall be automatic.

#### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. The alarm control/communicator panel, designated motion detectors, door switches, and thermostats shall be installed where indicated on the drawings or specified and as required by the equipment manufacturer.
- B. Do not install switches or equipment on labeled doors. Locate equipment so that it does not interfere with the designated functional uses of the area and where it is not easily subject to abuse or vandalism by the building occupants.
- C. Install motion detectors where indicated on drawings or specifications. Mount detectors where they will detect the earliest possible entry into the area with the least chance of false alarms. Mount detectors within 12 inches of finished ceiling, not exceeding manufacturers recommended maximum height. Provide wire guards on all units mounted in Gym and where noted on the drawings.
- D. Install door switches flush in door frames approximately 4 inches from strike side with wiring in raceway from above ceiling. Switches shall be installed one per door leaf.
- E. Install thermostats 12 inches from the ceiling. Thermostats shall be wired in series to activate signal when temperatures fall below 45 degrees F. or reach or exceed 110 degrees F.
- F. Cable shall be as recommended by the equipment manufacturer and as shown on the wiring diagram. Wiring shall be concealed. Cables may be run exposed above lay-in ceilings but not in return air plenums, and fastened with approved ties to the building structure. Cables shall not lie on any temperature control pipes or on ceiling. Cables that penetrate masonry walls, and runs within the boiler room, mechanical equipment rooms, and where exposed in unfinished rooms or spaces shall be installed in 0.75-inch EMT conduit. Run one 0.75-inch EMT conduit, with phone cables, from communicator to the telephone terminal board. All 120 volt wiring shall be encased in conduit to suit the area. Provide 24 hour 120 volt 60 hz power where required.

#### 3.2 DEMONSTRATION

- A. After adjusting the system, arrange a mutually convenient time for a test demonstration of the system prior to final acceptance.
- 3.3 OPERATING INSTRUCTIONS
  - A. As specified, provide operating instructions.
  - B. Provide at least four consecutive hours of additional instruction time for the systems and equipment specified in this section.
  - C. Provide the services of the BCPS "On-Call" service vendor to provide all final Alarm System programming to BCPS Central Station at Pulaski Park Office. Contractor provide all coordination with and shall pay for all services for the current BCPS "on-call" service vendor provider.
  - D. Test ALL Alarm Systems Devices and standard Alarm Panel condition to the BCPS Central Station. Upon completion and demonstration of the system, provide BCPS Safety and Security Department a typed list of all Alarm System "Points".
  - E. Upon completion and demonstration of the system, provide BCPS Safety and Security Department a typed list of all Alarm System "Points".

# **END OF SECTION**

#### SECTION 282300 – VIDEO SURVEILLANCE SYSTEM

#### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes a new closed-circuit television (CCTV) system for security surveillance, including cameras, mounting hardware, digital video recorder, monitor, and all cabling and connectors required to complete the system.
- B. Work specified in this section will be included if the Alternate for video surveillance system should be accepted.
- 1.2 RELATED SECTIONS
  - A. Requirements applicable to electrical work specified in Division 26 apply to work of this section.
  - B. Unit prices: Division 1.
  - C. Alternates: Division 1.
- 1.3 SYSTEM DESCRIPTION
  - A. Video cameras, camera outlets, camera controls, monitors, video switches, signal-processing equipment, control stations, distribution components, digital video recorder, and auxiliary recording computer create video images, process them, and distribute them. System shall display images on monitors and permit remote control of video-camera equipment. System shall be compatible with Baltimore County Public Schools video surveillance network.
- 1.4 SUBMITTALS
  - A. General: Comply with Division 1 and Divisions 26, 27, & 28.
  - B. Product data:
    - 1. Include data on features, components, ratings, and performance.
  - C. Shop drawings:
    - 1. Include dimensioned plan and elevation views of components and enclosures and details of control panels. Show access and working space requirements.
    - 2. Wiring diagrams detailing internal and interconnecting wiring for power, signal, and control and distinguishing between field-installed and factory-installed wiring.
    - 3. Coordination drawings: Plans drawn to scale, showing the locations of the CCTV equipment. Include mounting details.
  - C. Certificates: Signed by manufacturer, certifying products comply with specified requirements.
  - D. Qualification data for manufacturer and installer as specified in "Quality Assurance" below.

- 1. Include evidence of installer's RCDD from BiCSi.
- E. Field test reports for tests specified in Part 3.

## 1.5 QUALITY ASSURANCE

- A. Manufacturer qualifications:
  - 1. Firms experienced in manufacturing systems and equipment of the same types and capacities used for this project that have a record of successful in-service performance.
  - 2. Maintains a service center capable of providing training, parts, and emergency maintenance and repairs at the project site with a 24-hour maximum response time.
- B. Installer qualifications: Factory-authorized service representative of the television system manufacturer.
  - 1. Installer shall have on its regular full-time staff a registered communications distribution designer (RCDD) with LAN specialization, who shall approve and supervise cabling work and network integration.
  - 2. Installer shall obtain the equipment and materials from a fully factory authorized dealer, with a signed agreement from the manufacturer.
- D. Comply with NFPA 70, National Electrical Code.
- E. Comply with FCC Part 15, Rules and Regulations, Radio Frequency Devices.
- F. NRTL Listing: Provide listed and labeled system components for which there is a listing and labeling service.
  - 1. The Terms "listed" and "labeled": As defined in the National Electrical Code, Article 100.
  - 2. Listing and labeling agency qualifications: A Nationally recognized testing laboratory (NRTL) as defined in 29 CFR 1910.7.

#### 1.6 PROJECT CONDITIONS

- A. Environmental limitations: System components shall be equipped and rated for the environments where installed.
  - 1. Service conditions for outdoor equipment: Rate equipment for continuous operation under the following environmental conditions, unless otherwise indicated:
    - a. Temperature: Minus 22 deg F (30 deg C) to plus 122 deg F (50 deg C).
    - b. Relative humidity: 5 to 100 percent.
    - c. Weather: Enclosure housings shall prevent entry of moisture including ice and driven rain or snow.
  - 2. Service conditions for indoor equipment: Rate equipment for continuous operation under the following environmental conditions, unless otherwise indicated:
    - a. Temperature: 32 deg F (0 deg C) to 122 deg F (50 deg C).
    - b. Relative humidity: 0 to 95 percent.

#### 1.7 COORDINATION

- A. Coordinate layout and installation of CCTV equipment and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate all exact camera locations and confirm on site with the BCPS representative from BCPS Safety and Security Department prior to mounting devices.

## 1.8 EXTRA MATERIALS

- A. Furnish extra materials matching specified products, packaged with protective covering for storage, and identified with labels describing contents. Provide not less than 1 of each listed product. Deliver extra materials to the Owner.
  - 1. Fuses: One for every ten of each type and rating, but not less than one of each.
  - 2. Lenses: One for every ten of each type installed.

## PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

## 2.2 CAMERAS AND POWER SUPPLIES

- A. Manufacturers: General Electric.
- B. Camera: General Electric Legend IP series, part number D26SN. Dome Camera 26XZ00N, Day/Night Lens.
  - 1. Housing:
    - a. Interior: GE# GEA-FP9-D26N-1P. As indicated on drawings. Provide tamper-resistant hardware.
    - b. Exterior: GEA-RE8-D26N-1P rugged pendant with heater, fan and tamper-resistant hardware.
  - 2. Dome Bubble: "clear" polycarbonate on exterior installations and "smoke" polycarbonate on interior installations.
  - 3. Mounting Accessories: Wall-mount (GEA-102-Interior/DR-RWM-Exterior), parapet-mount, corner-mount (GEA-105-Interior/DR-RCM-Exterior), pole-mount, roof-mount, ceiling panel-mount (GEA-113), or parapet swing-arm-mount as indicated on drawings.

- C. Exterior dome power supply: General Electric model number KTP-24. Provide one per exterior camera.
- D. Central power supply: General Electric model number KTP-24-8I-400. Provide one per eight interior cameras. GE#KTP-24, 100VA Outdoor Power Supply for exterior cameras.
- 2.3 SIGNAL TRANSMISSION COMPONENTS
  - A. Cable: TIA/EIA Category 6, plenum rated. Jacket color shall be uniform throughout video surveillance system, and shall be different from data cables for school Local Area Network.
  - B. Cable Connectors: Category 6 rated, configured as directed by Video Surveillance System manufacturer.
  - C. Patch cables: Category 6. Provide sufficient patch cables in appropriate lengths as needed for a complete installation of the system.

## 2.4 MONITORS

A. Available manufacturers: Dell products are the basis of design for this project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 1 and Division 26, and submit product data and show drawings as required in article 1.3 above.

Sony LG Samsung

B. Monitor: Dell UltraSharp 1505FP Flat Panel Display. Provide one connected to Network Video Recorder. Provide ceiling-mounting hardware where necessary.

# 2.5 SOFTWARE

- A. Manufacturer: General Electric.
- B. General Electrical SymSecure Perfect package, consisting of:
  - 1. General Electric Live Viewer application software for remote viewing over a network.
    - a. SymSecure-P-1U-41 or higher client/user connection.
    - b. SymSecure-P-1C-41-4.1 or higher camera connection license.
  - 2. General Electric Network Video Recording software "SymServer-S" for archiving on the server described below.
    - a. SymSecure-P-Base 4.1 or higher
    - b. SymSecure-P-1C-41-4.1 or higher camera connection license for video inputs and monitor outputs: one per camera in system.
    - c. SymSecure-E-RA70-4.1 or higher: 70 camera archiver
    - d. SymSecure-E-FOD-4.1 or higher: failover directory server software.
    - e. Keyboard and monitor connection software as needed for a complete system.

3. General Electric configuration software for system configuration tools.

#### 2.6 VIDEO NETWORK SERVER AND NETWORK VIDEO RECORDER

A. Available manufacturers: <u>Dell products</u> are the basis of design for this project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 1 and Division 26, and submit product data and show drawings as required in article 1.3 above. Before purchase of any other manufacture than Dell, equipment data must be reviewed by BCPS Safety and Security Department prior to ordering equipment. Dell Hewlett Packard

IBM

- SUN
- B. Dell PowerEdge 2800 series server
  - 1. Provide 4 terrabyte hard drive capacity minimum.
  - 2. Provide keyboard.
  - 3. Intel Core 2x Dual Core Intel Xeon 5160, 3.00 GHz or higher, 4 MB Cache, 1333 MHz FSB
  - Microsoft Windows Server 2003 SP1/SP2 32-bit/64-bit, or Microsoft Windows Server 2003 R2 32-bit/64-bit
  - 3. 4.0 GB of RAM
  - 4. Standard VGA video card, or better
  - 5. Additional 80 GB hard drive for video storage
  - 6. 800 x 600 or higher screen resolution
  - 7. 10/100/1000 Ethernet Network Interface Card
  - 8. DVD ROM drive

#### 2.7 VIDEO NETWORK SWITCH – 1 Gig Network Switch

A. Available manufacturers: <u>Dell products</u> are the basis of design for this project. The following listed manufactures also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 1 and Division 26, and submit product data and show drawings as required in article 1.3 above.

3COM Cisco Belkin

- B. Dell PowerConnect 2700 series. Provide switches as needed to provide one port per camera and 25 percent spare ports.
- 2.8 MEDIA CONVERTER 1 Gig Media Converter
  - A. Available manufacturers: Allied Telesyn products are the basis of design for this project. The following listed manufactures also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 1 and Division 26, and submit product data and show drawings as required in article 1.3 above.

StarTech Tripp Lite TRENDnet

- B. Allied Telesyn Model number AT-MC-101 series.
  - 1. Provide model with fiber connectors to match building's fiber optic backbone.

#### 2.9 UNINTERRUPTIBLE POWER

A. Available manufacturers: APC products are the basis of design for this project. The following listed manufacturers also provide units of acceptable quality. If units by any of these manufacturers should be proposed, verify that they meet requirements specified in Division 1 and Division 26, and submit product data and show drawings as required in article 1.3 above.

MGE Liebert

- B. APC Backup-UPS RS 800VA, part number BR800. Provide at each CCTV rack in number as needed to power media converter, server, switches, monitors, and camera central power supplies.
- 2.10 CCTV EQUIPMENT RACKS
  - A. Wall-mounted modular metal racks arranged to house standard mounting electronic equipment, 21 inches wide, steel shelf enclosure with 16-gauge ends and 18-gauge shelves, six pieces bolted together, with four mounting holes on 16-inch centers for mounting to wall studs. Weight capacity 150 pounds. Finish: Standard black powder coat.
- 2.11 WORK STATIONS
  - A. Provide and install viewing software two (2) work stations, one (1) in the School Resource Officer's Office and one (1) in the Principals office. <u>Dell products</u> are the basis of design for this project. Specifications for the work stations shall be:
    - 1. Intel Core 2 Duo 2.93 GHz or higher, 4 MB Cache, 1066 MHz FSB
    - 2. Microsoft Windows XP Pro SP2 32-bit/64-bit, or Microsoft Windows Vista Business or Ultimate 32-bit/64-bit
    - 3. 2.0 GB of RAM
    - 4. 250 GB of storage or more
    - 5. 256 MB x16 nVidia Quadro FX3450 dual-head, or better
    - 6. 1600 x 1200 or higher screen resolution
    - 7. 10/100/1000 Ethernet Network Interface Card
    - 8. 16x DVD+/-RW drive
    - 9. Sound card

# PART 3 – EXECUTION

3.1 PREPARATION

A. Camera location test: Support each camera temporarily at the location indicated and connect to monitor. Adjust location and mounting and substitute fixed lenses, if required to obtain clear image at monitor. These adjustments shall be included in the contract sum.

## 3.2 INSTALLATION

- A. Comply with requirements of Division 26.
- B. Outdoor installation: Conform to ANSI C2, National Electrical Safety Code.
- C. Install wiring in raceways except as otherwise indicated.
- D. Wiring in enclosures: Bundle, lace, and train the conductors to terminal points with no excess. Provide and use lacing bars and distribution spools.
- E. Pulling Cable: Do not exceed manufacturers recommended pulling tensions. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between indicated termination, tap, or junction points. Remove and discard cable where damaged during installation and replace it with new cable.
- F. Grounding: As recommended by manufacturers except as otherwise indicated.
- G. Installer's RCDD shall supervise each final connection to equipment.
- H. Install cameras in the locations indicated, adjusted to final locations defined by camera location tests. Provide adequate headroom below cameras and their mountings. Where necessary, change the type of mounting to provide adequate headroom.
- I. Pan and tilt units: Set stops to suit final position and mounting and field required to be viewed by the camera.
- J. Install central power supply, and other auxiliary components in equipment rack.
- K. Install remote viewing software on security officer's desktop computer and on principal's desktop computer.
- L. Install all software, listed in Part 2, on Video Network Server.

#### 3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Division 26.

# 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's field services: Provide services of factory-authorized service representatives to supervise the field assembly and connection of components and system pretesting, testing, and adjustment. Installer's RCDD personnel shall supervise cabling and network integration.
- B. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

- C. Pretesting: Align and adjust the system and pretest all components, wiring, and functions to verify they conform to specified requirements. Replace malfunctioning or damaged items with new items. Retest until satisfactory performance and conditions are achieved.
- D. Final acceptance testing schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 2 weeks. Provide a minimum of 10 days notice of acceptance test performance schedule.
- E. Operational acceptance tests: Perform operational system tests to verify conformance to specifications. Include all modes of system operation. Methodically test for proper system operation in each functional mode.
- F. Record results of tests.
- G. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- 3.5 ADJUSTMENT
  - A. Occupancy adjustments: When requested, during the correction period required by the General Conditions and Division 26, provide on-site assistance in adjusting the system to suit actual occupied conditions. Provide visits for this purpose without additional cost.
- 3.6 CLEANING
  - A. Clean system components including camera housing windows and lenses. Use methods and materials recommended by manufacturer.
- 3.7 OPERATING INSTRUCTIONS
  - A. As specified in Division 26, provide operating instructions.
  - B. Arrange and pay for the services of a factory-authorized service representative to demonstrate adjustment, operation, and maintenance of the system and to train Owner's personnel. Include demonstration of methods to determine optimum settings for system controls.
  - C. Conduct a minimum of 6 hours of training for the system specified in this section. Schedule training and adjustment with at least 7 days advanced notice.
  - D. Upon completion and demonstration of the system, provide BCPS Safety and Security Department a typed list of all camera locations including assigned IP addresses, Server ID and Administrative Passwords.

# **END OF SECTION**

#### **SECTION 28 31 00 - FIRE DETECTION AND ALARM SYSTEMS**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Provide a complete fire detection and alarm system of the noncoded, addressable, analog type, with manual stations, detectors, notification appliances, controls, and devices.
- B. Costs of certification and testing, including tests required by NFPA 72, shall be included in the contract sum.
- 1.12 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION
  - A. Duct smoke detectors: Section 23 09 13.
- 1.14 RELATED SECTIONS
  - A. Division 08 section specifying door hardware for coordinating electrical hardware operators.
  - B. Section 21 10 00 for fire suppression system, for coordinating flow, pressure, and valve tamper switch requirements.
- 1.21 DEFINITIONS
  - A. FACP: Fire alarm control panel.
  - B. HVAC: Heating, ventilation, and air-conditioning.
  - C. LED: Light-emitting diode.
  - D. SPDT: Single pole, double throw.
  - E. Definitions in NFPA 72 apply to fire alarm terms used in this section.

#### 1.25 SYSTEM DESCRIPTION

- A. Control of system: By the FACP.
- B. System supervision: Automatically detect and report open circuits, shorts, and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
- C. Priority of signals: Automatic alarm response functions resulting from an alarm signal from one zone or device are not altered by subsequent alarm, supervisory, or trouble signals. An alarm signal is the highest priority. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even when the lower-priority condition occurs first. Annunciate and display all alarm, supervisory, and trouble signals regardless of priority or order received.
- D. Noninterference: A signal on one zone shall not prevent the receipt of signals from other zones.

- E. System reset: All zones are manually resettable from the FACP after initiating devices are restored to normal.
- F. Transmission to remote alarm receiving station.
- G. System alarm capability during circuit fault conditions: System wiring and circuit arrangement prevent alarm capability reduction when a single ground occurs in an initiating device circuit, signal line circuit, or notification-appliance circuit.
- H. Loss of primary power at the FACP initiates a trouble signal at the FACP. The FACP indicates when the fire alarm system is operating on the secondary power supply.
- I. Basic alarm performance requirements: Unless otherwise indicated, operation of a manual station, automatic alarm operation of a smoke or heat detector, or operation of sprinkler flow switch, initiates the following:
  - 1. Notification-appliance operation.
  - 2. Identification at the FACP and the remote annunciator of the zone and device originating the alarm.
  - 3. Release of fire and smoke doors held open by magnetic door holders.
  - 4. Operation of duct smoke detector shall initiate a supervisory signal and shutdown of fans and other air-handling equipment serving zone where alarm was initiated.
  - 5. Recording of the event in the system memory.
  - 6. Initiate the transmission of alarm to the Owner's remote alarm receiving station.
- J. In addition to functions mentioned above, elevator smoke detectors shall perform elevator recall functions in accordance with ANSI requirements. Elevator heat detectors shall activate the shunt trip breakers.
- K. Alarm silencing, system reset and indication: Controlled by switches in the FACP and the remote annunciator.
  - 1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
  - 2. Subsequent alarm signals from other devices or zones reactivate notification appliances until silencing switch is operated again.
  - 3. When alarm-initiating devices return to normal and system reset switch is operated, notification appliances operate again until alarm silence switch is reset. System reset shall be controlled only at the FACP.
- L. Remote detector sensitivity adjustment: Manipulation of controls at the FACP causes the selection of specific addressable, analog smoke detectors for adjustment, display of their current status and sensitivity settings, and control of changes in those settings. Same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity-adjustment schedule changes are recorded in system memory.
- M. Removal of an alarm-initiating device or a notification appliance initiates the following:

- 1. Transmission of trouble signal to remote alarm receiving station.
- N. FACP alphanumeric display: Plain-English-language descriptions of alarm, supervisory, and trouble events; and addresses and locations of alarm-initiating or supervisory devices originating the report. Display monitoring actions, system and component status, system commands, programming information, and data from the system's historical memory.

## 1.30 SUBMITTALS

- A. General:
  - 1. Comply with Division 01 and Section 28 01 01. When approved, no variation will be permitted except with the approval of the Architect.
  - 2. Submit to the authority having jurisdiction and to the Architect for review and approval.
- B. Shop drawings:
  - 1. Floor plans indicating final equipment and device locations and raceway routes.
  - 2. System operation description: Detailed description for this project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
  - 3. Details of graphic display.
  - 4. Wiring diagrams and riser diagrams.
- C. Product data: Schedule and each type of system component, including dimensioned plans and elevations showing minimum clearances and installed features and devices. Include UL listings.
- D. Battery calculations.
- E. Provide a complete project record drawing as specified in Division 01 and Section 28 01 01 showing the location of all the outlets, cable taps, cable routes, and other components installed. Drawings shall be made part of Operating and Maintenance Manuals.
- F. Certifications:
  - 1. UL Certificate of Compliance of system supplier as specified in "Quality Assurance" below.
  - 2. Fire and smoke detection system inspection and test report, completed by the factory representative, endorsed by the Owner and the factory representative, including test data, detector locations and serial numbers, a summary of maintenance performed, recommendations for relocation or addition of detectors and final action regarding these recommendations, and system certification.

# 1.40 QUALITY ASSURANCE

A. System and equipment shall be UL listed. Each major component shall bear the manufacturer's name and catalog number.

- B. UL labels and local testing (if required): As specified in Section 26 05 00, Common Work Results for Electronic Safety and Security.
- C. Single-source responsibility: Obtain system components from a single source who assumes responsibility for their compatibility.
- D. Qualifications of system supplier and installer:
  - 1. Staff shall consist of at least one NICET Level IV Technician or a professional engineer registered in Maryland.
  - 2. Has installed at least ten systems of the type specified which have performed satisfactorily for not less than two years.
  - 3. Maintains a facility with a sufficient stock of spare parts.
  - 4. Shall respond within 24 hours of notification to correct system failure or malfunction. During the project correction period defined in General Conditions and in Section 16050, perform such corrections at no addition to the Contract Sum.
- E. Factory-authorized service representative: Trained and certified by the manufacturer of the system, and experienced in the installation and operation of the type of system included in the work.
- F. Comply with NFPA 72, applicable local codes, and regulations and requirements of the authorities having jurisdiction. Baltimore County is the local code authority.
- 1.70 SEQUENCING AND SCHEDULING
  - A. Existing fire alarm equipment: Maintain fully operational until new equipment has been tested and accepted.
    - 1. Field verify existing system is fully operational before beginning work on the existing components. If existing system is not fully operational immediately notify the Owner and Architect in writing, and do not perform any work on the existing system until directed by the Architect.
    - 2. As new equipment is installed, label it NOT IN SERVICE until new equipment is accepted. As equipment is put in service, remove label and label existing equipment NOT IN SERVICE until it is physically removed.
  - B. Disconnected equipment: Remove equipment and restore damaged surfaces.
    - 1. Operational disconnected equipment: Package, label, and deliver to Owner.

# 1.91 INSPECTIONS AND SERVICE CONTRACT

- A. During the general project correction period, every six months starting six months after Substantial Completion, the supplier shall inspect and test the system.
  - 1. Submit written reports to the Owner and Architect, describing test results, including defects found and how they have been corrected, and listing components replaced.
- B. At the end of the correction period, offer the Owner a service contract for the complete system.

## PART 2 - PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-design system: Subject to compliance with requirements, provide system by Fire-Lite Alarms (Honeywell) or comparable system by one of the following:
  - 1. Edwards Systems Technology, Inc.; a GE UTC Fire and Security.
  - 2. Fire-Lite Alarms, Inc.
  - 3. Silent Knight
- B. The existing building fire alarm system is by Fire-Lite Alarms with a MS-9200 addressable fire alarm control panel. Provide equipment comparable and operable with existing system.
- C. Wire and Cable:
  - 1. Comtran Corporation.
  - 2. Helix/HiTemp Cables, Inc.; a Draka USA Company.
  - 3. Rockbestos-Suprenant Cable Corporation; a Marmon Group Company.
  - 4. West Penn Wire/CDT; a division of Cable Design Technologies.

#### 2.20 FIRE ALARM CONTROL PANEL

- A. Cabinet: Lockable steel enclosure. Arrange interior components so operations required for testing or for normal maintenance of the system are performed from the front of the enclosure. If more than one unit is required to form a complete control panel, fabricate with matching modular unit enclosure to accommodate components and to allow ample gutter space for field wiring and interconnecting panels.
  - 1. Mounting: Surface.
- B. Alarm and supervisory systems: Separate and independent in the FACP. Alarm-initiating zone boards consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.
- C. Control modules: Include types and capacities required to perform all functions of fire alarm systems.
- D. Indications: Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has a different sound.
- E. Resetting controls: Prevent the resetting of alarm, supervisory, or trouble signals while the alarm or trouble condition still exists.
- F. Alphanumeric display and system controls: Arranged for interface between human operator at the FACP and addressable system components, including annunciation, supervision, and control.

- 1. Display: A minimum of 80 characters; alarm, supervisory, and component status messages; and indicate control commands to be entered into the system for control of smoke detector sensitivity and other parameters.
- 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

## 2.21 EMERGENCY POWER SUPPLY

- A. General: Components include nickel-cadmium battery, charger, and an automatic transfer switch.
  - 1. Battery nominal life expectancy: 20 years, minimum.
- B. Battery capacity: 24 hours of supervisory power with 5 minutes of general alarm capability at end of 24 hours.
- C. Battery charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge. If batteries are fully discharged, the charger recharges them completely within four hours. Charger output is supervised as part of system power supply supervision.
- D. Integral automatic transfer switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.
- 2.22 ONE-WAY VOICE COMMUNICATION
  - A. The system shall have one-way voice communication and tone-generating capabilities. The voice messaging system shall be of the same manufacturer as the control panel.
  - B. Central audio control module: Alarm message or tone generation and microphone connections with continuous supervision and identification of the type of failure should a problem occur (e.g. main microphone trouble, tone trouble). Audio outputs shall have individual gain control.
  - C. Hand-held, push-to-talk microphone: Recessed within a protective panel-mounted enclosure, noise-canceling communication type with a frequency range of 200 Hz to 4000 Hz, equipped with a self-winding five-foot coiled cable. An LED indicator shall indicate the microphone push-to-talk button has been pressed and speaker circuits are ready for transmission. The microphone shall be supervised for disconnection.
  - D. Audio control switch and indication module: To provide manual access to audio operations for authorized personnel. Include a phone page select switch, tone select switch, tape select switch, and "Audio trouble Reset switch". These switches and associated LED indicators shall be supervised for disarrangement or failure.
  - E. Audio power amplifiers: Furnished with a self-contained filtered 24 Vdc power supply, transformer, and amplifier monitor circuits. The amplifiers shall provide a 25-V rms output with a frequency response of 120 Hz to 12,000 Hz. Provide sufficient amplification to operate all system speakers simultaneously plus 25 percent spare capacity.
  - F. Backup amplifier: Capable of automatically replacing any failed amplifier.

- G. Speaker circuits: Capable of supplying 25-V rms audio power from the system amplifiers. Provide supervision for open, short, or ground fault conditions; individual and distinct trouble indications for each fault; and one circuit for each zone or area of distinct communication.
- H. Digitized tones: For alarm (slow whoop) and auxiliary requirements (wail, horn, chime, and others).
- I. Pre-recorded digitized voice message capability: Automatically transmitted to occupants during alarm conditions.
  - 1. The automatic message player shall not rely on a tape or other mechanical means of transmitting the evacuation message.
  - 2. Provide a standard evacuation message, and message transmitter capable of transmitting a custom message up to 30 seconds long. A self-contained speaker shall provide testing of the message(s) without disturbing the occupants of the facility.
- J. Automatic voice evacuation sequence:
  - 1. Alarm tone shall sound for a maximum of 15 seconds, followed by automatic preselected voice evacuation messages. At the end of each voice evacuation message, the alarm tone shall resume. The alarm tones shall sound alternately until the Alarm Silence Switch at the FACP has been operated.
  - 2. Audible alarm operations (speaker circuit selection and alarm tone and voice message timing variations) shall be activated by the system software so that changes to the evacuation sequence can be made by authorized personnel without any component rewiring.
- K. Manual voice paging sequence:
  - 1. The system shall allow voice paging. Upon activation of speaker manual control switch, attention-getting beeps shall sound over the speakers indicating an impending voice message.
  - 2. Voice message: Operator shall be able to make announcements via the push-to-talk paging microphone.

#### 2.24 REMOTE ANNUNCIATOR AND GRAPHIC DISPLAY

- A. Remote annunciator: Flush-mounted liquid crystal display (LCD) annunciator.
  - 1. Display: Supervised, back-lit, LCD with no fewer than 4 lines with 20 characters per line.
    - a. Back lighting shall turn off after 4 minutes when there is no switch activity and no unacknowledged message.
    - b. The first event of the highest priority shall capture the display, so that arriving firefighters can view the first alarm event immediately.
  - 2. Key operated switches:
    - a. Alarm silence.
    - b. Trouble silence.
    - c. Test

- B. Description: Duplicate annunciator functions of the FACP for alarm, supervisory, and trouble indications. Also duplicate manual switching functions of the FACP, including alarm silence, trouble silencing, and test.
  - 1. Mounting: Recessed cabinet, NEMA 250, Type 1.
- C. Graphic display: As shown on drawings, panel indicating the building floor plan with a "You are here" note and zone and device locations permanently marked on panel surface.
  - 1. Mounting: Integral with remote annunciator, with individual lamps in locations shown
  - 2. Dimensions: 24-inches wide by 18-inches high, minimum.

## 2.25 MANUAL PULL STATIONS

- A. Description: Fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.
  - 1. Single-action mechanism initiates an alarm.
  - 2. Station reset: Key or wrench operated; double pole, double throw; switch rated for the voltage and current at which it operates.
  - 3. Integral addressable module: Arranged to communicate manual-station status (normal, alarm, or trouble) to the FACP.
  - 4. False alarm protector: Tamperproof clear polycarbonate shield in a frame that fits over the pull station. When the shield is lifted to gain access to the pull station, a warning horn shall sound. Include 9-V dc alkaline battery.

#### 2.26 SMOKE DETECTORS

- A. General: UL 268A listed. Include the following features:
  - 1. Operating voltage: 24-V dc, nominal.
  - 2. Self-restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
  - 3. Plug-in arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.
  - 4. Integral visual-indicating light: LED type. Indicates detector has operated.
  - 5. Sensitivity: Can be tested and adjusted in-place after installation.
  - 6. Integral addressable module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
  - 7. Remote controllability: Unless otherwise indicated, detectors are analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
    - a. Detectors which will be installed in ducts or other concealed locations shall be capable of being tested from an indicating and test station specified below.
- B. Photoelectric smoke detectors: Include the following features:

- 1. Sensor: LED or infrared light source with matching silicon-cell receiver.
- 2. Detector sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.
- 3. Integral thermal detector: Fixed-temperature type with 135 deg F (57 deg C) setting.
- C. Duct smoke detector: Photoelectric type.
  - 1. Sampling tube: Design and dimensions as recommended by the manufacturer for the specific duct size, air velocity, and installation conditions where applied.
  - 2. Relay fan shutdown: Contacts rated to interrupt fan motor-control circuit.

#### 2.27 OTHER DETECTORS

- A. Heat detector, fixed-temperature type:
  - 1. Actuated by temperature that exceeds a fixed temperature of the following:
    - a. Elevator shaft and elevator machine room: 135 degrees F (57 degrees C).
    - b. Other locations or where indicated on drawings: 190 degrees F (88 degrees C).
  - 2. Mounting:
    - a. Adapter plate for outlet box mounting.
    - b. Plug-in or twist-lock base, interchangeable with smoke detector bases.
  - 3 Integral addressable module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

#### 2.28 CONCEALED DETECTOR INDICATING AND TEST STATION

- A. Description: Flush-mounted, single-gang station for each duct smoke detector and other detector that is not readily visible, with indicating light and test switch.
- B. Indicating light: Flashes when the associated device is in an alarm or trouble mode.
- C. Test switch: Forces detector into alarm, allowing test of outputs programmed to occur following alarm initiation at devices.
- D. Device plate: Red plastic with engraved white letters reading SMOKE DETECTOR ABOVE CEILING, or other text as appropriate.

#### 2.29 NOTIFICATION APPLIANCES

- A. Description: Equipped for mounting as indicated and have screw terminals for system connections.
  - 1. Combination devices: Factory-integrated audible and visible devices in a single-mounting assembly.

- B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Horns produce a sound-pressure level of 90 dB, measured 10 feet (3 m) from the horn.
- C. Visible alarm devices: Synchronized xenon strobe lights listed under UL 1971 with clear or nominal white polycarbonate lens. Mount lens on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on a removable sleeve on the lens.
  - 1. Rated light output: Indicated on drawings for each location.
  - 2. Strobe leads: Factory connected to screw terminals.
- D. Concealed enclosure: Notification appliance housed in concealed enclosure where indicated on drawings. UL listed. Recessed mounted in wall. Equal to Concealite FA 100.
  - 1. Upon system activation, the door of the unit shall rotate 180 degrees and the notification appliance shall begin activation.
  - 2. Upon system de-activation, the door will rotate 180 degrees putting the appliance in the hidden stored position.
  - 3. Voltage shall match the fire alarm system voltage.
- 2.30 FIRE ALARM NOTIFICATION BOOSTER
  - A. Power supply booster designed to extend power available to notification appliance circuits.
  - B. Enclosure: Steel, with lockable front panel allowing access to all interior components, surfacemounted.
  - C. Functions: Contains circuits to monitor and charge batteries, control and supervise 4 Class B appliance circuits, and monitor two controlling inputs from external sources.
    - 1. Configurable to operate at any one of three signaling rates, or to follow the main panel's notification appliance circuit.
    - 2. Trouble contact with 16-second delay.
  - D. Batteries: Two, sized for 24 hours of standby followed by 5 minutes of alarm.
  - E. Indicators: LEDs, one for each circuit, one for battery supervision, one for ground fault, and one for power.

#### 2.31 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching door plate.
  - 1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
  - 2. Wall-mounted units: Flush mounted, unless otherwise indicated.
  - 3. Rating: 120-V ac.
- B. Material and finish: Match door hardware.

#### 2.32 ADDRESSABLE INTERFACE DEVICE

- A. Monitor module: Microelectronic monitor module listed for use in providing a system address for external alarm-initiating devices with normally open contacts.
  - 1. Dual circuit, intelligent, signaling circuit interface module.
- B. Control module: Microelectronic control relay module listed for use in providing control to external appliances or equipment shutdown, to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.
  - 1. One Form C (SPDT) dry relay contact rated at 2 amps and 24 volts DC.
- C. Isolator module: Microelectronic fault isolator module listed for isolating and removing a fault from a data circuit while allowing the remaining data loop to continue operating.
  - 1. Protect loop system against wire-to-wire short circuits by isolating section of loop and permitting other loop sections to continue to operate.
- D. Non-addressable control relay: Isolation relay for the control of HVAC unit contactors, magnetic door holders, and elevator recall circuits, UL 864 Listed.
  - 1. Construction: Sealed, non-removable, with terminations to pressure-type screw terminals.
  - 2. Rating: Use with circuits up to 240 volts AC at 7amperes inductive.

#### 2.33 WIRE AND WIRING SYSTEM

- A. Non-power-limited circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
  - 1. Low-voltage circuits: No. 16 AWG, minimum.
  - 2. Line-voltage circuits: No. 12 AWG, minimum.
- B. Power-limited circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer.
- C. Wiring system: Class B in accordance with NFPA 72.
- D. Type MC fire alarm cable: Equal to AFC Cable Systems FPLP metal-clad, multi-conductor, fire alarm and control cable.
  - 1. Ratings:
    - a. Plenum rated.
    - b. Approved for use as fixed wiring concealed in building.
    - c. Maximum operating temperatures:
      - (1) 105 degrees C dry for FPLP applications at nominal voltage ratings 300 V and less.

- (2) 90 degrees C dry for MC cable installations at nominal voltage ratings of 600 V and less.
- d. UL listed for penetrations of wall and floor assemblies of gypsum wallboard, concrete, and concrete masonry with one-, 2-, and 3-hour fire ratings.
- 2. Shield over conductor assembly: Laminated aluminum and mylar tape and tinned copper drain wire.
  - a. Drain wire: Minimum No. 18 AWG, in contact with aluminum shield.
- 3. Listed in accordance with UL 1596:
  - a. Insulated or bare grounding conductor in accordance with Table 6.3, cabled with the circuit conductors and identified in compliance with Section 35.
  - b. Galvanized steel armor, red, applied over inner cable assembly with positive interlock conforming to the requirements of Section 12.
  - c. Tested in accordance with applicable requirements.
- E. Survivability: Circuits necessary for the operation of notification appliances shall be protected by a 2-hour fire-rated cable, a 2-hour fire-rated cable system, or a 2-hour fire-rated enclosure.

## 2.34 PERIPHERAL EQUIPMENT

- A. Alarm reporting device: A digital communicator shall report an alarm or trouble condition. It shall notify Owner's fire alarm monitoring service and one or more facilities personnel. Provide unit compatible with the Owner's monitoring service.
- B. Sprinkler flow and tamper switches: Specified in fire suppression sprinkler system specifications. Provide a monitor module for addressing each device. Unit shall mount on 4-inch-square, 2.5-inch-deep back box.

#### PART 3 - EXECUTION

- 3.20 INSTALLATION, GENERAL
  - A. Factory-authorized service representative, as required in "Quality Assurance" in Part 1 above, shall supervise installation, software documentation, adjustment, preliminary testing, final testing, and certification of the system, and provide the operating instructions.
  - B. Provide wiring, conduit, and outlet boxes required for the complete system, in accordance with system manufacturer's instructions and with requirements specified in Division 16 for wiring, conduit, and boxes. Provide 12 inches of slack at each outlet.
    - 1. Install all wiring in conduit, except where noted on drawings to provide Type MC fire alarm cable.
    - 2. Install Type MC fire alarm cable in accordance with Article 330 of the National Electric Code (NFPA 70).
    - 3. Identification: Paint fire alarm junction box covers red.

- C. Wires, cables, conduits, and wiring connections are specified in Division 16, Electrical. Include in the work of this section, wiring, conduits, and equipment connections complying with the requirements of Division 16, so that the fire alarm system will function as specified and indicated on the drawings.
- D. Wiring: Free from grounds or crosses between conductors.
  - 1. Identification: Color code wiring, not duplicating building wiring colors. Tag each wire at each junction point.
- E. Final connections between equipment and the wiring system shall be made under the direction and supervision of the qualified supplier.
- F. Provide 20 percent spare capacity for each notification appliance circuit.
- G. Locate 135 degree F (57 degree C) rated heat detectors in elevator shafts and elevator machine rooms within 18 inches (457 mm) of sprinklers.
- 3.21 INSTALLATION, FIRE ALARM NOTIFICATION BOOSTER
  - A. Provide number of notification power supply boosters required for a complete fire alarm system.
  - B. Utilize spare single-pole, 20-ampere circuit breaker in a 120-volt emergency electrical panelboard to make electrical connection to each power supply booster.
    - 1. Circuit breakers shall match and shall be compatible with the other breakers in the panelboard.
  - C. Branch circuits from panelboards to each notification power supply booster: Two No. 10 wires and one No. 10 ground in conduit no less than 0.75 inch (21-mm) trade size.
  - D. Install conduits and wiring as specified in Sections 23 05 19 and 23 05 33.
  - E. Provide smoke detector above each power supply booster.

## 3.22 INTERFACE WITH OTHER WORK

- A. Furnish duct smoke detectors to be installed as part of ductwork specified in Division 23.
- B. Coordinate with installation of flow and tamper switches in fire suppression sprinkler system.
- C. Coordinate with sprinkler contractor for number and locations of sprinklers in elevator shaft and elevator machine room.

# 3.23 LOCATIONS OF FIRE ALARM EQUIPMENT

A. Locate the control panel, annunciator, and other associated equipment as shown on the drawings.

- B. Visual indicating appliances: Install where shown on the drawings. If field conditions require variation from drawings, do not violate ADA requirements, including, but not limited to, the following:
  - 1. Any room or space required to have a visual appliance, including corridors or hallways: No place shall be more than 50 feet from the indicating appliance in the horizontal plane.
  - 2. Rooms and spaces exceeding 100 feet in one dimension, without obstructions 6 feet above the finished floor: Indicating appliances may be placed around the perimeter, spaced approximately 100 feet apart.
- C. Mount indicating and test station for concealed smoke detectors near ceiling under detector. Text engraved on plate shall be descriptive of the device identified.
- D. Provide a smoke detector at each fire alarm panel location, including but not limited to main control, auxiliary control, and power panels.

#### 3.60 INSPECTION, TEST, ADJUSTMENT AND REPORT

- A. Furnish equipment and appliances for testing the complete system during progress of the work and after completion of the installation, including a megger test of wiring. The tests generally shall demonstrate the following:
  - 1. Circuits are continuous and free from short circuits.
  - 2. Circuits are free from unspecified grounds.
  - 3. Resistance to ground of non-grounded circuits is not less than one megohm.
  - 4. Circuits are properly connected in accordance with the applicable wiring diagrams.
  - 5. Each detector operates correctly.
  - 6. Detectors are correctly located and sufficient in number.
- B. Defects or omissions observed during general and system tests shall be repaired as quickly as possible and the tests reconducted.
- C. Submit report as required in Part 1 above.
- 3.81 OPERATING INSTRUCTIONS
  - A. As specified in Section 26 05 00, provide operating instructions.
  - B. Provide at least 8 hours of additional instruction time for the systems and equipment specified in this section, consisting of 2 periods of 4 consecutive hours, during a period of not more than 60 days.

# **END OF SECTION**

## SECTION 28 52 00 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS

PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to the work of this Section.
- 1.2 SUMMARY
  - A. Provide all materials and labor for the installation of a grounding and bonding system for communications infrastructure. This section includes requirements for providing a permanent grounding and bonding infrastructure for communications circuits, raceways, and cable tray.
  - B. Related Sections
    - 1. Division 27 Section "Conduit and Backboxes for Communications Systems"

#### 1.3 REFERENCES

- A. The applicable portions of the following specifications, standards, codes and regulations shall be incorporated by reference into these specifications.
  - 1. General:
    - a. National Electrical Code (NEC)
    - b. National Electrical Safety Code (NESC)
    - c. Occupational Safety and Health Act (OSHA)
  - 2. Communications:
    - a. TIA/EIA 568: Commercial Building Telecommunications Cabling Standard
    - b. TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
    - c. TIA/EIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
    - d. TIA/EIA 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
    - e. ISO/IEC IS 11801: Generic Cabling for Customer Premises
    - f. BICSI: BICSI Telecommunications Cabling Installation Manual
    - g. BICSI: BICSI Telecommunications Distribution Methods Manual (TDMM)
    - h. BICSI: BICSI Customer-Owned Outside Plant Design Manual (CO-OSP)

#### 1.4 DEFINITIONS

- A. "TMGB" shall mean *Telecommunications Main Grounding Busbar*. There is typically one TMGB per building, located in the main telecommunications room. This busbar is directly bonded to the electrical service ground.
- B. "TGB" shall mean *Telecommunications Grounding Busbar*. There is typically one TGB per telecommunications room. The TGB is connected both to the TMGB and to building structural steel or other permanent metallic systems.
- C. "TBB" shall mean *Telecommunications Bonding Backbone*. The TBB is a conductor used to connect TMGBs to TGBs.

#### 1.5 SYSTEM DESCRIPTION

- A. Furnish, install, and place into satisfactory and successful operation all materials, devices, and necessary appurtenances to provide a complete, permanent Grounding and Bonding infrastructure for communications circuits, raceways, and cable trays as hereinafter specified and/or shown on the Contract Documents. The Grounding and Bonding system shall support an ANSI/TIA/EIA and ISO/IEC compliant communications Structured Cabling System (SCS).
- B. The work shall include materials, equipment and apparatus not specifically mentioned herein or noted on the plans but which are necessary to make a complete working ANSI/TIA/EIA and ISO/IEC compliant Grounding and Bonding system.

## 1.6 SUBMITTAL INFORMATION

- A. Product Data Submittals: Provide submittal information for review before materials are delivered to the job site. Provide product data submittals for all products at the same time.
  - 1. Submit a letter stating that the materials will be provided as specified, and specifically listing any items that will not be provided as specified. The letter shall also state that the Contractor has reviewed the specified items and agrees that they are applicable to this project in all respects.
  - 2. For those items noted as allowing "or equal," and which are not being provided as specifically named, submit standard manufacturer's cut sheets or other descriptive information, along with a written description detailing the reason for the substitution.
  - 3. Provide standard manufacturer's cut sheets and the operating and maintenance (O&M) instructions at the time of submittal review for each device in the system, regardless of whether it is submitted as specified or as an approved equal. These instructions shall detail how to install and service the equipment and shall include information necessary for rough-in and preparation of the building facilities to receive the materials.
- B. Closeout Submittals: Provide submittal information for review as follows:
  - 1. O&M Manual for Communications At the completion of the project, submit O&M information from product data submittals (above), updated to reflect any changes during the course of construction, to the Designer in the telecommunications-specific O&M Manual for Communications binder labeled with the project name and description.

- 2. Records Maintain at the job site a minimum of one set of Record Drawings, Specification, and Addenda. Record Drawings shall consist of redline markups of drawings, specifications and spreadsheets.
  - a. Document changes to the system from that originally shown on the Contract Documents and clearly identify system component labels and identifiers on Record Drawings.
  - b. Keep Record Drawings at the job site and make available to the Owner and Designer at any time.
  - c. Keep Record Drawings current throughout the course of construction. ("Current" is defined as not more than one week behind actual construction).
  - d. Show identifiers for major infrastructure components on Record Drawings.

#### 1.7 SEQUENCING

- 1.8 CONTRACTOR WARRANTY:
  - A. Provide a Contractor-endorsed two-year service warranty against defects in materials and workmanship.
    - 1. Provide labor attributable to the fulfillment of this warranty at no cost to the Owner.
    - 2. The Contractor Warranty period shall commence upon Owner acceptance of the work.

#### PART 2 - PRODUCTS

#### 2.1 GENERAL

A. Materials shall consist of busbars, supports, bonding conductors and other incidentals and accessories as required.

#### 2.2 MATERIALS

- A. Grounding/Bonding:
  - 1. Telecommunications Main Grounding Bus Bar (TMGB):
    - a. Large (20" x 4" x <sup>1</sup>/<sub>4</sub>"), Pre-drilled: CPI 10622-020, or equal
    - b. Small (10" x 4" x <sup>1</sup>/<sub>4</sub>"), Pre-drilled: CPI 10622-010, or equal
  - 2. Telecommunications Grounding Bus Bar (TGB):
    - a. Large (20" x 4" x <sup>1</sup>/<sub>4</sub>"), Pre-drilled: CPI 10622-020, or equal
    - b. Small (10" x 4" x <sup>1</sup>/<sub>4</sub>"), Pre-drilled: CPI 10622-010, or equal
  - 3. Telecommunications Bonding Backbone: #6 AWG insulated (green in color) copper conductor.

- 4. Grounding Conductor: #6 AWG insulated (green in color) copper conductor.
- B. Firestopping Material: Conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of the actual field conditions.
- C. Labels: As recommended in ANSI/TIA/EIA 606. Permanent (i.e. not subject to fading or erasure), permanently affixed, and created by a hand-carried label maker or a computer/software-based label making system. Handwritten labels are not acceptable.
  - 1. Hand-carried label maker:
    - a. Brady: ID Pro Plus (or approved equal).
  - 2. Labels:
    - a. Brady: Bradymaker Wire Marking Labels WML-511-292 (or approved equal)

## PART 3 - EXECUTION

- 3.1 GENERAL
  - A. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances.
  - B. All work shall comply with applicable safety rules and regulations including OSHA. All work shall comply with the requirements of the National Electrical Safety Code (NESC) and the NEC except where local codes and/or regulations are more stringent, in which case the local codes and/or regulations shall govern.
  - C. All work shall comply with the standards, references and codes listed in PART 1 --REFERENCES above. Where questions arise regarding which standards, references, or codes apply, the more stringent shall prevail.
  - D. All work shall comply with the requirements and recommendations of the product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.
  - E. Replace and/or repair to original (or better) condition any existing structures, materials, equipment, etc. inadvertently demolished or damaged by the Contractor during the course of construction at no additional cost to the Owner.
  - F. Install the grounding and bonding system in a manner ensuring that communications circuits, when installed, are able to fully comply with the ANSI/TIA/EIA and other references listed in Part 1 References, above.
  - G. Remove surplus material and debris from the job site and dispose of legally.

#### 3.2 INSTALLATION

- A. The grounding and bonding infrastructure system shall not make use of the building plumbing system, unless required to do so by the NEC.
  - 1. Coordinate the installation of the grounding and bonding system with the electrical power distribution system grounding infrastructure.
- B. Ground/Bonding:
  - 1. TMGB: Provide a minimum of one TMGB per telecommunications entrance room for each building and as shown on the Contract Documents. Install TMGB(s) and directly bond TMGB(s) to electrical service ground and to associated TBB(s). Group protector, busbar bonding, and approved building grounding conductors toward one end of the TMGB and leave space for equipment grounding conductors on the other end.
  - 2. TGB: Provide a minimum of one TGB per telecommunications room for each building and as shown on the Contract Documents and as required by the standards, references and codes listed in PART 1 -- REFERENCES above. Directly bond each TGB to its associated TBB and to the nearest building structural steel or other permanent metallic system. Group protector, busbar bonding, and approved building grounding conductors toward one end and leave space for equipment grounding conductors on the opposite end.
  - 3. TBB(s) and Grounding Conductors: Provide TBB(s) and grounding conductors as shown on the Contract Documents and as required to bond all non-current carrying metal telecommunications equipment and materials to the nearest TGB. Use TBB(s) to connect the TMGB to each TGB. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. Insulate TBB(s) and conductors from their support. TBB(s) and grounding conductors shall be continuous (without splices).
    - a. Ensure that bonding breaks through paint to bare metallic surface of all painted metallic hardware.
- C. Firestopping
  - 1. Only employees trained/certified by the firestopping manufacturer shall apply firestopping materials.
  - 2. Maintain the fire rating of all penetrated fire barriers. Fire stop and seal all penetrations made during construction.
    - a. Provide firestopping material for through and membrane penetrations of fire-rated barriers.
    - b. Install firestops in strict accordance with manufacturer's detailed installation procedures.
    - c. Install firestops in accordance with fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and applicable codes and standards referenced in PART 1 REFERENCES. Apply of sealing material in a manner acceptable to the local fire and building authorities.

- d. For demolition work, apply firestopping to open penetrations in fire rated barriers where cable is removed. Apply firestopping regardless of whether or not the penetrations are used for new cable or left empty after construction is complete.
- e. Firestopping material used to seal open penetrations through which cable passes shall be re-usable/re-enterable.

## D. Labels:

- 1. Label TMGB(s) with "TMGB"
- 2. Label TGB(s) with "TGB".
- 3. Label TBB(s) and bonding conductors "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

# **END OF SECTION**

# SECTION 28 58 00 - CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS

PART 1 - GENERAL

- 1.1 RELATED DOCUMENTS
  - A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- 1.2 SUMMARY
  - A. Provide all materials and labor for the installation of a pathway system for inside plant communications circuits. This section includes requirements for horizontal and building backbone raceways, fittings, and boxes specific to communications circuits (cabling) for voice and data.
  - B. Related Sections:
    - 1. Division 27 Section "Grounding and Bonding for Communications Systems"

#### 1.3 REFERENCES

- A. Incorporate by reference the applicable portions of the following specifications, standards, codes into this specification section.
  - 1. General:
    - a. National Electrical Code (NEC)
    - b. National Electrical Safety Code (NESC)
    - c. Occupational Safety and Health Act (OSHA)
  - 2. Communications:
    - a. ANSI/TIA/EIA 568: Commercial Building Telecommunications Cabling Standard
    - b. ANSI/TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
    - c. ANSI/TIA/EIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
    - d. ANSI/TIA/EIA 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
    - e. ISO/IEC IS 11801: Generic Cabling for Customer Premises
    - f. BICSI: BICSI Telecommunications Cabling Installation Manual

g. BICSI: BICSI Telecommunications Distribution Methods Manual (TDMM)

# 1.4 DEFINITIONS

- A. "EMT" shall mean Electrical Metallic Tubing.
- B. "RMC" shall mean Rigid Metal Conduit.
- C. "SMR" shall mean Surface Metal Raceway.
- D. "Raceway" shall mean any enclosed channel for routing wire, cable or busbars.
- E. "TMGB" shall mean *Telecommunications Main Grounding Busbar*. There is typically one TMGB per building, located in the main telecommunications room. This busbar is directly bonded to the electrical service ground.
- F. "TGB" shall mean *Telecommunications Grounding Busbar*. There is typically one TGB per telecommunications room. The TGB is connected both to the TMGB and to building structural steel or other permanent metallic systems.
- G. "TBB" shall mean *Telecommunications Bonding Backbone*. The TBB is a conductor used to connect TMGBs to the TGBs.
- H. "Pullbox" shall mean a metallic box with a removable cover, used to facilitate pulling cable through conduit runs longer than 100' or in which there are more than 180 degrees of bends.
- I. "Junction box" shall mean a pullbox wherein a feeder conduit transitions to multiple distribution conduits.

#### 1.5 SYSTEM DESCRIPTION

- A. Furnish, install, and place into satisfactory and successful operation all materials, devices, and necessary appurtenances to provide a complete Raceway system as hereinafter specified and/or shown on the Contract Documents. The Raceway system shall support an ANSI/TIA/EIA and ISO/IEC compliant communications Structured Cabling System (SCS) as specified in 2715 00 -Inside Plant Communications Systems
- B. The work shall include materials, equipment and apparatus not specifically mentioned herein or noted on the Contract Documents but which are necessary to make a complete working Raceway system.

#### 1.6 SUBMITTALS

- A. Product Data Submittals: Provide submittal information for review before materials are delivered to the job site. Provide product data submittals for all products at the same time.
  - 1. Submit a letter stating that the materials will be provided as specified, and specifically listing any items that will not be provided as specified. The letter shall also state that the Contractor has reviewed the specified items and agrees that they are applicable to this project in all respects.

- 2. For those items noted as allowing "or equal," and which are not being provided as specifically named, submit standard manufacturer's cut sheets or other descriptive information, along with a written description detailing the reason for the substitution.
- 3. Provide standard manufacturer's cut sheets and the operating and maintenance (O&M) instructions at the time of submittal review for each device in the system, regardless of whether it is submitted as specified or as an approved equal. These instructions shall detail how to install and service the equipment and shall include information necessary for rough-in and preparation of the building facilities to receive the materials.
- B. Closeout Submittals: Provide submittal information for review as follows:
  - 1. O&M Manual for Communications At the completion of the project, submit all O&M information from product data submittals (above), updated to reflect any changes during the course of construction, to the College in the telecommunications-specific O&M Manual for Communications binder labeled with the project name and description.
  - 2. Records Maintain at the job site a minimum of one set of Record Drawings, Specification, and Addenda. Record Drawings shall consist of redline markups of drawings, specifications and spreadsheets, including maintenance hole/handhole butterfly drawings.
    - a. Document changes to the system from that originally shown on the Contract Documents and clearly identify system component labels and identifiers on Record Drawings.
    - b. Keep Record Drawings at the job site and make available to the Owner and Designer at any time.
    - c. Keep Record Drawings current throughout the course of construction. ("Current" is defined as not more than one week behind actual construction).
    - d. Show identifiers for major infrastructure components on Record Drawings.

#### 1.7 CONTRACTOR WARRANTY:

- A. Provide a Contractor-endorsed one-year service warranty against defects in materials and workmanship.
  - 1. Provide labor attributable to the fulfillment of this warranty at no cost to the Owner.
  - 2. The Contractor Warranty period shall commence upon Owner acceptance of the work.

## 1.8 QUALITY ASSURANCE

- A. Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled.
  - 1. The Terms "Listed" and "Labeled": As defined in NEC, Article 100.
  - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

- B. Comply with NECA's "Standard of Installation."
- C. Comply with NEC.

#### 1.9 COORDINATION

A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS

#### 2.1 GENERAL

- A. Materials shall consist of conduit, surface metal raceway, outlet boxes, fittings, enclosures, pull boxes, and other raceway incidentals and accessories as required for inside plant communications circuits.
- 2.2 MATERIALS
  - A. Conduit:
    - 1. EMT. 1" minimum conduit size. Flexible metal conduit (FMC) is not acceptable.
      - a. Conduit: Galvanized steel tubing meeting ANSI C80.3.
      - b. Couplings: Steel, cast iron, or malleable iron compression type employing a split, corrugated ring and tightening nut, with integral bushings and locknuts. Indent-type and setscrew-type couplings are not permitted.
    - 2. RMC. 1" minimum conduit size.
      - a. Conduit: Hot dipped galvanized steel with threaded ends meeting ANSI C80.1.
      - b. Couplings: Unsplit, NPT threaded steel cylinders with galvanizing equal to the conduit.
      - c. Nipples: Same as conduit, factory-made up to 8 inches in diameter, no running threads.
  - B. Sleeves: EMT conduit, with insulated throat bushings for each end
  - C. Surface Raceway: Wiremold V2400 series or equivalent Two piece, steel, single channel surface raceway.
  - D. Outlet boxes: Minimum 4"x4" size, 2 1/8" minimum depth, with extension rings (if needed) and single gang covers (i.e.; mud rings), unless otherwise noted on the Contract Documents. Combined interior depth of outlet box, extension ring and cover shall be a minimum 2-1/2". Stamped steel, deep drawn one piece (without welds or tab connections), galvanized, with knockouts for 1" trade size conduit or connector entrance, meeting NEMA OS 1.
    - 1. Acceptable manufacturers:
      - a. Appleton, Raco, Steel City, or equal

- 2. Wiremold Extra Deep Switch and Receptacle Box: V5744-2 (two gang), or equal
- E. Junction Boxes and Pull Boxes: Stamped steel, deep drawn one piece (without welds or tab connections), galvanized, with knockouts for conduit or connector entrance. Boxes 6"x6"x4" or larger may be code gauge fabricated steel continuously welded at seams and painted after fabrication.
  - 1. Dry locations: meeting NEMA OS 1.
  - 2. Wet locations: NEMA OS 3R.
- F. Miscellaneous Fittings:
  - 1. Locknuts and conduit bushings: Malleable iron
    - a. Appleton, Crouse Hinds, OZ Gedney, or equal
  - 2. Through wall seals and floor seals shall be:
    - a. OZ Gedney FS and WS series, or equal.
- G. Pull Strings: Plastic or nylon with a minimum test rating of 200 lb.
- 2.3 FIRESTOPPING
  - A. Material: Conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of the actual field conditions.
- 2.4 LABELING AND ADMINISTRATION
  - A. Labels: As recommended in ANSI/TIA/EIA 606. Permanent (i.e. not subject to fading or erasure), permanently affixed, typed, and created by a hand-carried label maker or an approved equivalent software-based label making system. Handwritten labels are not acceptable.
    - 1. Hand-carried label maker:
      - a. Brady: ID Pro Plus (or approved equal).
    - 2. Labels:
      - a. Brady: Bradymaker Wire Marking Labels WML-511-292 (or approved equal).

#### PART 3 - EXECUTION

#### 3.1 GENERAL

- A. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances.
- B. All work shall comply with applicable safety rules and regulations including OSHA. All work shall comply with the requirements of the National Electrical Safety Code (NESC) and the
NEC except where local codes and/or regulations are more stringent, in which case the local codes and/or regulations shall govern.

- C. All work shall comply with the standards, references and codes listed in PART 1 --REFERENCES above. Where questions arise regarding which standards, references, or codes apply, the more stringent shall prevail.
- D. All work shall comply with the requirements and recommendations of the product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.
- E. Install the raceway system in a manner ensuring that communications circuits, when installed, are able to fully comply with the ANSI/TIA/EIA and other references listed in Part 1 References, above.
- F. Replace and/or repair to original (or better) condition any existing structures, materials, equipment, etc. inadvertently demolished or damaged by the Contractor during the course of construction at no additional cost to the Owner.
- G. Remove surplus material and debris from the job site and dispose of legally.

# 3.2 EXAMINATION

A. Examine surfaces and spaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

# 3.3 INSTALLATION

- A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions. Provide a raceway for each location indicated. Do not gang raceway into wireways, pullboxes, junction boxes, etc., without specific approval from the Designer.
- B. Conduit:
  - 1. Install EMT unless other conduit is shown on the Contract Documents or is required by Code.
  - 2. Install conduit as a complete, continuous system without wires, mechanically secured and electrically connected to metal boxes, fittings and equipment. Blank-off unused openings using factory-made knockout seals.
  - 3. Run conduit in the most direct route possible, parallel to building lines. Do not route conduit through areas in which flammable material may be stored.
  - 4. Keep conduit at least 6 inches away from parallel runs of flues and steam or hot-water pipes or other heat sources operating at temperatures above one-hundred degrees Fahrenheit. Install horizontal conduit runs above water piping.
  - 5. Keep conduit away from sources of electromagnetic interference as follows:

- a. 5 inches from fluorescent lighting
- b. 12 inches from conduit and cables used for electrical power distribution
- c. 48 inches from motors or transformers
- 6. Do not exceed 90 meters total length for a given conduit run to be used for distribution cabling (from outlet box to telecommunications room), including intermediate conduits and junction boxes.
- 7. Install conduit exposed, except in finished areas or unless shown otherwise on the drawings. Do not install conduit below grade/slab unless specifically shown on the Contract Documents as being installed below grade/slab.
- 8. Install exposed conduit in lines parallel or perpendicular to building lines or structural members except where the structure is not level. Follow the surface contours as much as practical. Do not install crossovers or offsets that can be avoided by installing the conduit in a different sequence or a uniform line.
  - a. Run parallel or banked conduits together, on common supports where practical.
  - b. Make bends in parallel or banked runs from same centerline to make bends parallel.
- 9. Conduits concealed above ceilings, furred spaces, etc., which are normally inaccessible may be run at angles not parallel to the building lines.
- 10. Wherever practical, route conduit with adjacent ductwork or piping and support on common racks. Base required strength of racks, hangers, and anchors on combined weights of conduit and piping.
- 11. Where conduits cross building expansion joints, use suitable sliding or offsetting expansion fittings. Unless specifically approved for bonding, use a suitable bonding jumper.
- 12. Support conduits as specified in Section "Basic Electrical Materials and Methods."
  - a. Provide anchors, hangers, supports, clamps, etc. to support the conduits from the structures in or on which they are installed. Do not space supports farther apart than five feet.
  - b. Provide sufficient clearance to allow conduit to be added to racks, hangers, etc. in the future.
  - c. Support conduit within three feet of each outlet box, junction box, gutter, panel, fitting, etc.
- 13. Ream conduits to eliminate sharp edges and terminate with metallic insulated grounded throat bushings. Seal each conduit after installation (until cable is installed) with a removable mechanical-type seal to keep conduits clean, dry and prevent foreign matter from entering conduits.
- 14. Install a pull string in each conduit.

- 15. For conduits entering through the floor of a telecommunications room, terminate conduits 6" above the finished floor.
- 16. Do not install communications conduits in wet, hazardous or corrosive locations.
- 17. Where conduit is shown embedded in masonry, embed conduit in the hollow core of the masonry. Horizontal runs in the joint between masonry units are not permitted.
- 18. Where conduit is shown embedded in concrete, embed conduit a minimum of two inches from the exterior of the concrete. Do not place conduit in concrete less than 4 inches thick.
  - a. One inch trade size conduit shall be used. Conduits sized smaller than one inch trade size conduit are not permitted embedded in concrete without approval from the College.
  - b. Run conduit parallel to main reinforcement.
  - c. Conduit crossovers in concrete are not permitted.
- 19. Where conduit exits from grade or concrete, provide a rigid steel elbow and adapter.
- 20. Where conduit enters a space through the floor and terminates in that space, terminate the conduit at 6" above the finished floor.
- 21. Where conduits terminate at a cable tray, the conduits shall be consistently terminated no more than 8" from the cable tray, and have a visually uniform appearance.
- 22. Where several circuits follow a common route, stagger pullboxes or fittings.
- 23. Where several circuits are shown grouped in one box, individually fireproof each conduit.
- 24. Bend and offset metal conduit with standard factory sweeps or conduit fittings. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
  - a. Conduit sweeps:
    - 1) Sweeps shall not exceed 90 degrees.
    - 2) Do not exceed 180 degrees for the sum total of conduit sweeps for a section of conduit (between conduit termination points).
    - 3) Sweep radius shall be at least 10 times the internal diameter of the conduit.
    - 4) 90-degree condulets (LB's) and electrical elbows are not acceptable.
  - b. Factory-manufactured sweeps are required for bends in conduit larger than  $1-\frac{1}{4}$ " trade size.
  - c. For bends in 1 <sup>1</sup>/<sub>4</sub>" trade size conduit and larger, field-manufactured bends (using a hydraulic bender with a 1 <sup>1</sup>/<sub>4</sub>" boot) are permitted only when factory-manufactured

sweeps are not suitable for the conditions. In all other cases, factory-manufactured sweeps are required. "Hickey-bender" use is prohibited.

- 25. Connect conduit to hubless enclosures, cabinets and boxes with double locknuts and with insulating type bushings. Use grounding type bushings where connecting to concentric or eccentric knockouts. Make conduit connections to enclosures at the nearest practicable point of entry to the enclosure area where the devices are located to which the circuits contained in the conduit will connect.
- 26. Penetrations for raceways:
  - a. Do not bore holes in floor and ceiling joists outside center third of member depth or within two feet of bearing points. Holes shall be 1-1/4" diameter maximum.
  - b. Penetrate finished walls and finished surfaces with a PVC or sheet metal sleeve with an interior diameter (ID) at least 1/4" greater than the outer diameter (OD) of the conduit, set flush with walls, pack with fiberglass, seal with silicone sealant.
  - c. Penetrate poured-in-place walls and free slabs with a cast iron sleeve (or Schedule 40 PVC black pipe sleeve for above-grade only) with retaining ring or washer. Set sleeves flush with forms or edges of slab. Pack around conduit with fiberglass and seal with silicone sealant.
- 27. Raceway terminations and connections:
  - a. Join conduits with fittings designed and approved for the purpose and make joints tight. Do not use set indent-type or screw-type couplings.
  - b. Make threaded connections waterproof and rustproof by applying a watertight, conductive thread compound. Clean threads of cutting oil before applying thread compound.
  - c. Make conduit terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
  - d. Cut ends of conduit square using a hand saw, power saw or pipe cutter. Ream cut ends to remove burrs and sharp ends. Where conduit threads are cut in the field, cut threads to have same effective length, same thread dimensions and same taper as specified for factory-cut threads.
  - e. Provide double locknuts and insulating bushings at conduit connections to boxes and cabinets. Align raceways to enter squarely and install locknuts with dished part against the box. Use grounding type bushings where connecting to concentric or eccentric knockouts.
  - f. Where conduits are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.

- 28. Install conduit sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed conduits, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
  - a. Where conduits pass from warm to cold locations, such as the boundaries of air conditioned or refrigerated spaces and where conduits enter or exit buildings from outdoor areas, including underground ducts or conduit runs.
  - b. Where otherwise required by the NEC.
- 29. Conduit shall be clean and dry.
- C. Sleeves:
  - 1. Provide sleeves where required, sized as noted on the Contract Documents. Where not noted, sleeve sizing shall be determined by the type and quantity of cable to be routed through the sleeve per TIA/EIA 569A cable capacity standards, plus an additional 20% for future expansion.
  - 2. Provide roto-hammering or core drilling where required for installation.
  - 3. Seal between sleeve and wall or floor in which the sleeve is installed. Firestop all penetrations to restore wall or floor to pre-penetration fire-rating.
- D. Surface Raceway:
  - 1. Provide surface raceway for all surface mounted telecommunications outlet boxes and as shown on the Contract Documents.
  - 2. Surface raceway shall be routed parallel to and perpendicular to surfaces or exposed structural members, and follow surface contours.
  - 3. Surface raceway color shall match as closely as possible the existing wall finish. Do not paint Surface Raceway.
  - 4. Surface raceway systems shall be completely installed, including insulating bushings and inserts as required by manufacturer's installation requirements. Unused openings in the surface raceway shall be closed using manufactured fittings.
  - 5. Surface raceway shall have a minimum two inch radius control at all bend points.
  - 6. Surface raceway shall be securely supported by screws or other anchor-type devices at intervals not exceeding 10 feet and with no less than two supports per straight raceway section. Surface raceway shall be securely supported in accordance with the manufacturer's requirements. Tape and glue are not acceptable support methods.
  - 7. Mechanically and electrically continuous surface raceway shall be bonded and grounded to the Telecommunications Grounding system.
- E. Outlet Boxes:

- 1. Provide outlet boxes and covers as shown on the Contract Documents and as needed. Verify that the appropriate cover type and depth is provided for each type of wall and finish. Provide extension rings as needed.
- 2. Coordinate box locations with building surfaces and finishes to avoid bridging wainscots, joints, finish changes, etc.
- 3. Install boxes in dry locations (not wet, corrosive, or hazardous).
- 4. Attach boxes securely to building structure with a minimum of two fasteners. Provide attachments to withstand a force of one hundred pounds minimum, applied vertically or horizontally.
- 5. Install boxes at the following heights to the bottom of the box, except where noted otherwise:
  - a. Wall mounted telephones: 48" above finished floor.
  - b. Workstation outlets: 18" above finished floor.
  - c. Place boxes for outlets on cabinets, countertops, shelves, and similar boxes located above countertops two inches above the finished surface or two inches above the back splash. Coordinate and verify size, style, and location with the supplier or installer of these items prior to outlet box installation.
- 6. Recessed mounted outlet boxes:
  - a. Recess boxes in the wall, floor, and ceiling surfaces in finished areas. Set boxes plumb, level, square and flush with finished building surfaces within one-sixteenth inch for each condition. Set boxes so that box openings in building surfaces are within one-eighth inch of edge of material cut-out and fill tight to box with building materials. Single gang opening shall extend at least to the finished wall surface and extend not more than 1/8 inch beyond the finished wall surface. Provide backing for boxes using structural material to prevent rotation on studs or joists.
  - b. Install floor boxes level and adjust to finished floor surface.
- 7. Surface-mounted outlet boxes:
  - a. For boxes surface-mounted on finished walls, provide Wiremold outlet box or equivalent. Cut box as necessary to accept conduit.
  - b. For boxes surface-mounted on unfinished walls (i.e. electrical rooms, mechanical rooms), provide 4"x4" (minimum) outlet box with single gang cover.
- F. Floor Boxes:
  - 1. Provide floor boxes as shown on the Contract Documents.
  - 2. Set device boxes plumb, level, square and flush with floor, within 1/16" tolerance for each condition.

- 3. For floor boxes with combined power and telecommunications circuits, provide metal dividers to separate power from telecommunications circuits.
- G. Junction Boxes:
  - 1. Provide junction boxes as shown on the Contract Documents and as required.
    - a. Where sizing is not shown on the Contract Documents, size junction box length and depth according to the size of the feeder conduit in the following table:

Feeder	Box	Box Depth
Conduit Size	Length	
1"	12"	4"
1-1/4"	12"	4"
1-1/2"	12"	4"
2"	24"	4"
2-1/2"	24"	6"
3	36"	6"
3-1/2"	48"	6"
4"	60"	6"

- b. Where sizing is not shown on the Contract Documents, size junction box width according to the following formula:
  - 1) From the table below, select the width associated with the largest conduit on the distribution side of the box. For each additional distribution conduit, add the "Increase Width" value associated with the size of that distribution conduit to the box width for the largest distribution conduit.
    - a) For example, if the distribution side of the junction box has one  $1-\frac{1}{4}$ " distribution conduit and three 1" distribution conduits, the total distribution-side width would be 6"+2"+2"=10".
  - 2) Repeat the above process for the feeder side of the junction box. Junction boxes are typically fed by a single conduit, therefore unless the box has more than one feeder conduit, the "Increase Width" part of the formula is unnecessary.
    - a) For example, if the feeder side of the junction box has two 2" feeder conduits the total feeder-side width would be 8"+5"=13".
  - 3) The larger of the two width calculations (distribution side vs. feeder side) shall be the width of the junction box to be provided.

Conduit Size	Box Width	For each additional conduit Increase Width
1"	4"	2"
1-1/4"	6"	3"
1-1/2"	8"	4"
2"	8"	5"
2-1/2"	10"	6"
3	12"	6"
3-1/2"	12"	6"
4"	15"	8"

a) For example, if the distribution-side width were 10" and the feederside width were 13", provide a 13" wide junction box.

- 2. A junction box may not be substituted for a 90-degree bend. 90 degree condulets (LB's) are not acceptable.
- 3. Install junction boxes in a location readily accessible both at time of construction and after building occupation. Do not install junction boxes in inaccessible interstitial building spaces.
- 4. Where junction boxes are to be mounted on ceiling structure above ceiling grid, do not mount higher than 4' above grid.
- 5. Install hinged-cover enclosures and cabinets plumb, and supported at each corner.
- 6. Install junction boxes so that the access door opens from the side where the cable installer will normally work typically from the bottom (floor side) of the box.
  - a. Where a junction box is installed in a ceiling space, coordinate with other trades to provide full access to the junction box door and adequate working room for both the installation personnel and for proper looping of cable during installation.
  - b. Provide a lockable access cover (or junction box door if junction box is exposed) in hard lid ceilings.
- 7. Install junction boxes such that conduits enter and exit at opposite ends of the box as follows:



- H. Pull Boxes:
  - 1. Provide pull boxes as shown on the Contract Documents and as required.

Size of Largest	Box Width	Box Length	Box Depth
1"	4"	12"	1 <sup>2</sup> / <sub>4</sub> <sup>2</sup>
$1 - \frac{1}{1 - \frac{1}{4}}$	т 6"	12	т Д"
$1 - \frac{1}{2}$	8"	12"	ч 4"
2"	8"	24"	4"
2-1/2"	10"	24"	6"
3	12"	36"	6"
3-1/2"	12"	48"	6"
4"	15"	60"	6"

a. Where sizing is not shown on the Contract Documents, size pull boxes as follows:

- b. Where a pull box is required with conduits 1" trade size or smaller, an outlet box may be used as a pull box. Where outlet boxes are used as pull boxes, the outlet boxes shall be dedicated for use as a pull box and shall not host cable termination hardware.
- 2. A pull box may not be substituted for a 90-degree bend. 90 degree condulets (LB's) are not acceptable.
- 3. Install pull boxes in an accessible location, readily accessible both at time of construction and after building occupation. Do not install pull boxes in inaccessible interstitial building space.
- 4. Where pull boxes are to be mounted on ceiling structure above ceiling grid, do not mount higher than 4' above grid (mount on wall instead).
- 5. Install hinged-cover enclosures and cabinets plumb, and supported at each corner.

- 6. Install pull boxes so that the access door opens from the side where the cable installer will normally work (typically from the bottom, or floor side, of the box).
  - a. Where a pull box is installed in a ceiling space, provide full access to the junction box door and adequate working room for both the installation personnel and for proper looping of cable during installation.
  - b. Provide a lockable access cover (or pull box door if pull box is exposed) in hard lid ceilings.
- 7. Install pull boxes such that conduits enter and exit at opposite ends of the box as follows:



- I. Firestopping:
  - 1. Only employees trained/certified by the firestopping manufacturer shall apply firestopping materials.
  - 2. Maintain fire rating of penetrated fire-rated walls. Firestop and seal each penetration made during construction.
    - a. Provide firestopping material for through and membrane penetrations of fire-rated barriers.
    - b. Installation shall be performed in strict accordance with manufacturer's detailed installation procedures.
    - c. Install firestops in accordance with fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and applicable codes and standards referenced in PART 1 REFERENCES. Apply all sealing material in a manner acceptable to the local fire and building authorities.
- J. Grounding/Bonding: Grounding and bonding work shall comply with the Virginia Uniform Statewide Building Code, Uniform Fire Code, National Electrical Code, and UL 467, ANSI/TIA/EIA standards and the references listed in PART 1 REFERENCES above, as well as local codes which may specify additional grounding and/or bonding requirements.
  - 1. Bond metallic raceway together and to the nearest TGB (as provided under Division 27 Section "Grounding and Bonding for Communications Systems"). Ensure that bonding breaks through paint to bare metallic surface of painted metallic hardware.

# 3.4 LABELS:

- A. Conduits: For any conduit extending beyond the space or room in which it starts, label each such conduit end in a clear manner by designating the location of the other end of the conduit (i.e. room name, telecommunications room name, pull box identifier, outlet identifier (use the label of the first port of the outlet as the outlet identifier), etc.). Indicate conduit length on the label.
  - 1. Where a conduit is intended for future cabling use outside of the Contract, the conduit shall be labeled in a clear manner by designating the location of the other end of the conduit (i.e. room name, telecommunications room name, pull box identifier, etc.) along with a sequential number for each spare conduit terminated into a single room. Indicate conduit length on the label.
    - a. Suggestion: The second spare conduit (whether spare or in use) between Room 100 and telecommunications room 1A might be labeled in the telecommunications room as "Room 100 #2, \_\_\_\_\_ feet." In Room 100 the same conduit might be labeled "1A #2, \_\_\_\_\_ feet."
- B. Pull Boxes: Label each pullbox with a unique identifier. Identifiers shall be of the form "RN-Y" where "RN" is the room name of the room closest to (or containing) the pull box, and "Y" is the sequential number of the pull box for each "RN".
  - 1. Example: The second pull box in the vicinity of room "100" would have the label "100-2".
- C. Pull Strings: For any conduit extending beyond the space or room in which it starts, label its pull string in a clear manner by designating the location of the other end of the pull string (i.e. room name, telecommunications room name, pull box identifier, outlet identifier (use the label of the first port of the outlet as the outlet identifier), etc.).
  - 1. Where a pull string is installed in a conduit intended for future cabling use outside of the Contract, the pull string shall be labeled similar to the spare conduit in which it is installed.

# 3.5 **PROTECTION**

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and in accordance with accepted industry practice, that ensure coatings, finishes, and cabinets are without damage or deterioration at the time of Substantial Completion.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

# 3.6 CLEANING

1. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

# **END OF SECTION**

#### SECTION 31 10 00 – SITE CLEARING

# PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. General Conditions and Section 1 of the Baltimore County Board of Education's Specifications for Site Development.
- C. Baltimore County Department of Public Works Standard Details for Construction dated 2007 and as amended.
- D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

# 1.2 SUMMARY

- A. This Section includes the following:
  - 1. Protection of existing trees indicated to remain.
  - 2. Removal of trees and other vegetation.
  - 3. Topsoil stripping.
  - 4. Clearing and grubbing.
  - 5. Removal and disposal of pavement areas, inclusive of pavement base courses, sidewalk, curb, and combination curb and gutter.
  - 6. Removal of above-grade improvements pertains to those shown on the drawings and all those existing improvements readily visible at the site and in the drawings which interfere with the work.
  - 7. Removing below-grade improvements pertains to those items shown on the drawings, and those associated with the above grade improvements to be removed, if they impede the proposed work.
  - 8. Removal and/or abandonment of utilities and appurtenances.

# 1.3 PROJECT CONDITIONS

- A. Traffic: Conduct site-clearing operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities. Do not close or obstruct streets, walks, or other occupied or used facilities without permission from authorities having jurisdiction. The Contactor shall provide Maintenance of Traffic (MOT) in accordance with the requirements of Baltimore County Department of Public Works.
- B. Protection of Existing Improvements: Provide protections necessary to prevent damage to existing improvements indicated to remain in place.
  - 1. Protect improvement on adjoining properties and on Owner's property.

- 2. Restore damaged improvements to their original condition, as acceptable to property owners.
- C. Soil Erosion and Sediment Control: Soil erosion and sediment control measures are required for this site in accordance with the approved plans. Soil erosion and sediment control measures disturbed or damaged by clearing operations shall be restored to operating condition in accordance with the requirements of the approved plan before the end of the work day.
- D. Protection of Existing Trees and Vegetation: Protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking or skinning of roots, skinning or bruising of bar, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Provide temporary guards to protect trees and vegetation to be left standing.
  - 1. Water trees and other vegetation to remain within limits of contract work as required to maintain their health during course of construction operations.
  - 2. Provide protection for roots over 1-1/2 inch in diameter that are cut during construction operations. Coat cut faces with emulsified asphalt or other acceptable coating formulated to use on damaged plant tissues. Temporarily cover exposed roots with wet burlap to prevent roots from drying out, cover with earth as soon as possible.
  - 3. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations in manner acceptable to Architect. Employ a licensed arborist to repair damage to trees and shrubs.
  - 4. Replace trees that cannot be replaced and restored to full-growth status, as determined by arborist.
- E. Improvements on Adjoining Property: Authority for performing removal and alteration work on property adjoining Owner's property will be obtained by Owner prior to award of contract.
  - 1. Extent of work on adjacent property is indicated on Drawings.
- F. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated or directed. Refer to Division 01 Section "Construction Waste Management and Disposal."

# 1.4 EXISTING SERVICES

- A. General: Indicated locations are approximate, determine exact locations before commencing Work.
- B. Arrange and pay for disconnecting, removing, capping, and plugging, utility services. Notify affected utility companies in advance and obtain approval before starting this Work.
- C. Place markers to indicated location of disconnected services. Identify service lines and capping locations on Project Record Documents.

# PART 2 PRODUCTS

# Not Applicable

#### PART 3 EXECUTION

#### 3.1 SITE CLEARING

- A. The contractor shall prepare and submit a demolition/construction staging plan to Baltimore County Public Schools for approval prior to beginning any construction. Refer to Division 01 Section "Construction Waste Management and Disposal."
- B. General: Remove trees, shrubs, grass, and other vegetation, improvements, or obstructions, as required, to permit installation of new construction. Remove similar items elsewhere on site or premises as specifically indicated. Removal includes digging out and off-site disposal of stumps and roots.
  - 1. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
- C. Topsoil: Topsoil is defined as friable clay loam surface soil found in a depth of not less than 4 inches. Satisfactory topsoil is reasonably free of subsoil, clay lumps, stones, and other objects over 1/2 inches in diameter, and without weeds, roots, and other objectionable material.
  - 1. Strip topsoil to whatever depths encountered in a manner to prevent intermingling with underlying subsoil or other objectionable material. Remove heavy growths of grass from areas before stripping.
    - a. Where existing trees are indicated to remain, leave existing topsoil in place within drip lines to prevent damage to root system.
  - 2. Stockpile topsoil in storage piles in areas indicated or directed. Construct storage piles to provide free drainage of surface water. Cover storage piles, if required, to prevent wind erosion.
  - 3. The thick organic plow layers that are to be stripped generally consist of sandy soils and are expect to be suitable for reuse in the athletic field areas.
  - 4. Dispose of unsuitable or excess topsoil as specified for disposal of waste material.
- D. Clearing and Grubbing: Clear site of trees, shrubs, and other vegetation, except for those indicated to be left standing.
  - 1. Completely remove stumps, roots, and other debris protruding through ground surface.
  - 2. Use only hand methods for grubbing inside drip line of trees indicated to remain.
  - 3. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated.
    - a. Place fill material in horizontal layers not exceeding 8 inches loose depth, and thoroughly compact each layer to a density not less than 92 percent of the

maximum dry density when tested in accordance with AASHTO T180.

- E. Removal of Improvements: Remove existing above-grade and below-grade improvements as indicated and as necessary to facilitate new construction.
  - 1. Removal of pavement, including base courses, sidewalk, curb, and combination curb and gutter, shall be for the full depth thereof.
  - 2. Existing foundations shall be removed in their entirety.
  - 3. The Contractor shall use suitable equipment, tools, and methods for cutting and trimming as well as removing the materials to the neat lines set by the Owner and shall not in any manner disturb or damage the sections of base or pavement to be salvaged.
  - 4. Damage done by the Contractor's equipment or methods to those areas designated for salvaging shall be replaced at the Contractor's expense.
  - 5. Where the old subgrade is satisfactory as to condition and elevation, special care shall be taken in the removal operation in order to avoid the disturbing of the old grade.
  - 6. Abandonment or removal of certain underground pipe or conduits may be indicated on mechanical or electrical drawings and is included under work of related Division 23 and 26 Sections. Removing abandoned underground piping or conduits interfering with construction shall be as follows:
    - a. Underground improvements shall be completely removed to a depth of two feet below indicated subgrade under structures and paving or finished grade in other areas or where it conflicts with proposed construction.
    - b. Pipes and other utilities indicated to be abandoned in place shall have open ends plugged with concrete for a minimum length of one foot. Structures, manholes, and other utility appurtenances shall be filled with compacted subgrade materials.
  - 7. Fill depressions caused by clearing and grubbing and removal of improvements with satisfactory material, unless further excavation or earthwork is indicated.

# 3.2 DISPOSITION OF UTILITIES

- A. Verify with the Authority having jurisdiction that utility lines indicated to be removed or abandoned are no longer in service before beginning removal or abandonment.
- B. Relocation of Utilities: Where utility services (which include water, sewer, storm drains, electrical, gas, telephone, etc.) Are to be relocated as a part of the work of this contract, the Contractor shall maintain the existing utility services in service until the relocate services have been completed and approved. The Contractor shall coordinate with the Authority having jurisdiction to make temporary service connections, re-route services and make tie-ins all as may be required.

C. Unknown Utilities: Where utilities are encountered in the work, the presence of which is not shown or indicated on the drawings, the Contractor shall immediately notify the Authority having jurisdiction. The Contractor shall immediately notify the Authority having jurisdiction and maintain these unknown utility services until instructed by the Authority having jurisdiction as to the proper disposition of the utility.

# 3.3 DISPOSAL OF WASTE MATERIALS

- A. Burning on Owner's Property: Burning is not permitted on Owner's property.
- B. Removal from Owner's Property: Remove waste materials and unsuitable or excess topsoil from Owner's property and dispose of off-site in accordance with local regulations.

#### 3.4 RECORD DRAWINGS

A. Survey and include on record drawings location and depth of all utilities encountered which have not been removed.

# **END OF SECTION**

# SECTION 31 23 00 – EXCAVATING AND FILLING

#### PART 1 GENERAL

- 1.1 RELATED DOCUMENTS:
  - A. Requirements of the General Provisions apply to all work under this section.
  - B. General Conditions and Section 2 of the Baltimore County Board of Education's Specifications for Site Development.
  - C. Baltimore County Department of Public Works Standard Details for Construction dated February 2000 and as amended.
  - D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

# 1.2 DESCRIPTION

- A. This Section includes the following:
  - 1. Backfilling operation to bring the existing site to grade.
  - 2. Preparing and grading sub grades to slabs-on-grade, walks, pavements, and landscaping.
  - 3. Excavating and backfilling for buildings and structures.
  - 4. Drainage and moisture -control fill course for slabs-on-grade.
  - 5. Subbase course for walks and pavements.
  - 6. Subsurface drainage backfill for walls and trenches.
  - 7. Excavating and backfilling trenches within building lines.
  - 8. Excavating and backfilling for underground utilities and appurtenances.
- B. Related Sections:
  - 1. Section 311000: Site Clearing
  - 2. Section 329000: Planting
  - 3. Division 03: Cast-in-Place Concrete

#### 1.3 DEFINITIONS

- A. Excavation consists of the removal of material encountered to subgrade elevations and the reuse or disposal of materials removed.
- B. Subgrade: The uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
- C. Borrow: Soil material off-site when sufficient approved soil material is not available from on-site excavations.
- D. Subbase Course: The layer between the subgrade and base course in a paving system or the layer placed between the subgrade and surface of a pavement or walk.

- E. Base Course: The layer placed between the subbase and surface pavement in a paving system.
- F. Drainage Fill: Course of washed granular material supporting slab-on-grade placed to cut off upward capillary flow of pore water.
- G. Unauthorized excavation consists of removing materials beyond indicated subgrade elevations or dimensions without direction by the Architect. Unauthorized excavation, as well as remedial work directed by the Architect, shall be at the Contractor's expense.
- H. Additional excavation: When excavation has reached required subgrade elevations, notify the Inspection Agency, who will make an inspection of conditions. The Contractor is responsible for scheduling the inspections such that there is no delay in the Project. If the Inspection Agency determines that bearing material at required subgrade elevations are unsuitable, continue excavation until suitable bearing materials are encountered and replace excavated material as directed by them.
- I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below ground surface.
- J. Utilities include on-site underground pipes, conduits, ducts, and cable, as well as underground services within building lines.
- K. Rock Excavation in Trench Excavation and Pits, including continuous wall footings and individual column footings, shall consist of:
  - 1. The removal of/and disposal of solid rock, ledge rock, rock hard cementitious materials and/or boulders ½ cubic yards or more in volume in trench excavations less than 10 feet in width and pits less than 30 feet in either length or width.
  - 2. Excavation of materials that required the use of:
    - a) Excavating equipment which exceeds standard Earth Excavating Equipment as defined herein.
    - b) Systematic drilling.
    - c) Hand-held or backhoe mounted pneumatic hammers
    - d) Blasting.
  - 3. Blasting will only be permitted after receiving permission from the owner and local authorities. The Contractor shall obtain special liability insurance to protect all parties, including the Owner and Engineers from all claims resulting from any blasting.
- L. Rock Excavation in open excavation (all excavations other than trench excavation and pit excavation) shall consist of the following:
  - 1. The removal and disposal of solid rock, ledge rock, rock hard cementitious material and/or boulders 2 cubic yards or more in volume.
  - 2. Excavation of materials that requires the use of:
    - a. Excavation equipment which exceeds standard Earth Excavation Equipment as defined herein.
    - b. Systematic drilling.
    - c. Hand-held or backhoe mounted pneumatic hammers.

- d. Blasting.
- 3. Blasting will only be permitted after receiving permission from the owner and local authorities. The Contractor shall obtain special liability insurance to protect all parties, including the Owner and Engineers from all claims resulting from any blasting.
- M. The Contractor is advised that minimum standard earth excavation equipment is defined as follows:
  - 1. For Trench Excavation as defined herein: 250 H.P., track mounted, hydraulic excavator with a 3-foot rock bucket.
  - 2. For Open Excavation as defined herein: 280 H.P. crawler dozer with a single shank ripper.

# 1.4 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for the following:
  - 1. Each type of warning tape.
  - 2. Filter fabric.
- C. LEED Submittals:
  - 1. Product Data for Credit MR 4: For recycled content materials, documentation indicating percentages of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.
  - 2. Product Data for Credit MR 5: For regional materials, documentation indicating location of manufacture and location of extraction or recovery of primary raw materials. Include statement indicating cost of each product with regional material content.
- D. Test Reports: In addition to test reports required under field quality control, submit the following:
  - 1. Laboratory analysis of each soil material proposed for fill and backfill from on-site and borrow sources, including classification per ASTM D2487.
  - 2. One moisture density curve for each soil material, per AASHTO T-180.
  - 3. Reports of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.

# 1.5 QUALITY ASSURANCE

- A. Codes and Standards: Perform earthwork complying with requirements of Authorities having jurisdiction.
- B. Testing and Inspection Service: The Owner will engage a qualified independent geotechnical engineering testing agency to classify proposed on-site and borrow soils to verify that soils comply with specified requirements and to perform required field and laboratory testing during earthwork operations and to check bearing capacities of excavated footings to confirm required bearing capacity prior to installation of reinforcing steel and concrete.
- 1.6 PROJECT CONDITIONS

- A. Backfilling below-grade areas: The backfilling operation required to bring actual grades to the grade elevations shown on the drawings as existing grades.
  - 1. The borrow material shall be removed and then either stored or disposed. If the testing agency verifies that the borrow material complies with these specifications for backfill material, then the Contractor may use it to backfill this area to grade.
  - 2. Any additional backfill material necessary to complete this operation shall comply with these specifications.
  - 3. This backfilling operation shall be the first earthwork operation performed on site after establishment of the sediment control devices.
- B. Site Information: Data in subsurface investigation reports was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as representations or warranties of accuracy or continuity between soil borings. The Owner, Architect or Engineers will not be responsible for interpretations or conclusions drawn from this data by the Contractor.
  - 1. Additional test borings and other exploratory operations may be performed by the Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.
- C. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by the Architect and then only after acceptable temporary utility services have been provided. If existing utilities are indicated to be abandoned, the Contractor shall remove such utility, if necessary, at no additional cost to the Owner.
  - 1. Provide a minimum 48-hours notice to the Architect and receive written notice to proceed before interrupting any utility.
- D. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shutoff services if lines are active.
- E. Should uncharted or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.
- F. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights. Open excavation within the roadways shall be plated and shall be posted with warning devices in accordance with the <u>Manual of Uniform Traffic Control Devices</u>.
  - 1. Perform excavation by hand within dripline of large trees to remain. Protect root systems from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with moistened burlap.
  - 2. Work which affects the public right-of-way shall be in accordance with the Baltimore County requirements and regulations.
- G. Moisture Sensitive Soils:
  - 1. The on-site founding materials are moisture sensitive and will be easily disturbed by excessive construction activity.
  - 2. The exposed founding materials shall be protected against detrimental changes in

engineering qualities as a result of disturbance from rain or frost.

- 3. Surface runoff shall be drained away from the excavations and not allowed to pond.
- 4. If possible, concrete shall be placed in the footings the same day the excavations are made, or the founding materials may be covered by mud mats in order to protect the founding soil from becoming saturated due to forecasted precipitation and/or disturbed due to excessive construction activity during the placement of steel reinforcement.
- 5. The presence of moisture sensitive fine-grained soils poses the potential for high moisture content. Soils may be found to be at or near their plastic limit; consequently, the on-site soils may require discing, aeration, and/or manipulation to achieve efficient compaction.
- 6. Any regions exhibiting poor drainage characteristics, and low lying areas, shall be expected to display moisture contents which are excessively high for normal earthwork operations.
- 7. Any standing water shall be drained or pumped into approved sediment control facilities prior to commencement of earthwork.
- 8. Excavations near to subgrade and all fills should be protected from traffic of heavy equipment, including heavy compaction equipment, when on-site soils exhibit high moisture contents, in order to minimize pumping and a generalized deterioration of these materials.
- H. The Contractor is solely responsible for the protection of the sub-grade until it receives final surface treatment and shall maintain the sub-grade as suitable and acceptable to the Owner or Owner's Representative at all times. He shall be completely responsible for restoration or replacement of the sub-grade due to moisture damage, construction traffic, or any other cause. Repair or replacement of the sub-grade shall be performed at no additional cost to the Owner.

# PART 2 PRODUCTS

# 2.1 SOIL MATERIALS

- A. General: Provide approved borrow soil materials from off-site when sufficient approved soil materials are not available from excavations. Classification of materials shall be made by the Owners independent testing agency.
  - 1. Provide subbase and backfill manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.
- B. Satisfactory Soil Materials: ASTM D 2487 soil classification groups SW, SP, SM, SC, GM, GW, GP, GC; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter. Clay content shall not exceed 20 percent and plasticity index shall be less than 15 for satisfactory soils. Soil materials SC, GC, and ML shall not be used as backfill for Retaining or Subsurface Walls.
- C. Unsatisfactory Soil Materials: ASTM D 2487 soil classification groups CL, MH, CH, OL, OH, and PT.
- D. Backfill and Fill Materials: Satisfactory soil materials.
- E. Subbase and Base Material: naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand, ASTM D 2940. Graded aggregate for subbase courses shall meet the requirements for G A S/B as shown in Table 312300-1. Recycled concrete (RC-6) sub-base and fill material, acceptable except under building slab and pavement areas.

Table 312300-1					
SIEVES		MASS PERCENT PASSING			
Mm	Standard	BRG S/B	G A S/B		
100	4 in.				
90	3.5 in.				
63	2.5 in.	100			
50	2 in.		100		
37.5	1.5 in.		90 - 100		
25	1 in.	90 - 100			
19	<sup>3</sup> ⁄ <sub>4</sub> in.				
12.5	1/2 in.	60 - 100			
9.5	3/8 in.				
4.75	#4		30 - 60		
2.36	#8				
2.0	#10	35 - 90			
0.60	#30				
0.425	#40	20 - 55			
0.075	#200	5 - 25	0 - 12		

- F. Engineered Fill: Subbase or base materials
- G. Bank Run Gravel for subbases: Bank Run Gravel for subbase courses shall meet the requirements for BRG S/B as shown in Table 312300-1.
- H. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, AASHTO M43, coarse aggregate grading size 57, with 100 percent passing a 1-1/2 inch sieve and not more than 5 percent passing a No. 8 sieve.
- I. Filtering Material: Evenly graded mixture of natural or crushed gravel or crushed stone and natural sand, with 100 percent passing a 1inch sieve and 0 to 5 percent passing a No. 50 sieve.
- J. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

# 2.3 ACCESSORIES

a.

- A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick minimum, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep.
  - 1. Tape Colors: Provide tape colors to utilities as follows:
    - Red: Electric
    - b. Yellow: Gas, oil, steam, and dangerous materials
    - c. Orange: Telephone and other communications
    - d. Blue: Water Systems
    - e. Green: Sewer Systems
- B. Filter Fabric: Manufacturer's standard nonwoven previous geotextile fabric of polypropylene, nylon, or polyester fibers, or a combination.
  - 1. Provide filter fabrics that meet or exceed the listed minimum physical properties determined according to ASTM D4759 and the referenced standard test method in parentheses:
    - a. Grab Tensile Strength (ASTM D 4362): 100lb.
    - b. Apparent Opening Size (ASTM D 4751): #100 U.S. Standard sieve.
    - c. Permeability (ASTM 4491): 150 gallons per minute per sq. ft.

# PART 3 EXECUTION

#### 3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.
- C. Provide erosion control measures to prevent erosion or displacement of soils and discharge of soilbearing water runoff or airborne dust to adjacent properties and walkways.
- D. Tree protection is specified in the Division 31 Section 311000- "Site Clearing".

# 3.2 DEWATERING

- A. Prevent surface water and subsurface or groundwater from entering excavations, from ponding on prepared subgrades, and from flooding project site and surrounding area.
- B. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- C. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, and sumps, suction and discharge lines, and

other dewatering system components necessary to convey water away from excavations.

1. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water to be removed from excavation to collecting or runoff areas. Do not use excavations as temporary drainage ditches.

#### 3.3 BACKFILLING BELOW-GRADE AREAS

- A. Completely fill below-grade areas and void resulting from the demolition of the site improvements and pavements with compacted fill, as described below, to the grades as shown as existing grades on the drawings.
  - 1. Use satisfactory soil materials, as defined by ASTM D 2487, consisting of SW, SP, SM, SC, GP, GW, GC, GM, free from debris, trash, frozen materials, roots, rocks larger than 6 inches in diameter, and other organic matter. All material must have a liquid limit of less than 40 and a plasticity index less than 15.
  - 2. Prior to placement of compacted structural fill, the fill subgrade should be stripped of organic layers and then proofrolled under the observation of the Owners Testing Agency. A minimum 20-ton loaded dump truck should be used for proofrolling. Proofrolling should be performed in a grid pattern to check the subgrade conditions in all directions. Areas of subgrade that exhibit pumping or contain organic material should be removed down to firm, natural soils. Any additional loose or unsuitable soils found should be removed and replaced with compacted fill.
  - 3. Place fill materials in horizontal layers not exceeding 6 inches in loose depth. In pavement areas, the top 12 inches of fill should be compacted to 95% of the maximum density when tested in accordance with ASTM D-1557 (AASHTO T-180), Modified Proctor. Pavement fill below the top 12 inches may be compacted to 90 percent. Fill materials should be placed at moisture contents within  $\pm 3$  points of the optimum moisture content. No compacted fill shall be placed unless a soils technician is present to monitor fill compaction.
- B. Testing Agency shall verify compliance of borrow material at both the in-situ location and after the material has been brought to the site.

# 3.4 EXCAVATION

- A. Explosives: Do not use explosives.
- B. Unclassified Excavation: Excavation is unclassified and includes excavation to required subgrade elevations regardless of the character of materials and obstructions encountered.

# 3.5 STABILITY OF EXCAVATIONS

- A. Comply with local codes, ordinances, and requirements of authorities having jurisdiction to maintain stable excavations.
- B. Slope sides of excavation to comply with local codes, ordinances, and requirements of authorities having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.

C. Shoring and bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces in good serviceable condition. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Extend shoring and bracing as excavation progresses.

# 3.6 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within tolerance of plus or minus <sup>1</sup>/<sub>2</sub> inches. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspection.
  - 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
  - 2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Appurtenances: Excavate to elevations and dimensions indicated within a tolerance of plus or minus <sup>1</sup>/<sub>2</sub> inches. Do not disturb bottom of excavations intended for bearing surface.

# 3.7 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated cross sections, elevation and grades.

# 3.8 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated slopes, lines, depths, and invert elevations.
  - 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe conduit, unless otherwise indicated.
  - 1. Clearance: 12 inches each side of pipe or conduit.
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels, of pipes and for joints, fittings, and bodies of conduits. Remove stones and sharp objects to avoid point loading.
  - 1. For pipes or conduit less than 6 inches in nominal diameter and flat-bottomed, multipleduct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
  - 2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill. At each pipe joint, dig bell holes to relieve pipe bells of loads and ensure continuous bearing of pipe barrel on bearing surface.

# 3.9 UNAUTHORIZED EXCAVATION

A. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top

elevation. Lean concrete fill or crushed stone may be used to bring elevations to proper position, when acceptable to Architect.

- B. In locations other than those above, backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by the Architect.
- 3.10 APPROVAL OF SUBGRADE
  - A. Notify Engineer when excavations have reached required subgrade.
  - B. When Engineer determines that unforeseen unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
    - 1. Unforeseen additional excavation and replacement material will be paid according to the Contract provisions for changes in Work.
  - C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Engineer.

# 3.11 STORAGE OF SOIL MATERIALS

- A. Stockpile excavated materials acceptable for backfill and fill soil materials, including acceptable borrow materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent wind-blown dust.
  - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

# 3.12 BACKFILL

- A. Backfill excavations promptly, but not before completing the following:
  - 1. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
  - 2. Surveying locations of underground utilities for record documents.
  - 3. Testing, inspecting, and approval of underground utilities.
  - 4. Concrete formwork removal.
  - 5. Removal of trash and debris from excavation.
  - 6. Removal of temporary shoring and bracing, and sheeting.
  - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

# 3.13 UTILITY TRENCH BACKFILL

- A. Place and compact bedding course on unyielding bearing surface and to fill unauthorized excavations. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- B. Concrete backfill trenches that carry below or pass under footings and that are excavated within 18 inches of footings. Place concrete to level of 4 inches above bottom of footings.
- C. Provide 4 inch thick concrete base slab support for piping or conduit less than 30 inches below surface of roadways. After installation and testing, completely encase piping or conduit in a

minimum 4 inches of concrete before backfilling or placing roadway subbase.

- D. Place and compact initial backfill of satisfactory soil material or subbase material, free of particles large than 1 inch, to a height of 12 inches over the utility pipe or conduit.
  - 1. Carefully compact material under pipe haunches and bring backfill evenly up to both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
- E. Coordinate backfilling with utilities testing.
- F. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.
- G. Place and compact final backfill of satisfactory soil material to final subgrade.
- H. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

# 3.14 BUILDING SLAB DRAINAGE COURSE

- A. General: Drainage course consists of placement of drainage fill material, in layers of indicated thickness, over subgrade surface to support concrete building slabs.
- B. Placing: Place drainage fill material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting material during placement operations.
  - 1. Provide minimum 12 inches of drainage fill below all slabs. Drainage fill shall be an evenly graded mixture of natural or crushed gravel or crushed stone and natural sand with 100 percent passing a 1-1/2 inch sieve and less than 5 percent passing a No. 50 sieve. Place in a single layer and compact. Place in multiple layers if over 6 inches thick. Overlay fill with vapor barrier below all slabs.

# 3.15 SUBSURFACE DRAINAGE BACKFILL

- A. Subsurface Drain: Place a layer of filter fabric around perimeter of drainage trench or at footing, as indicated. Place a 6 inch compacted course of filtering material on filter fabric to support drainage pipe. After installing and testing, encase drainage pipe in a minimum of 6 inches of compacted filtering material and wrap in filter fabric, overlapping edges at least 6 inches.
- B. Impervious Fill: Place and compact impervious fill material for top 12" to final subgrade.

# 3.16 FILL

- A. Preparation: Remove vegetation, topsoil, debris, wet, and unsatisfactory soil materials, obstruction, and deleterious materials from ground surface prior to placing fills.
  - 1. Plow strip, or break up sloped surface steeper than 1 vertical 4 horizontal so fill material will bond with existing surface. Compact all surfaces with a minimum 10-ton smooth drum

or sheepfoot roller.

- B. When subgrade or existing ground surface to receive fill has density less than required for fill, break up ground surface to depth required, pulverize, moisture-condition or aerate soil and recompact to required density.
- C. Place fill material in layers to required elevations for each location listed below.
  - 1. Under grass, use satisfactory excavated or borrow soil material.
  - 2. Under walks, pavements, and footings use subbase or base material, or satisfactory excavated or borrow soil material.
  - 3. Under steps and ramps, use subbase material.
  - 4. Under piping and conduit and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation. Shape excavation bottom to fit bottom 90 degrees of cylinder.

# 3.17 MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 3 percent of optimum moisture content.
  - 1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
  - 2. Remove and replace, or scarify and air-dry satisfactory soil material that is too wet to compact to specified density.
    - a. Stockpile or spread and dry removed wet satisfactory soil material.

# 3.18 COMPACTION

- A. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill materials evenly on all sides of structures to required elevations to prevent wedging action. Place backfill and fill uniformly along the full length of each structure.
- C. Control soil and fill compaction, providing minimum percentage of density specified for each area classification indicated below. Correct improperly compacted areas or lifts as directed by Architect if soil density tests indicate inadequate compaction.
- D. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum dry density according to ASTM D-1557 (AASHTO T-180) (Modified Proctor):
  - 1. Under structures, building slabs, steps and top 12 inches of pavement subgrade, compact the to 95 percent maximum density.
  - 2. Under walkways and pavements compact each layer of backfill or fill material at 90 percent maximum density.
  - 3. Under lawn or unpaved areas, compact the top 6 inches below subgrade and each layer of backfill or fill material at 85 percent maximum density.

- E. Proofroll all areas which are to receive pavements and slab-on-grade for the proposed school building with vehicle having a minimum axle load of 20 tons. Unsuitable materials shall be removed and replaced with new compacted fill.
- F. When existing ground surface has a density less than that specified under "Compaction" for particular area classification, break up ground surface, pulverize, moisture-condition to optimum moisture content, and compact to required depth and percentage of maximum density.

# 3.19 GRADING

- A. General: Uniformly grade areas to a smooth surface free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
  - 1. Provide a smooth transition between existing adjacent grades and new grades.
  - 2. Cut out soft spots, fill low spots, and trim high spots to conform to required surface tolerances.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1.	Lawn or Unpaved Areas:	Plus or minus 2 inches.
2.	Walks:	Plus or minus 2 inches.
3.	Pavements:	Plus or minus 2 inches

- C. Grading Inside Building Lines: Finish subgrade to a tolerance of 2 inches when tested with a 10-foot straightedge.
- 3.20 SUBBASE AND BASE COURSES
  - A. Under pavements and walks, place subbase course material on prepared subgrades. Place base course material over subbases to pavements.
    - 1. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of ASTM D 4254 relative density.
    - 2. Shape subbase and base to required crown elevations and cross-slope grades.
    - 3. When thickness of compacted subbase or base course is 6 inches or less, place materials in a single layer.
    - 4. When thickness of compacted subbase or base course exceed 6 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.
  - B. Pavement Shoulders: Place shoulder along edges of subbase and base course to prevent lateral movement. Construct shoulders at least 12 inches wide of acceptable soil materials and compact simultaneously with each subbase and base layer.

# 3.22 DRAINAGE FILL

- A. Under slabs-on-grade, place drainage fill course on prepared subgrade.
  - 1. Compact drainage fill to required cross sections and thickness,
  - 2. When compacted thickness of drainage fill is 6 inches or less, place materials in a single

layer.

3. When compacted thickness of drainage exceeds 6 inches thick place materials in equal layers, with no layer more than 6 inches thick nor less than 3 inches thick when compacted.

#### 3.23 FIELD QUALITY CONTROL

- A. Testing Agency Service: Allow testing agency to inspect and test each subgrade and each fill or backfill layer. Do not proceed until test results for previously completed work verify compliance with requirements.
  - 1. Perform field-in-place density tests according to ASTM D 1556 (sand cone method) or nuclear method (ASTM D-2922).
    - a. Field-in-place density tests may be performed by the nuclear method according to ASTM D 2922, provided that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM D 1556. With each density calibration check, check the calibration curves furnished with the moisture gages according to ASTM D 3017.
    - b. When field-in-place density tests are performed using nuclear methods, make calibration checks of both density and moisture gages at beginning of work, on each difference type of material encountered, and at intervals as directed by the Engineer.
  - 2. Footing Subgrade: Inspect bearing state at each column footing and at twenty foot intervals in wall footings, at the footing subgrade, to verify required bearing capacity.
  - 3. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, perform at least one field in-place density test for every 2000 sq. ft. or less of paved areas or building slab, but in no case fewer than three tests.
  - 4. Foundation Wall Backfill: In each compacted backfill layer, perform at least one field inplace density test for each 50 feet or less of wall length, but no fewer than two tests along a wall face.
  - 5. Trench Backfill: In each compacted backfill layer, perform at least one field in-place density test for each 50 feet or less of trench, but no fewer than two tests.
- B. When testing agency reports that subgrades, fills, or backfills are below specified density, scarify and moisten or aerate, or remove and replace soil to the depth required, recompact and retest until required density is obtained. Retesting will be paid by the Contractor.

# 3.24 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or lose compaction due to subsequent construction operations or weather conditions.
  - 1. Scarify or remove and replace material to depth directed by the Architect; reshape and recompact at optimum moisture content to the required density.
- C. Settling: Where settling occurs during the Project correction period, remove finished surfacing, backfill with additional approved material, compact, and reconstruct surfacing.

2. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

# 3.25 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Contractor shall remove and dispose of offsite all excess topsoil and/or borrow remaining after final grading has been completed.
  - 1. Remove waste material, including unsatisfactory soil trash, debris, and legally dispose of off the Owner's property.

# **END OF SECTION**

#### **SECTION 31 23 14 - GEOTHERMAL TRENCHES AND BOREHOLES**

#### PART 1 - GENERAL

#### 1.11 SECTION INCLUDES

- A. Drilling boreholes and trenching for ground heat exchanger piping system.
- 1.14 RELATED SECTIONS
  - A. Ground heat exchanger piping system: Section 23 21 16.
  - B. Trenching: Section 23 05 01.
  - C. Unit costs: Division 01.

# 1.20 REFERENCES

- A. International Ground Source Heat Pump Association (IGSHPA):
  - 1. OSU/IGSHPA-2: Closed-Loop/Ground-Source Heat Pump Systems/Installation Guide.

#### 1.30 SUBMITTALS

- A. General: Comply with Division 01 and Section 23 01 01.
- B. Shop drawings: Drilling plan, showing locations determined as shown on drawings, and describing selected method(s) of drilling.

#### 1.40 QUALITY ASSURANCE

- A. Earthwork for the entire geothermal field, including boreholes and horizontal piping, including the header, shall be performed under the supervision of the ground heat exchanger piping system subcontractor.
- B. Well driller shall be licensed to drill wells in Maryland.
- C. Follow instructions of the manufacturer of the pipe and use backfilling methods which protect the piping from damage during installation.
- D. Follow recommendations of OSU/IGSHPA-2 except as specified otherwise.

# 1.51 TEST BORING DRILL LOG INFORMATION

A. A complete copy of the formation thermal conductivity test is provided at the end of this section for reference.

# PART 2 - PRODUCTS

# 2.10 MATERIALS

- A. Bedding for horizontal piping: Sand (natural or crushed) or stone dust, with not more than 8 percent passing a No. 200 (0.075-mm) sieve.
- B. Backfill materials: Specified in Division 23.
- C. Topsoil: Specified in another Section in Division 32.
- D. Spoil: Materials excavated from the trenches and boreholes.
- E. Underground marking tape: Detectable marking tape, 0.005 inch (0.125 mm) thick with solid foil core and laminate with printed film encapsulated in a clear film six inches (152 mm) wide equal to Reef Industries, Inc. "Terra Tape". Provide colors and labeling in accordance with APWA and AASHTO standards. Markings shall be repeated continuously along the entire length, legend appropriate for the line being identified.
- F. Electronic marker system: Four inch (100 mm) diameter marker ball with passive tuned antenna, water-resistant high-density polyethylene shell, and self-leveling deign equal to 3M "ScotchMark Electronic Marker System". Provide color-coding in accordance to APWA standards. Marker balls shall be detectable within five feet vertically of finished grade. Provide hand held device for locating markers.

# PART 3 - EXECUTION

# 3.02 EXAMINATION

- A. Before beginning boring, excavation, or trenching, locate and mark buried utilities.
- 3.41 BOREHOLES (WELLS)
  - A. Before each hole is bored, the borehole assembly shall have been assembled and tested as specified in Section 23 21 16.
  - B. Vertical bores: 5 feet (1.5 m) deeper than the length of the loop, clean edges, and of sufficient diameter to allow the installation of the U-bend assembly and a third pipe for pressure grouting.
    - 1. Bores shall contain no large, sharp, or jagged rocks and no debris.
    - 2. Geothermal test boring required 6-inch steel casing to 185-feet. As a minimum, each borehole indicated on the drawings shall include 185-feet of 6-inch steel casing, permanent or temporary as required by drilling contractor.
  - C. Use wet rotary, mud rotary, or air rotary drilling.
  - D. Borehole assemblies shall be installed and grouted as specified in Section 23 21 16.

# 3.42 BACKFILLING

- A. Do not backfill horizontal piping until sand bed has been installed as shown on drawings.
- B. Backfill with suitable fill materials as specified in Division 23, following manufacturer's instructions to protect piping and piping assemblies from damage.
- C. Spoil may be used for backfilling if it is suitable material, and if used shall be installed at least 7 inches (175 mm) below finished grade.
- D. Stockpile area is shown on the civil drawings.
- E. Install underground marking tape above all horizontal piping locate tape approximately 12 inches (305 mm) below grade.
- F. Install marker balls at the end of each row and every 20 feet in the trench along with horizontal piping. Install prior to backfill, assuring that balls are not more than five feet vertically below finished grade. Provide additional markers at specific locations identified on the drawings.

# 3.43 FINISH GRADING

A. Restore and reestablish grades as shown on civil drawings. Surface layer shall be topsoil no less than 6 inches (152 mm) deep.

# 3.75 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste material including unsatisfactory soil, trash, and debris, and dispose of it off Owner's property.

# END OF SECTION

(Formation Thermal Conductivity Test Follows This Section)



# FORMATION THERMAL CONDUCTIVITY TEST & DATA ANALYSIS

TEST LOCATION

# Lansdowne Elementary School Baltimore, MD

**TEST DATE** August 26-28, 2016

ANALYSIS FOR Allied Environmental Services, Inc. P.O. Box 129 Annapolis Junction, MD 20701 Phone: 301-776-8370 Fax: 301-776-8374

TEST PERFORMED BY Allied Environmental Services, Inc.
# EXECUTIVE SUMMARY

A formation thermal conductivity test was performed at Lansdowne Elementary School at 2301 Alma Road in Baltimore, Maryland. The vertical bore was completed on July 11, 2016 by Allied Environmental Services, Inc. Geothermal Resource Technologies' (GRTI) test unit was attached to the vertical bore on the afternoon of August 26, 2016.

This report provides an overview of the test procedures and analysis process, along with plots of the loop temperature and input heat rate data. The collected data was analyzed using the "line source" method and the following average formation thermal conductivity was determined.

## Formation Thermal Conductivity = 1.35 Btu/hr-ft-°F

Due to the necessity of a thermal diffusivity value in the design calculation process, an estimate of the average thermal diffusivity was made for the encountered formation.

## Formation Thermal Diffusivity $\approx 0.88 \text{ ft}^2/\text{day}$

The undisturbed formation temperature for the tested bore was established from the initial loop temperature data collected at startup.

#### Undisturbed Formation Temperature ≈ 57.2-57.8°F

The formation thermal properties determined by this test do not directly translate into a loop length requirement (i.e. feet of bore per ton). These parameters, along with many others, are inputs to commercially available loop-field design software to determine the required loop length. Additional questions concerning the use of these results are discussed in the frequently asked question (FAQ) section at <u>www.grti.com</u>.

# TEST PROCEDURES

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has published recommended procedures for performing formation thermal conductivity tests in the ASHRAE HVAC Applications Handbook, Geothermal Energy Chapter. The International Ground Source Heat Pump Association (IGSHPA) also lists test procedures in their Design and Installation Standards. GRTI's test procedures meet or exceed those recommended by ASHRAE and IGSHPA, with the specific procedures described below:

**Grouting Procedure for Test Loops** – To ensure against bridging and voids, it is recommended that the bore annulus is uniformly grouted from the bottom to the top via tremie pipe.

**Time Between Loop Installation and Testing** – A minimum delay of five days between loop installation and test startup is recommended for bores that are air drilled, and a minimum waiting period of two days for mud rotary drilling.

**Undisturbed Formation Temperature Measurement –** The undisturbed formation temperature should be determined by recording the loop temperature as the water returns from the u-bend at test startup.

**Required Test Duration –** A minimum test duration of 36 hours is recommended, with a preference toward 48 hours.

Data Acquisition Frequency - Test data is recorded at five minute intervals.

**Equipment Calibration/Accuracy** – Transducers and datalogger are calibrated per manufacturer recommendations. Manufacturer stated accuracy of power transducers is less than  $\pm 2\%$ . Temperature sensor accuracy is periodically checked via ice water bath.

**Power Quality** – The standard deviation of the power should be less than or equal to 1.5% of the average power, with maximum power variation of less than or equal to 10% of the average power.

**Input Heat Rate** – The heat flux rate should be 51 Btu/hr (15 W) to 85 Btu/hr (25 W) per foot of installed bore depth to best simulate the expected peak loads on the u-bend.

**Insulation** – GRTI's equipment has 1 inch of foam insulation on the FTC unit and 1/2 inch of insulation on the hose kit connection. An additional 2 inches of insulation is provided for both the FTC unit and loop connections by insulating blankets.

**Retesting in the Event of Failure** – In the event that a test fails prematurely, a retest may not be performed until the bore temperature is within 0.5°F of the original undisturbed formation temperature or until a period of 14 days has elapsed.

# DATA ANALYSIS

Geothermal Resource Technologies, Inc. (GRTI) uses the "line source" method of data analysis to determine the thermal conductivity of the formation. The line source method assumes an infinitely thin line source of heat in a continuous medium. A plot of the late-time temperature rise of the line source temperature versus the natural log of elapsed time will follow a linear trend. The linear slope is inversely proportional to the thermal conductivity of the medium. When a ubend grouted in a borehole is used to inject heat into the ground at a constant rate in order to determine the average formation thermal conductivity, the test must be run long enough to allow the finite dimensions of the u-bend pipes and the grout to become insignificant. Experience has shown that approximately ten hours is required to allow the error of early test times and the effects of finite borehole dimensions to become insignificant.

In order to analyze real data from a formation thermal conductivity test, the average temperature of the water entering and exiting the u-bend heat exchanger is plotted versus the natural log of elapsed testing time. Using the Method of Least Squares, linear coefficients are then calculated to produce a line that fits the data. This procedure is repeated for various time intervals to ensure that variations in the power or other effects are not producing inaccurate results.

The calculated results are based on test bore information submitted by the driller/testing agency. GRTI is not responsible for inaccuracies in the results due to erroneous bore information. All data analysis is performed by personnel that have an engineering degree from an accredited university with a background in heat transfer and experience with line source theory. The test results apply specifically to the tested bore. Additional bores at the site may have significantly different results depending upon variations in geology and hydrology.

Through the analysis process, the collected raw data is converted to spreadsheet format (Microsoft Excel®) for final analysis. If desired, please contact GRTI and a copy of the data will be made available in either a hard copy or electronic format.

**CONTACT:** Chad Martin Regional Managing Engineer Asheville, NC (828) 225-9166 cmartin@grti.com

# TEST BORE DETAILS (As Provided by Allied Environmental Services, Inc.)

Site Name	Lansdowne Elementary School
Location	Baltimore, MD
Driller	Allied Environmental Services, Inc.
Installed Date	July 11, 2016
Borehole Diameter	8 5/8 inches, 0-185 ft
	6 inches, 185-405 ft
Casing	Permanent 6 inch steel casing to 185 ft
Casing U-Bend Size	Permanent 6 inch steel casing to 185 ft 1 1/4 inch DR-11 HDPE
Casing U-Bend Size U-Bend Depth Below Grade	Permanent 6 inch steel casing to 185 ft 1 1/4 inch DR-11 HDPE 405 ft
Casing U-Bend Size U-Bend Depth Below Grade Grout Type	Permanent 6 inch steel casing to 185 ft 1 1/4 inch DR-11 HDPE 405 ft Baroid Barotherm Gold
Casing U-Bend Size U-Bend Depth Below Grade Grout Type Grout Mixture	Permanent 6 inch steel casing to 185 ft 1 1/4 inch DR-11 HDPE 405 ft Baroid Barotherm Gold 250 lb sand per 50 lb bentonite

## DRILL LOG

FORMATION DESCRIPTION	DEPTH (FT)
Top soil	0'-1'
Red soil	1'-5'
Black soil	5'-7'
Tan clay	7'-14'
Red clay	14'-18'
Purple clay	18'-20'
Tan clay	20'-22'
Gray clay	22'-25'
Light gray clay	25'-38'
Rock layer	38'-47'
Gray clay	47'-50'
Rock layer	50'-51'
Gray clay	51'-65'
Rock layer	65'-66'
Gray clay	66'-100'
Rock layer	100'-101'
Soft red clay	101'-170'
Gravel	170'-173'
Med hard red clay	173'-180'
Med hard gray rock	180'-405'

Note: Bore produced 10 gpm water at 50 ft; 12 gpm at 100 ft.



## THERMAL CONDUCTIVITY TEST DATA

FIG. 1: TEMPERATURE & HEAT RATE DATA VS TIME

Figure 1 above shows the loop temperature and heat input rate data versus the elapsed time of the test. The temperature of the fluid supplied to and returning from the U-bend are plotted on the left axis, while the amount of heat supplied to the fluid is plotted on the right axis on a per foot of bore basis. In the test statistics below, calculations on the power data were performed over the analysis time period listed in the Line Source Data Analysis section.

#### SUMMARY TEST STATISTICS

Test Date	August 26-28, 2016
Undisturbed Formation Temperature	Approx. 57.2-57.8°F
Duration	43.1 hr
Average Voltage	241.1 V
Average Heat Input Rate	34,065 Btu/hr (9,981 W)
Avg Heat Input Rate per Foot of Bore	84.1 Btu/hr-ft (24.6 W/ft)
Calculated Circulator Flow Rate	10.0 gpm
Standard Deviation of Power	0.15%
Maximum Variation in Power	0.31%



# LINE SOURCE DATA ANALYSIS

FIG. 2: TEMPERATURE & HEAT RATE VS NATURAL LOG OF TIME

The loop temperature and input heat rate data versus the natural log of elapsed time are shown above in Figure 2. The temperature versus time data was analyzed using the line source method (see page 3) in conformity with ASHRAE and IGSHPA guidelines. A linear curve fit was applied to the average of the supply and return loop temperature data between 10 and 35.0 hr. The slope of the curve fit was found to be 4.95. The resulting thermal conductivity was found to be **1.35 Btu/hr-ft-°F**.

# THERMAL DIFFUSIVITY

The reported drilling log for this test borehole indicated that the formation consisted of soil, clay, gravel, and gray rock. Based on the USGS geologic map the rock was assumed to be gneiss. A heat capacity value for gneiss was calculated from specific heat and density values listed by Kavanaugh and Rafferty (Ground-Source Heat Pumps - Design of Geothermal Systems for Commercial and Institutional Buildings, ASHRAE, 1997). A weighted average of heat capacity values based on the indicated formation was used to determine an average heat capacity of 36.8 Btu/ft<sup>3</sup>-°F for the formation. A diffusivity value was then found using the calculated formation thermal conductivity and the estimated heat capacity. The thermal diffusivity for this formation was estimated to be  $0.88 \text{ ft}^2/\text{day}$ .



# CERTIFICATE OF CALIBRATION

GRTI maintains calibration of the datalogger, current transducer and voltage transducer on a regular schedule. The components are calibrated by the manufacturer using recognized national or international measurement standards such as those maintained by the National Institute of Standards and Technology (NIST).

FTC Unit	220

DA Unit 33

PRIMARY EQUIPMENT			
COMPONENT	CALIBRATION DATE	CALIBRATION DUE DATE	
Datalogger	8/19/2015	8/19/2018	
Current Transducer	8/24/2015	8/24/2018	
Voltage Transducer	8/24/2015	8/24/2018	

GRTI periodically verifies the combined temperature sensor/datalogger accuracy via an ice water bath. Temperature readings are simultaneously taken with a digital thermometer that has been calibrated using instruments traceable to NIST.

DATE	8/28/2015		
THERMOCOUPLE 1 (°F)	31.8 31.9 31.9		
THERMOCOUPLE 2 (°F)	31.8 31.8 31.8		
THERMOCOUPLE 3 (°F)	31.9 31.8 31.8		
THERMOCOUPLE 4 (°F)	31.8 31.8 31.9		
DIGITAL THERMOMETER (°F)	32.0 32.0 32.0		

## SECTION 31 25 00 – SOIL EROSION AND SEDIMENT CONTROL

#### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. General Conditions of the Baltimore County Board of Education's Specifications for Site Development.
- C. Baltimore County Department of Public Works "Standard Details for Construction" dated 2007 and as amended.
- D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.
- E. Maryland Department of the Environment, "Erosion and Sediment Control Guidelines for State and Federal Projects", dated December 2011, and addenda thereto.
- F. Baltimore County Soil Conservation District "2012 Urban Policy and Guidelines Manual", dated 2012 and as amended.

#### 1.2 SUMMARY

A. The extent of soil erosion and sediment control facilities is shown on the Erosion and Sediment Control Plans, approved by the Baltimore County Soil Conservation District.

#### 1.3 QUALITY ASSURANCE

- A. Comply with local codes where applicable and the requirements of all permits.
- B. Comply with the provisions outlined in Division 1.

## PART 2 PRODUCTS

## 2.1 MATERIALS REQUIREMENTS

A. Material requirements are specified on the drawings.

## PART 3 EXECUTION

## 3.1 GENERAL

A. Installation of the soil erosion and sediment control facilities shall be as shown and specified on

the Sediment/Erosion Control Plans and Detail sheets C-6.1 through C-6.12of the Contract Drawings.

- 3.2 TIMING
  - A. All perimeter control shall be installed and approved by the Sediment Control Inspector as specified in the "Sequence of Construction" on sheet C-6.7 of the Contract Drawings.

#### 3.3 MAINTENANCE

- A. All soil erosion and sediment control measures shall be maintained continuously during the construction period.
- B. Soil erosion and sediment control measures shall be inspected daily, and any measure which has been disturbed or damaged shall be repaired and restored to operating condition in accordance with the approved plan before the end of each work day.

#### 3.4 REMOVAL

A. Soil erosion and sediment control measures shall not be removed until the removal has been authorized by the Sediment Control Inspector.

## **END OF SECTION**

## SECTION 31 32 13.16 - CEMENT SOIL STABILIZATION

#### PART 1 GENERAL

#### 1.1 SECTION INCLUDES

- A. Description. Soil cement treatment shall consist of pulverizing and mixing existing asphalt pavement or subgrade soils with Portland cement, soil and water to produce a dense, hard, cement treated base. It shall be proportioned, mixed, placed, compacted, and cured in accordance with this specification, and shall conform to the lines, grades, and thicknesses as shown on the plan.
- B. Quantity and Location: Contractor to include a total of 5000 square yards to be located in the field during construction.

## 1.2 REFERENCE STANDARDS

- A. ASTM C150/C150M Standard Specification for Portland Cement; 2015.
- B. ASTM D558 Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures; 2011.
- C. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method; 2007.
- D. ASTM D1633 Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders; 2000 (reapproved 2007).

## 1.3 SUBMITTALS

- A. See Section 01 30 00 Administrative Requirements, for submittal procedures.
- B. Submit mix design and materials mix ratio that will achieve specified requirements.
- C. Test reports on compressive strength of mix.

#### 1.4 FIELD CONDITIONS

A. Do not install mixed materials in wind in excess of 10 mph or when temperature is below 40 degrees F.

## PART 2 PRODUCTS

## 2.1 MATERIALS

- A. Base Material. Shall consist of the existing asphalt pavement or subgrade soils. The subgrade material shall not contain roots, topsoil, or any material deleterious to its reaction with cement. The maximum size of the processed material shall be less than 3 inches.
- B. Mix Design Obtain samples to the specified depth and perform appropriate testing to establish mix design. Submit mix design to the owner for approval one week before the planned start of work. Approval of the mix design by the owner is solely for monitoring quality control and in no way releases the Contractor from his responsibilities.
  - 1. Mix Design Development Samples must be obtained inclusive of the depth to be treated. Sampled materials must be properly processed and prepared to closely simulate field conditions. A Qualified Technical Representative will analyze the samples and provide the following information as part of the mix design to the owner:
    - a. Location of samples.
    - b. Thickness and description of existing pavement and aggregate layers to be reclaimed as necessary.

- c. A selected matrix of soils testing standards.
  - 1) Moisture Content AASHTO T265
  - 2) Mechanical and Hydrometer Particle Size Analysis of Soils AASHTO T88-90
  - 3) Liquid Limit, Plastic Limit AASHTO T89
  - 4) Unconfined Compression AASHTO T208 To be performed only if more than 20% of the underlying subgrade is to be included in the Portland Cement stabilized layer.
  - 5) Moisture-density test AASHTO T-99 or ASTM D-698
- C. Portland Cement. Shall comply with the latest specifications for portland cement (ASTM C 150, ASTM C 1157, or AASHTO M 85).
- D. Water. Shall be free from substances deleterious to the hardening of the cement-treated material.

## PART 3 EXECUTION

- 3.1 EQUIPMENT
  - A. Description. Soil cement shall be constructed with any machine or combination of machines or equipment that will produce a satisfactory product meeting the requirements for pulverization, cement and water application, mixing, compacting, finishing, and curing as provided in this specification.
  - B. Mixing Methods. Mixing shall be accomplished in place, using single-shaft or multiple-shaft mixers. Agricultural disks or motor graders are not acceptable for mixing.
  - C. Cement Proportioning. Spreading of the portland cement shall be done with a spreader truck designed to spread dry particulate such as portland cement to insure a uniform distribution. Spreaders or distributors used shall be able to demonstrate a consistent and accurate application rate, as well as dust control during application The mechanical cement spreader shall be capable of dispensing a measured quantity of cement +/- 3 lbs per square yard in advance of the pulverizor just prior to each pass of the stabilizing operation. The pulverizor shall abut or slightly overlap (1/2") previous pass to ensure a continuous homogeneous mass of granular material and cement. Cement spreader does not have to abut or overlap previous pass as long as the calculated quantity of cement is dispersed in front of the pulverizor.
  - D. Application of Water. Water may be applied through the mixer or with water trucks equipped with pressure-spray bars.
  - E. Compaction. The processed material shall be compacted with one or a combination of the following: vibratory sheepfoot roller, pneumatic-tire roller, smooth drum vibratory roller, jumping jack, or vibrating-plate compactor. The mixed soils shall be rolled with a vibratory sheepfoot roller and a vibratory steel smooth drum compactor.

## 3.2 CONSTRUCTION REQUIREMENTS

- A. Preparation. Prior to the start of the soil cement operation, all utilities and drainage systems shall be checked first and milling be performed according to the drawings.
  - 1. Methods, equipment, tools, and any machinery to be used during construction shall be approved by the Engineer prior to the start of the project. Prior to the actual reclaiming, drop inlets or catch basins that might be affected shall be sufficiently barricaded to prevent reclaimed base material, silt or runoff from plugging the drainage system.
  - 2. Sufficient surface drainage must be provided for each stage of construction so that ponding does not occur on the reclaimed sub-base course prior to the placement of bituminous concrete.

- 3. Soil cement shall be accomplished by means of a self-propelled, traveling rotary reclaimer or equivalent machine capable of tilling to a depth of at least 15 inches with one pass. The machine shall be equipped with an adjustable grading blade leaving its path generally smooth for initial compaction.
- 4. A motor grader shall be used for shaping, fine grading, and finishing the surface of the reclaimed material or any other granular materials placed to form the surface prior to paving. Loader is not acceptable for final grading.
- 5. Any surface irregularities which develop during or after the above described work shall be corrected until it is brought to a firm and uniform surface satisfactory to the Engineer.
- B. Mixing and Placing. A mix thickness of 12 inches shall be conducted. Soil cement processing shall not commence when the soil aggregate or sub-grade is frozen, or when the air temperature is below 40°F (4°C). Moisture in the subgrade soils at the time of cement application shall not exceed the quantity that will permit a uniform and intimate mixture and shall be within 3 % of the optimum moisture content for the processed material at start of compaction.
  - 1. The operation of cement application, mixing, spreading, compacting, and finishing shall be continuous and completed within 3 hours from the start of mixing. Any processed material that has not been compacted and finished, shall not be left uncompacted for longer than 1 hr.
- C. Scarifying. Before cement is applied, initial pulverization or scarification may be required to the full depth of mixing. Scarification or pre-pulverization is a requirement for the following conditions:
  - 1. When the processed material is more than 3% above or below optimum moisture content.
  - 2. When the material is below optimum moisture content, however, water shall be added. The pre-pulverized material shall be sealed and properly drained at the end of the day or if rain is expected.
- D. Application of Cement. The specified quantity of cement shall be applied uniformly in a manner that minimizes dust and is satisfactory to the engineer. If cement is applied as a slurry, the time from first contact of cement with water to application on the soil shall not exceed 60 minutes. The time from cement placement on the soil to start of mixing shall not exceed 30 minutes. A cement content of 5% by weight shall be used for this project.
  - 1. Mixing. Mixing shall begin as soon as possible after the cement has been spread and shall continue until a uniform mixture is produced. The final pulverization test shall be made at the conclusion of mixing operations. Mixing shall be continued until the product is uniform in color, meets gradation requirements, and is at the required moisture content throughout. The entire operation of cement spreading, water application, and mixing shall result in a uniform pulverized asphalt, soil, cement, and water mixture for the full design depth and width.
- E. Compaction. The processed material shall be uniformly compacted to a minimum of 95% of maximum density according to ASTM D-698. Field density of compacted material can be determined by nuclear method in the direct transmission mode (ASTM D 2922, AASHTO T 310) and sand cone method (ASTM D 1556, AASHTO T 191). Optimum moisture and maximum density shall be determined prior to start of construction and also in the field during construction by a moisture-density test (ASTM D 558 or AASHTO T 134).
  - 1. At the start of compaction, the moisture content shall be within 2% of the specified optimum moisture. No section shall be left undisturbed for longer than 1 hr during compaction operations. All compaction operations shall be completed within 3 hours from start of mixing.

- F. Finishing. As compaction nears completion, the surface of the soil cement material shall be shaped to the specified lines, grades, and cross sections. If necessary or as required by the engineer, the surface shall be lightly scarified or broom-dragged to remove imprints left by equipment or to prevent compaction planes. Compaction shall then be continued until uniform and adequate density is obtained.
  - 1. During the finishing process the surface shall be kept moist by means of water spray devices that will not erode the surface. Compaction and finishing shall be done in such a manner as to produce a dense surface free of compaction planes, cracks, ridges, or loose material. All finishing operations shall be completed within 4 hours from start of mixing.
- G. Curing. Finished portions of the soil cement base that are traveled on by equipment used in constructing an adjoining section shall be protected in such a manner as to prevent equipment from marring or damaging completed work.
  - 1. After completion of final finishing, the surface shall be cured by application of a bituminous or other approved sealing membrane, or by being kept continuously moist for a period of 3 days with a water spray that will not erode the surface of the soil cement base. If curing material is used, it shall be applied as soon as possible, but not later than 24 hours after completing finishing operations. The surface shall be kept continuously moist prior to application of curing material.
  - 2. For bituminous curing material, the FDR base surface shall be dense, free of all loose and extraneous materials, and shall contain sufficient moisture to prevent excessive penetration of the bituminous material. The bituminous material shall be uniformly applied to the surface of the completed cement treated material.
  - 3. Should it be necessary for construction equipment or other traffic to use the bituminous-covered surface before the bituminous material has dried sufficiently to prevent pickup, sufficient sand cover shall be applied before such use.
  - 4. Sufficient protection from freezing shall be given the cement-treated material for 3 days after its construction or as approved by the engineer. Contractor assumes all materials and costs to keep soil cement base moist for a period of three (3) days, or until the asphalt base is applied.
- H. Traffic. Completed portions of soil cement base can be opened immediately to light traffic and to light construction equipment, provided the curing material or moist curing operations are not impaired, and provided the soil cement base is sufficiently stable to withstand marring or permanent deformation. The section can be opened up to all traffic after the soil cement base has received a curing compound or subsequent surface and is sufficiently stable to withstand marring or permanent deformation. If continuous moist curing is employed in lieu of a curing compound or subsequent surfacing within 3 days, the soil cement base can be opened to all traffic after the 3-day moist curing period, provided the soil cement base has hardened sufficiently to prevent marring or permanent deformation.
- I. Proofrolling. On the next day of completed FDR, the treated subgrade shall be carefully examined by the Engineer. If cracks or unstable subgrade is observed, the damaged portions shall be removed and replaced with stone base or asphalt base.
- J. Surfacing. Subsequent pavement layers (asphalt, chip-seal, or concrete) can be placed after 7 day curing period when the soil-cement is sufficiently stable to support the required construction equipment without marring or permanent distortion of the surface.
- K. Maintenance. The contractor shall maintain the cement-treated material in good condition until all work is completed and accepted. Such maintenance shall be done by the contractor at his own expense.

1. Maintenance shall include immediate repairs of any defects that may occur. If it is necessary to replace any processed material, the replacement shall be for the full depth, with vertical cuts, using either cement-treated material or asphalt. No skin patches will be permitted.

## 3.3 INSPECTION AND TESTING

- A. Description. The contractor shall assist the testing company to perform the testing work to ensure the conformance of the work to the contract documents. These inspections and tests may include, but shall not be limited to:
  - 1. Mixing operations including drum speed, yield monitoring, monitoring treatment depth, procedures for avoiding recycling and curing in inclement weather, methods to ensure that segregation is minimized, procedures for mix design modification, grading and compacting operations, and cement application procedure.
  - 2. Density testing of the compacted soil cement shall be performed using the nuclear method.
  - 3. Only those materials, machines, and methods meeting the requirements of the contract documents shall be used unless otherwise approved by the engineer.
  - 4. All testing of processed material or its individual components, unless otherwise provided specifically in the contract documents, shall be in accordance with the latest applicable ASTM or AASHTO specifications in effect as of the date of advertisement for bids on the project.

# **END OF SECTION**

## SECTION 31 60 00 - RAMMED AGGREGATE PIERS FOR GROUND IMPROVEMENT

## PART 1 – GENERAL

## 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, geotechnical engineering report and Division 01 Specification Sections, apply to this Section.

## 1.2 SUMMARY

- A. This work includes the following:
  - 1. Furnishing all necessary design, permits, supervision, labor, materials and equipment to perform all work necessary to install subsurface ground improvements by constructing Rammed Aggregate Piers (RAP) in accordance with these specifications and in close conformity with the lines, grades, design, and dimensions shown on the plans or as directed by the Architect.
  - 2. Soil reinforcement shall be performed by constructing RAPs within the in--situ soil or soils, using special high energy impact densification equipment. Mandrel-installed RAP pier locations may be predrilled.
- B. Related Sections include the following:
  - 1. Section 03 20 00 Concrete Reinforcement
  - 2. Section 03 31 00 Cast-in-Place Structural Concrete
  - 3. Section 31 00 00 Earthwork

## 1.3 APPROVED INSTALLERS

- A. Installers shall also be experienced in this type of geotechnical construction work and shall furnish to the Architect for review and acceptance certification that he has a minimum of 5 years of experience with the installation of aggregate piers, has successfully installed RAPs on at least 20 projects of similar size and nature, The RAP Installer's certification shall include the date, location, owner's name and contact information, and quantity of three previous projects.
  - 1. Architect and/or the Owner shall be the final determinant of whether or not the qualifications submitted meet the project requirements. Architect and Owner reserve the right to reject the installer based solely on their individual or joint judgement.

## 1.4 RELATED WORK

- A. The RAP Installer shall furnish all supervision, labor, equipment, materials, and engineering services and certifications necessary to perform all RAP ground improvement work.
- B. The stationing, limits and pattern spacing for the RAP work shall be determined by RAP Installer and shall be reviewed and approved by the project design team. In addition, the RAP Installer shall prepare site specific construction drawings showing specific RAP locations and identification numbers and provide these to the Architect prior to construction.
- C. Spoils Removal Drilling spoils generated by RAP installation shall be removed from the RAP work area in a timely manner and consolidated into a common area and will be removed from the site.
- D. Footing Preparation Reference Section "31 00 00 Earthwork" for measures employed for preparation for the placement of footings.
- E. RAP Protection Reference Section "31 00 00 Earthwork" for measures employed for protection of the RAPs.

- F. RAP Layout The Contractor shall be responsible for the layout and location of RAP supported foundations for this project, including layout of individual RAPs. The piers shall be marked in the field using survey stakes or similar means at locations shown on the drawings submitted by the RAP Installer and approved by the design team.
- G. The Contractor shall be provided copies of all records of site compaction work to verify the suitability of the fill material as structural fill by the Third Party Inspection Agency a minimum of 1 week before the initiation of RAP.

## 1.5 SUBMITTALS

- A. RAP Design Report A complete report describing the size and location of RAPs and Mandrel-Installed RAPs shall be submitted to the Architect, Third Party Inspection Agency, and the project Structural and Geotechnical Engineer at least 21 days prior to the scheduled start of Aggregate Pier production. The report shall include the following:
  - Engineering Calculations The design by the RAP Installer shall consider the bearing capacity and settlement of all footings supported by RAPs, and shall be in accordance with acceptable engineering practice and these specifications. Detailed calculations shall be prepared by the RAP Installer's Professional Engineer, licensed in the state of Maryland, shall be signed and sealed by the Installer's Engineer, and shall include anticipated loads, design assumptions, and relevant subsurface information. Total allowable settlement shall be less than 1 inch, and the differential settlement shall not be more than ½ inch. The design life of the structure shall be 50 years. The RAP design shall meet the following criteria:
    - a. Maximum allowable bearing pressure shall be 5000 psf for RAP.
    - b. Minimum pier depth below bottom of footing shall be 8 feet.
    - c. Actual design depth shall be as required to meet the project design criteria.
    - d. Minimum RAP to spread footing area ratio shall be 0.1.
    - e. Maximum RAP to spread footing area ratio shall be 0.4.
    - f. All RAPs installed shall fully penetrate the uncontrolled fill or soft soils as detailed in the geotechnical report.
    - g. RAP design analysis shall consider adjacent footing stress.
    - h. RAP design analysis shall consider any stresses imposed by new fill placed on and/or adjacent to the site
  - 2. RAP Installation and Location Drawing Drawings shall be signed and sealed by the Installer's Professional Engineer licensed in the State of Maryland and shall include the following information:
    - a. Aggregate pier numbering.
    - b. Dimensioned aggregate pier locations relative to building column grid as defined in contract drawings. Include layout of piers beneath footings.
    - c. Length of aggregate piers. Include cut off elevation.
    - d. Aggregate pier diameter.
    - e. Aggregate pier design load (compression and tension).
    - f. Identification of uplift aggregate piers.
  - 3. Modulus Test Requirements A minimum of one modulus test for compression piers is required. Actual number shall be as submitted by the RAP Installer and approved by the design team. A modulus test schedule shall be prepared for each modulus test, based on the project requirements. The proposed modulus test location shall be shown on the shop drawings

- 4. Modulus Test Report Once the modulus test(s) is(are) authorized and performed a report of modulus test results shall be submitted no later than five (5) working days after completion of the modulus test.
- 5. Provide Work Plan including schedule, safety plan, and construction quality control plan. The submissions are required prior to the mobilization and start of the work and must be shown in the project schedule.
- B. Daily RAP Progress Reports The Owner's Third Party Inspection Agency shall furnish a complete and accurate record of RAP installation to the RAP Installer and Architect within two (2) days of pier installation. The record shall include the pier location, equipment used, elevation of top and bottom of aggregate pier, approximate aggregate tonnage, average diameter and lift thickness for each pier, results of dynamic cone penetrometer tests, flow test (if applicable) and bottom-stabilization tests performed and any pertinent remarks such as elevation of ground water table, and modifications to procedures. A tabular record of the compaction energy (densification time) for each aggregate lift shall be kept for all piers. The date and pier identification shall be kept on each record. Any unusual conditions shall be documented and reported to the Architect immediately. Report must list RAP Installer personnel by position/job class/title and hours worked as part of the report content and information.
- C. Any alternate or optional methods of construction proposed with the RAP design and installation shall be subject to review and acceptance by the Architect and the Owner's Geotechnical Engineer.
- D. Upon completion of the project, submit record drawings showing the locations, depths, and details of construction of the RAPs and/or Mandrel-installed RAPs. The Installer shall provide a summary report of the installation. This report shall be sealed by a professional engineer, registered in the State of Maryland, and shall certify that the installation has been successful and the ground improvements will meet the required design capacities.
- E. Qualification data as specified.
- 1.6 QUALITY ASSURANCE
  - A. The RAP Installer shall have a full-time Quality Control representative to verify and report all QC installation procedures.
  - B. The Owner shall employ a Third Party Inspection Agency, who shall monitor the RAP installation and modulus test and provide Quality Assurance services. The Third Party Inspection Agency shall monitor the installation of all test RAPs to document procedures and criteria used for constructing the test pier(s). The Third Party Inspection Agency shall monitor the installation of RAPs and submit copies of all field reports within two (2) days of field activity to the Architect (including the Structural Engineer and Geotechnical Engineer) for review. The Installer shall adhere to all design requirements, approved submittals, methods, standards, and codes described herein, unless a deviation is submitted to and authorized in writing by the Architect. The Owner's Third Party Inspection Agency shall immediately notify the Architect of any changes made in the field.
  - C. The Geotechnical Engineer of Record, or an approved representative of, shall be notified not less than 24 hours prior to the start of the modulus. Failure to provide proper notification shall cause the work to be rescheduled until such time as the full and proper notice is given by the Installer. If delay in the project occurs as a result of the rescheduled test, the delay shall be fully borne by the Contractor. The Architect or Owner may waive the notice provision on a case by case basis without prejudging or setting precedent for subsequent notice and tests.

#### 1.7 PROJECT CONDITIONS

- A. Test boring logs, laboratory data and geotechnical engineering report prepared by Geotech Engineers, Inc. are not guaranteed to represent all conditions which may be encountered. The RAP Installer shall make their own interpretations of the subsurface conditions which may affect the methods or cost of construction of the work required under this contract.
- B. The Contractor shall use every precaution to prevent damage to areas that are adjoining or included in the site area, and shall repair or replace at their own expense any material or work damaged or destroyed by their forces, while performing the work of this Section.
- C. Protection of Existing Structures: Protect structures, underground utilities, existing Metro tunnel, and other adjoining construction from damage caused by RAP installation operations.
- D. The limits of the working area and acceptable laydown areas will be established to the General Contractor upon request.

#### 1.8 DESIGN REQUIREMENTS - GENERAL

A. The design submitted by the Contractor shall consider the bearing capacity and settlement of all footings supported by aggregate piers, and shall be in accordance with acceptable engineering practice and these specifications. Total and differential settlement shall be considered.

## 1.9 AGGREGATE PIER DESIGN

- A. Aggregate piers shall be designed in accordance with generally accepted engineering practice and the method described in "Control of Settlement and Uplift of Structures Using Short Aggregate Piers", by Every C. Lawton, Nathaniel S. Fox, and Richard L. Handy, reprinted from IN-SITU DEEP SOIL IMPROVEMENT, Proceedings of sessions sponsored by the Geotechnical Engineering Division/ASCE in conjunction with the ASCE National Convention held October 9 - 13, 1994, Atlanta Georgia. The design shall meet the following criteria:
  - 1. Allowable Bearing Pressure for Aggregate Pier Improved Soil; 5,000 (min.) psf
  - 2. Minimum Aggregate Pier Area Coverage (Spread Footings) 30%\*
  - 3. Estimated Total Long-Term Settlement for footings < 1 inch \*
  - 4. Est. Long-Term Differential Settlement for Adjacent Footings < 0.5 inches\*

## 1.10 THIRD PARTY INSPECTION AGENCY QUALIFICATIONS

- A. An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548. Agency shall meet "Recommended Requirements for Independent Laboratory Qualification", published by American Council of Independent Laboratories". Testing and inspections shall be performed under the direction of a Licensed Professional Geotechnical Engineer, registered in the State of Maryland.
- B. Inspector Qualifications:
  - 1. Current Level II certification in geotechnical engineering technology/construction from the National Institute for Certification in Engineering Technologies (NICET).
  - 2. Engineer-in-Training (EIT) with relevant experience.
- C. Cost of the testing to be borne by the Owner.

## PART 2 – PRODUCTS

## 2.1 AGGREGATE

- A. Aggregate used for RAPs constructed above the water table shall be Type I Grade B in accordance with ASTM D-1241-68, or shall be other graded aggregate selected by the RAP Installer approved by the project Geotechnical Engineer of Record and successfully used in the modulus test. It shall be compacted to a densification and strength which provides resistance to the dynamic penetration test (ASTM STP 399) of a minimum average of 15 blows per 1.75 inch vertical movement.
- B. Aggregate used for RAPs constructed below the water table shall be Type II, which is the same as Type I Gradation B, except that there will be no particles passing the No. 40 sieve. Alternately, No. 57 stone or other stone selected by the RAP Installer and approved by the project Geotechnical Engineer of Record and used successfully in the modulus test may be used. Dynamic penetration resistance is inappropriate for this material.Aggregate used for the installation of mandrel-installed RAPs shall be No. 57 stone or shall be other graded aggregate selected by the RAP Installer, successfully used in the modulus test and approved by the project Geotechnical Engineer of Record.
- C. Aggregate used by the RAP Installer shall include approval for appropriateness of use by the RAP design engineer for the RAP system, approval of which shall be provided to the Geotechnical Engineer of Record

## PART 3 - EXECUTION

- 3.1 GENERAL
  - A. Rammed aggregate pier (RAP) ground improvement shall be performed following rough grading of the project site or building pad.
  - B. Mandrel installed RAP's may be pre-drilled if necessary for installation.
  - C. If cave-ins occur during excavation such that the sidewalls of the shaft are deemed to be unstable, a temporary steel casing may be used to stabilize the excavation.
  - D. If cave-ins occur on top of a lift of aggregate such that the volume of the caved soils is greater than 25 percent of the volume of the aggregate in the lift, then the aggregate shall be considered contaminated and shall be removed and replaced with uncontaminated aggregate.

## 3.2 RAMMING AND DENSIFICATION OF AGGREGATE

- A. Special high-energy impact ramming apparatus shall be employed to install the RAP elements for support of foundations. The ramming assembly shall include a 3,500 lb. class hydraulic hammer that imparts vertical ramming energy. The apparatus shall apply direct downward impact ramming energy to each lift of aggregate.
- B. Ramming and densification shall be performed using a beveled rammer foot. The beveled rammer foot is required to improve the matrix soil and to adequately increase the lateral earth pressure in the matrix soil during installation.
- C. A minimum hydraulic hammer CIMA energy level of 3,000 foot-pounds impact energy shall be applied by the energy source. Downward pressure shall be applied to the rammer apparatus during ramming of aggregate with a minimum 22 ton hydraulic excavator.
- D. After drilling of the shaft, the rammer energy shall be applied on the first lift of Type 2 aggregate to form the bottom bulb. After construction of the bottom bulb, Type 1 or Type 2

aggregate shall be rammed in thin lifts in the shaft to the planned top elevation as shown in the drawings.

- E. Well-graded Type 1 aggregate shall be rammed to a density that provides resistance to the dynamic penetration test (ASTM STP 399) of a minimum average of 15 blows per 1.75 inches vertical movement.
- F. Each lift of aggregate shall be rammed for a minimum of 5 to 10 seconds depending on soil conditions.
- G. Aggregate lift thickness shall not exceed 18 inches in loose thickness.
- H. Type 1 aggregate above the water table shall be placed at within 2 percent of optimum moisture content as determined by ASTM D1557. Maximum density determination and curve including optimum moisture content shall be provided prior to the start of RAP installation for each proposed and stockpiled aggregate. Work installed without the appropriate information provided prior to the start of installation may be rejected. If delay in the project schedule occurs as a result of the Installer's failure to provide appropriate information which causes rejection of the work; then the delay shall be fully borne by the Contractor.

## 3.3 MODULUS TEST

- A. Prior to the start of aggregate pier installation, not less than one (1) test RAPs shall be installed within the building pad at a location identified on the shop drawings for the purpose of establishing quality control procedures. The RAP Installer shall furnish a description of installation equipment, installation records, complete test data and analysis of the test data including design parameter values for each test pier. The report shall be prepared under the supervision of a registered Maryland Professional Engineer experienced in this type of geotechnical design and installation. Test piers may not be part of the finished work.
- B. A minimum of one modulus test shall be performed by the RAP Installer, as identified on the plans, to verify the parameter values selected for design. If mandrel-installed RAPs are utilized, perform one modulus test on a RAP and the other on a mandrel-installed RAP. Testing shall be performed to a stress level of 150% of the design stress identified on the plans. A telltale shall be installed at the bottom of all test piers so that bottom-of-pier deflections may be determined. Acceptable performance is indicated when the bottom of the pier deflection is no more than 20% of the top of pier deflection at the design stress level. The modulus test schedule shall be as follows:

Increment	Approximate Load (percent design)	Minimum Duration (minutes)	Maximum Duration (minutes)
Seat	<5	0	N/A
1	17	15	60
2	33	15	60
3	50	15	60
4	67	15	60
5	83	15	60
6	100	15	60
7	117	60	120
8	133	15	60
9	150	15	60
10	100	N/A	N/A
11	66	N/A	N/A

12	33	N/A	N/A
13	0	N/A	N/A

Each load increment shall be held for the minimum duration shown. For each load increment the deflection of the top plate and the bottom plate shall be measured. The top plate shall be located on top of the Aggregate Pier or on top of concrete cast on top of the Aggregate Pier. The bottom plate shall be located within 1 foot of the bottom design depth of the pier. With the exception of the load increment representing approximately 117% of the design maximum top of aggregate pier stress, if the rate of the Aggregate Pier deflection exceeds 0.01 inches per hour, the load shall be held in 15 minute increments until the rate of the Aggregate Pier deflection is less than 0.01 inches per hour (0.0025 inches per 15 minutes), or the maximum duration is reached. The load increment that represents approximately 117% of the design maximum of 4 hours and until the rate of deflection reduces to 0.01 inch per hour or.

- C. Test RAP deflections of each plate shall be measured using a minimum of two dial gauges graduated to 0.001 inches. Dial gauges shall be anchored to the loading jack base, with gauge plungers set on reference beams anchored at least two diameters from the RAP.
- D. A seating load equal to 5 percent of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance. If actual parameters measured do not meet design criteria then piers shall be added and/or lengthened to meet the design criteria at the RAP Installer's expense. All RAPs shall have the minimum modulus specified on the design submittal with less than 1" of settlement under the design stress as identified on the plans.

## 3.4 PRODUCTION PIER ACCEPTANCE TESTING

- A. Bottom stabilization tests shall be performed by the RAP Installer, in the presence of the Owner's Third Party Inspection Agency, on the test piers and subsequently during construction (at least twice per day) or as required by the Architect, to verify adequate pier stabilization and that production piers are comparable in quality to modulus test pier. The Owner's Third Party Inspection Agency shall conduct a minimum of two independent stabilization tests per day. The bottom stabilization test consists of applying tamper energy to the bottom lift of aggregate for the same duration as in the modulus test, turning off the energy source, placing a reference bar over the hole, marking a reference point on tamper shaft, restarting the energy for 15 seconds, turning off the energy source, marking the tamper shaft again at the reference bar and measuring the downward displacement. If the displacement is less than 1.5 times the displacement measured in the approved modulus test for that area, the bottom stabilization test is acceptable. If the displacement exceeds 1.5 times the value measured in the approved modulus test shall be performed until acceptable values are achieved.
- B. Dynamic cone penetrometer testing of piers shall be performed by the RAP installer, in the presence of the Third Party Inspection Agency, on the test piers and subsequently during construction (at least twice per day) or as required by the Architect, to verify sufficient energy is being imparted to the aggregate. The Third Party Inspection Agency shall conduct a minimum of two independent dynamic cone penetrometer tests per day. The dynamic cone penetrometer test consists of a 15 pound mass falling a distance of 20 inches to strike an anvil above a 1.5 inch diameter cone with a 45-degree vertex angle. The "N" value is defined as the number of blows required to produce 1.75 inches of penetration after an initial seating interval

of 2 inches. Standard "E" rods should be used, if necessary, to extend the depth of testing. Alternatively, cone penetrometers may be permitted, with approval of the Architect, provided that they are calibrated on the modulus test pier. Dynamic cone penetrometer testing is not appropriate for No. 57 aggregate.

## 3.5 ALLOWABLE CONSTRUCTION TOLERANCES

- A. The center of each pier shall be within six inches of the locations indicated on the plans. RAP Installer shall provide a method of quality control and verification of installation location as part of the Quality Control Plan.
- B. RAP elements and mandrel-installed RAP elements improperly located or installed beyond the maximum allowable tolerances shall be abandoned or reinstalled with new piers, as required by the Architect on a case-by-case basis. RAP Installer shall submit proposed remedial measures to the Architect for review and approval. RAP Installer shall not proceed with remedial measures without Architect's approval. All material and labor required to replace rejected piers shall be provided at no additional cost to the Owner, unless the cause of the rejection is due to an obstruction.

## **END OF SECTION**

#### SECTION 32 12 00 – FLEXIBLE PAVING

## PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. General Conditions and Section 7 of the Baltimore County Board of Education's Specifications for Site Development.
- C. Baltimore County Department of Public Works Standard Details for Construction dated 2007 and as amended.
- D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

## 1.2 SUMMARY

- A. This Section includes the following:
  - 1. Hot-mix asphalt paving.
  - 2. Hot-mix asphalt patching
  - 3. Hot-mix asphalt overlays.
  - 4. Asphalt surface treatments:
    - a. Fog seals
    - b. Slurries
  - 5. Multi-purpose court seal coating.
  - 6. Pavement-marking paint.
- B. Related Sections:
  - 1. Section 312300: Excavating, Filling & Grading
  - 2. Section 321300: Rigid Paving

## 1.3 SYSTEM DESCRIPTION

- A. Provide hot-mix asphalt pavement according to the materials, workmanship, and other applicable requirements of the Baltimore County Standards and the Standard Specifications for Construction and Materials of the Maryland Department of Transportation, State Highway Administration, latest edition, are hereby by reference made a part of these specifications where applicable.
- B. Bituminous concrete pavement shall consist of aggregate asphalt mixed and constructed in accordance with these specifications and placed to the depth, grade, and cross section shown on the Construction Details.

#### 1.4 SUBMITTALS

- A. Product Data: For each product specified. Include technical data and tested physical and performance properties.
- B. LEED Submittals:
  - 1. Product Data for Credit MR 4: For recycled content materials, documentation indicating percentages of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.
  - 2. Product Data for Credit MR 5: For regional materials, documentation indicating location of manufacture and location of extraction or recovery of primary raw materials. Include statement indicating cost of each product with regional material content.
- C. Job-Mix Designs: For each job mix proposed for the Work.
- D. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate dedicated handicapped spaces with international graphics symbol.
- E. Qualification Data: For firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
- F. Material Test Reports: Indicate and interpret test results for compliance of materials with requirements indicated.
- G. Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.

## 1.5 QUALITY ASSURANCE

- A. Installed Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- B. Manufacture Qualifications: Engage a firm experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-services performance.
  - 1. Firm shall be a registered and approved paving mix manufacturer with the Baltimore County Department of Public Works or with the Maryland State Highway Administration.
- C. Testing Agency Qualifications: The Owner will engage a qualified independent testing agency has the experience and capability to satisfactorily conduct the testing indicated without delaying the Work.
- D. Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt paving work on public property.

- E. Asphalt-Paving Publication: Comply with AI's "The Asphalt Handbook", except where more stringent requirements are indicated.
- D. In the event of a discrepancy between the Project Specifications, Construction Documents, Baltimore County Standard Specifications and Details, or other guidelines set forth by the authorities having jurisdiction the more stringent will apply.

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location and within temperature range required by manufacturer. Protect stored materials from direct sunlight.

## 1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if substrate is wet or excessively damp or if the following conditions are not met:
  - 1. Prime and Tack Coats: Minimum surface temperature of 40 deg F.
  - 2. Slurry Coat: Comply with weather limitations of ASTM D 3910.
  - 3. Asphalt Base Course: Minimum surface temperature of 32 deg F and rising at time of placement.
  - 4. Asphalt Surface Course: Minimum surface temperature of 40 deg F at time of placement.
- B. Pavement-marking Paint: Apply pavement marking on clean, dry surfaces as specified at the manufacturer's recommended ambient, surface and material temperatures.

## PART 2 PRODUCTS

## 2.1 AGGREGATES

- A. General: Use locally available, extracted within 500 mile radius of Project Site, materials and gradation that exhibit a satisfactory record of previous installations. Bituminous concrete shall meet the requirements of the S.H.A. Specifications, Section 904, as later specified herein or as indicated on the drawings.
- B. Coarse Aggregate: Sound, angular crushed stone; crushed gravel; or properly cured, crushed blast-furnace slag, complying with ASTM D 692-88.
- C. Fine Aggregate: Sharp-edged natural sand or sand prepared from stone; gravel, properly cured blast-furnace slag; or combination thereof, complying with ASTM D 1073.
  - 1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.
- 2.2 ASPHALT MATERIALS

- A. Asphalt Cement: ASTM D 3381 for viscosity-graded material, ASTM D 946 for penetrationgraded material.
- B. Undersealing Asphalt: ASTM D 3141, pumping consistency.
- C. Prime Coat: ASTM D 2027; medium-curing cutback asphalt; MC-30, MC-70, or MC-250.
- D. Tack Coat: ASTM D 977, emulsified asphalt.
- E. Water: Portable.

## 2.3 AUXILIARY MATERIALS

- A. Herbicide: Commercial chemical for weed control, registered by Environmental Protection Agency (EPA). Provide granular, liquid, or wettable powder form.
- B. Sand: ASTM D 1073, Grade Nos. 2 or 3.
- C. Paving Geotextile: Nonwoven polypropylene, specifically designed for paving applications, resistant to chemical attack, rot, and mildew.
- D. Pavement-Marking Paint: Latex, waterbased emulsion, ready mix complying with FS-TT-P-1952 F, Type 1.
  - 1. Color: White.
  - 2. Color: Yellow.
  - 3. Color: Blue.
- E. Glass Beads
- F. Aggregate Base Course and fill material per Section 312300 and Bid Documents.
- 2.4 MIXES
  - A. Hot-Mix Asphalt: Provide dense, hot-laid, hot- mix asphalt plant mixes approved by authorities having jurisdiction and complying with the following requirements:
    - 1. Base Course: Hot mix Asphalt Superpave 9.5 mm PG 64-22 Level 2.
    - 2. Surface Course: Hot mix Asphalt Superpave 12.5 mm PG 64-22 Level 2.

## PART 3 EXECUTION

## 3.1 EXAMINATION

- A. Verify that subgrade is dry and in suitable condition to support paving and imposed loads.
- B. Proof-roll subbase using heavy, pneumatic-tired rollers to locate areas that are unstable or that

require further compaction.

C. Notify Architect in writing of any unsatisfactory conditions. Do not begin paving installation until these conditions have been satisfactorily corrected.

## 3.2 COLD MILLING

- A. Clean existing paving surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement, including hot-mix asphalt and as necessary, unboundaggregate base course, by cold milling to grades and cross sections indicated.
  - 1. Repair or replace curbs, manholes, and other construction damaged during cold milling.

## 3.3 PATCHING AND REPAIRS

- A. Patching: Saw cut perimeter of patch and excavate existing pavement section to sound base. Recompact new subgrade. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically.
  - 1. Tack coat faces of excavation and allow to cure before paving.
  - 2. Fill excavation with dense-graded, hot-mix asphalt base mix and, while still hot, compact flush with adjacent surface.
  - 3. Partially fill excavation with dense-graded, hot-mix asphalt base mix and compact while still hot. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.
- B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.
  - 1. Pump hot undersealing asphalt under rocking slabs until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
  - 2. Remove disintegrated or badly broken pavement. Prepare and patch with hot-mix asphalt.
- C. Leveling Course: Install and compact leveling course consisting of dense-graded, hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.
  - 1. Install leveling wedges in compacted lifts not exceeding 3 inches thick.
- D. Crack and Joint Filling: Remove existing filler material from cracks or joints to a depth of <sup>1</sup>/<sub>4</sub> inch. Refill with asphalt joint-filling material to restore watertight condition. Remove excess filler that has accumulated near cracks or joints.
- E. Tack Coat: Apply uniformly to existing surface of previously constructed asphalt or Portland cement concrete paving to surfaces abutting or projecting into new, hot-mix asphalt pavement. Apply at a uniform rate of 0.01 to 0.05 gal./sq. ft. of surface.
  - 1. Allow tack coat to cure undisturbed before paving.
  - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings.

Remove spillages and clean affected surfaces.

## 3.4 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
  - 1. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.
- B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface or compacted-aggregate base before applying paving materials.
  - 1. Mix herbicide with prime coat when formulated by manufacturer for that purpose.
- C. Prime Coat: Apply uniformly over surface of compacted-aggregate base at a rate of 0.15 to 0.50 gal./sq. yd. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure for 72 hours minimum.
  - 1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use just enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
  - 2. Protect primed substrate from damage until ready to receive paving.
  - 3. Prime coat shall be applied at a temperature of  $75^{\circ}$  to  $100^{\circ}$ .

## 3.5 HOT-MIX ASPHALT PLACING

- A. Bituminous concrete shall not be placed when the ambient air and surface temperature is below 40°F. When the surface temperature falls below these limits, material enroute may be placed at the risk of the Contractor.
- B. Apply prime and tack coats when ambient temperature is above 40° F and when temperature has not been below 32° F for 12 hours immediately prior to applications. Do not apply when base is wet or contains an excess of moisture.
- C. Machine place hot-mix asphalt mix on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness, when compacted. Place each course to required grade, cross section, and thickness, when compacted.
  - 1. Place hot-mix asphalt base course in number of lifts and thickness indicated.
  - 2. Place hot-mix asphalt surface course in single lift.
  - 3. Spread mix at minimum temperature of 225 degrees F.
  - 4. Begin applying mix on high side of one-way slopes, unless otherwise indicated.
  - 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- D. Place paving in consecutive strips no less than 10 feet wide, except where infill edge strips of a

lesser width are required.

- 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete asphalt base course for a section before placing asphalt surface course.
- E. Promptly correct surface irregularities in pacing course behind paver. Use suitable hand tools to remove excess material forming high spots. File depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

## 3.6 JOINTS

- A. Construct joints to ensure continuous bond between adjoining paving sections. Construct joints free of depressions with same texture and smoothness as other sections of hot-mix asphalt course.
  - 1. Clean contact surfaces and apply tack coat.
  - 2. Offset longitudinal joints in successive course a minimum of 6 inches.
  - 3. Offset transverse joints in successive course by the length of the paver.
  - 4. Construct transverse joints by bulkhead method or sawed vertical face method as described in AL's "The Asphalt Handbook".
  - 5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
  - 6. Compact asphalt at joints to a density within 2 percent of specified course density.
- B. Longitudinal and transverse joints shall be made in a careful manner.
  - 1. Well bonded and sealed joints are required. If necessary, in order to obtain this result, joints shall be painted with asphalt.
  - 2. Both longitudinal and transverse joints in successive courses shall be staggered so as not to be one above the other.
  - 3. Longitudinal joints shall be staggered a minimum of 6 inches and shall be arranged so that the longitudinal joint in the top course being constructed shall be at the location of the lane dividing the traffic lanes.
- C. Joints between old and new pavements, or between successive days work, shall be carefully made in such a manner as to ensure a thorough and continuous bond between old and new surfaces.
  - 1. In the case of surface courses, the edge of the old and new surface course shall be cut back for its full depth so as to expose a fresh surface.
  - 2. To obtain a well bonded joint, the surface shall be painted with hot asphalt, after which the hot surface mixture shall be placed in contact with it and raked to a proper depth and grade.
  - 3. Before placing the mixture against them, all contact surfaces, of curbs, gutters, headers, manholes, etc., shall be painted with a thin uniform coating of hot asphalt cement or asphalt cement dissolved in Naptha.

## 3.7 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or vibratory-plate compactors in areas inaccessible to rollers.
  - 1. Complete compaction before mix temperature cools below 185 deg F (85 deg C).
- B. Breakdown Rolling: Accomplish breakdown or initial rolling immediately after rolling joint and outside edge. Examine surface immediately after breakdown rolling for indicated grade, and smoothness, Repair surface by loosening displaced material, filling with hot-mix asphalt, and rerolling to required elevations.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling, while hotmix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to an in-place density of 92.0 to 97.0 percent of the maximum density.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while still hot, with back of rake or smooth iron. Compact thoroughly using tamper or other satisfactory method.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials. Remove paving course over are affected and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled to less than 140 ° F or as directed by the Engineer.

## 3.8 INSTALLATION TOLERANCES

- A. Thickness: Compact each course to produce the thickness indicated within the following tolerances:
  - 1. Base Course: Plus or minus 1/2 inch.
  - 2. Surface Course: Plus 1/4 inch, no minus.
- B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
  - 1. Base Course: 1/4 inch
  - 2. Surface Course: 1/8 inch
  - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

## 3.9 SURFACE TREATMENTS

A. Slurry Seals: Apply slurry coat in a uniform thickness according to ASTM D 3910 and allow to

cure.

1. Roll slurry to smooth ridges and provide a uniform, smooth surface.

#### 3.10 PAVEMENT MARKING

- A. Do not apply pavement-marking paint or symbols until layout, colors, and placement have been verified with Architect.
- B. Allow paving to cure per the pavement manufacturer's recommendations before starting pavement marking.
- E. Pavement surfaces shall be dried free of oil, dirt, grease, and other contaminants prior to application of pavement markings. Surfaces not in conformance shall be cleaned by the Contractor to a width of 4 to 6 inches wider than the markings to be applied.
- F. Existing pavement markings that conflict with new or altered traffic pattern shall be completely removed by the Contractor. The method used by the Contractor for removal shall not damage the pavement surface and shall be approved by the Engineer. Any pavement damaged shall be repaired or replaced as determined by the Engineer at no additional cost to the Owner.
- G. Apply paint with mechanical equipment to produce pavement marking of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

## 3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing agency to perform field inspections and tests and to prepare test reports.
  - 1. Testing agency will conduct and interpret tests and state in each report whether tested Work complies with or deviates from specified requirements.
- B. Additional testing, at Contractor's expense, will be performed to determine compliance of corrected Work with specified requirements.
- C. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
- D. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- E. In-Place Density: Samples of uncompacted paving mixtures and compacted pavement will be secured by testing agency according to ASTM D 979.
  - 1. Reference laboratory density will be determined by averaging results from 4 samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D1559, and compacted according to job-mix specifications.
    - a. One core sample will be taken for every 100 sq. yd. or less of installed pavement, but in no case will fewer than 3 cores be taken.

- b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
- F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

# END OF SECTION

#### SECTION 32 13 00 – RIGID PAVING

#### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. General Conditions and Section 5 of the Baltimore County Board of Education's Specifications for Site Development.
- C. Baltimore County Department of Public Works Standard Details for Construction dated 2007 and as amended.
- D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

#### 1.2 SUMMARY

- A. This Section includes exterior Portland cement concrete paving for the following:
  - 1. Curbs and gutters.
  - 2. Walkways.
  - 3. Reinforced Concrete pad
- B. Related Sections:
  - 1. Section 312300: Excavating and Filling
  - 2. Section 03: Cast-in-Place Concrete

## 1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specifications Sections.
- B. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, joint systems, curing compounds, dry-shake finish materials, and others if requested by Architect.
- C. LEED Submittals:
  - 1. Product Data for Credit MR 4: For recycled content materials, documentation indicating percentages of pre-consumer and post-consumer recycled content. Include statement indicating cost of each product with recycled content.
  - 2. Product Data for Credit MR 5: For regional materials, documentation indicating location of manufacture and location of extraction or recovery of primary raw materials. Include statement indicating cost of each product with regional material content.

- D. Design mixes for each class of concrete. Include revised mix proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
- E. Laboratory test reports for evaluation of concrete materials and mix design tests.
- F. Material certificates in lieu of material laboratory test reports when permitted by Architect. Material certificate shall be assigned by manufacturer and Contractor certifying that each material item complies with or exceed requirements. Provide certification from admixture manufacturers that chloride content complies with requirements.

## 1.4 QUALITY ASSURANCE

- A. Concrete Standards: Comply with provisions of the following standards, except where more stringent requirements are indicated.
  - 1. American Concrete Institute (ACI) 301, "Specifications for Structural Concrete for Buildings".
  - 2. ACI 318, "Building Code Requirements for Reinforced Concrete".
  - 3. Concrete Reinforcing Steel Institute (CRSI) "Manual of Standard Practice".
- B. Concrete Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- C. Concrete Testing Service: The Owner will engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixes.

## 1.5 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

## PART 2 PRODUCTS

## 2.1 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other acceptable panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
- B. Form Release Agent: Provide commercial formulation form release agent with a maximum of 350 fL volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

## 2.2 REINFORCING MATERIALS

- A. Reinforcing Bars and Tie Bars: ASTM A 615, Grade 60, deformed.
  - 1. Provide steel with minimum 95 percent recycled content, 60 percent post-consumer.
  - 2. Provide steel manufactured and of primary raw materials extracted or recovered within 500 mile radius of Project Site.

- B. Welded Steel Wire Fabric: ASTM A 185.
  - 1. Furnish in flat sheets, not rolls, unless otherwise acceptable to Architect.
- C. Joint Dowel Bars: Plain steel bars, ASTM A 615, Grade 60. Cut bars true to length with end square and free of burrs.
- D. Hook Bolts: ASTM A 307, Grade A bolts, internally and externally threaded. Design hook bolt joint assembly to hold coupling against pavement form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
- E. Supports for Reinforcement: Chairs, spacers, dowel bar supports, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire fabric, and dowels in place. Use wire bar-type supports complying with CRSI specifications.
  - 1. Use supports with sand plates or horizontal runners where base material will not support chair legs.

## 2.3 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Type I.
  - 1. Use one brand of cement throughout project unless otherwise acceptable to Architect.
  - 2. Mix shall be in accordance with the Portland Association publication #IS174.02T "Concrete for Small Jobs".
  - 3. All concrete shall be 3000 psi, air-entrained  $(5\% \pm 1\%)$  and the proportions by volume shall be in accordance with Table 321300-1, unless otherwise noted.
  - 4. Contractor shall furnish to the Owner delivery tickets for the concrete at the time of delivery.

TABLE 321300-1 PROPORTIONS BY VOLUME				
Maximum Size Coarse Aggregate	Cement	Sand	Aggregate	Water
3/8"	1	2-1/4	1-1/2	1/2
1/2"	1	2-1/4	2	1/2
3/4"	1	2-1/4	2-1/2	1/2
1"	1	2-1/4	2-3/4	1/2
1-1/2"	1	2-1/4	3	1/2

B. Normal-Weight Aggregates: ASTM C 33, Class 4, and as follows: Provide aggregates from a single source.
- 1. Maximum Aggregate Size: 1-1/2 inches
- 2. Do not use fine or coarse aggregates that contain substances that cause spalling.
- 3. Local aggregates not complying with ASTM C33 that have been shown to produce concrete of adequate strength and durability by special tests or actual service may be used when acceptable to Architect.
- 4. Provide aggregate extracted or recovered within 500 mile radius of Project Site.
- C. Water: Potable.

## 2.4 ADMIXTURES

- A. Provide concrete admixtures that contain not more than 0.1 percent chloride ions.
- B. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.
- C. Water-Reducing Admixture: ASTM C 494, Type A.
- D. Products: Subject to compliance with requirements, provide one of the following:
  - 1. Air-Entraining Admixture:
    - a. Air-Tite or Amex 210; Cormix Construction Chemicals.
    - b. Air-Mix or Perma-Air; Euclid Chemical Co.
    - c. Darex AEA or Daravair; W.R. Grace & Co.
    - d. MB-VR or Micro-Air, Master Builders, Inc.
    - e. Sealtight AEA; W.R. Meadows, Inc.
    - f. Sika AER; Sika Corp.
  - 2. Water-Reducing Admixture:
    - a. Chemtard; ChemMasters Corp.
    - b. Type A Services; Cormix Construction Chemicals
    - c Eucon WR-75; Euclid Chemical Co.
    - d. WRDA; W.R. Grace & Co.
    - e. Pozzolith Normal or Polyheed; Master Builders, Inc.
    - f. Metco W.R.; Metalcrete Industries
    - g. Plastocrete 161; Sika Corp.

# 2.5 CURING MATERIALS

- A. Moisture-Retaining Cover: polyethylene sheet material shall have finished product weight of not less than 10 oz. per square yard.
- B. Liquid Membrane-Forming Curing Compound: AASHTO M-148.
- C. Products: Subject to compliance with requirements, provide one of the following:
  - 1. Liquid Membrane-Forming Curing Compound:
    - a. Clear Cure; Anti-Hydro Co., Inc.
    - b. Spartan-Cote; The Burke Co.
    - c. All Resin; Conspec Marketing & Mfg. Co.

- d. Sealco 309; Cormix Construction Chemicals
- e. Day-Chem Cure and Seal; Dayton Superior Corp.
- f. Diamond Clear; Euclid Chemical Corp.
- g. #64 Resin Cure-Clear; Lambert Corp.
- h. L&M Cure R; L&M Construction Chemicals
- i. Masterkure; Master Builders, Inc.
- j. 3100 Series; W.R. Meadows, Inc.
- k. Seal N Kure; Metalcare Industries
- l. Kure-N-Seal; Sonneborn-Chemrex
- m. Horn Clear Seal; Tamms/A.C. Horn

## 2.6 RELATED MATERIALS

- A. Boiled Linseed Oil Mixture: Combination of boiled linseed oil and mineral spirits, complying with AASHTO.
- B. Bonding Agent: Acrylic or styrene butadiene.
- C. Epoxy Adhesive: ASTM C 881, two-component material suitable for dry or damp surfaces. Provide material type, grade, and class to suit requirements.
- D. Products: Subject to compliance with requirements, provide one of the following:
  - 1. Dry-Shake Color Hardener
  - 2. Bonding Agent
    - a. Acrylic Bondcrete; the Burke Co.
    - b. Stringbond; Conspec Marketing and Mfg. Co.
    - c. Day-Chem Ad Bond (J-40); Dayton Superior Corp.
    - d. SBR Latex; Euclid Chemical Co.
    - e. Daraweld C; W.R. Grace & Co.
    - f. Everbond; L&M Construction Chemicals, Inc.
    - g. Acryl-Set; Master Builders, Inc.
    - h. Intralok; W.R Meadows, Inc.
    - i. Acrylpave; Metalcare Industries
    - j. Sonocrete, Sonneborn-Chemrex
    - k. Stonlok LB2; Stonhard, Inc.
    - l. Strong Bond; Symons Corp.
  - 3. Epoxy Adhesive:
    - a. Burke Epoxy M.V.; the Burke Co.
    - b. Spec-Bond 100; Conspec Marketing and Mfg. Co.
    - c. Resi-Bond (J-58); Dayton Superior
    - d. Euco-Epoxy System #452 or #620; Euclid Chemical Co.
    - e. Concresive Standard Liquid; Master Builders, Inc.
    - f. Rezi-Weld 1000; W.R. Meadows, Inc.
    - g. Metco Hi-Mod Epoxy; Metalcrete Industries
    - h. Sikadur 32 Hi-Mod; Sika Corp.
    - i. R-6000 Series; Symons Corp.
    - j. Epoxtite Binder 2390; Tamms/A.C. Horn, Inc.

## 2.7 CONCRETE MIX

- A. Prepare design mixes for each type and strength of normal-weight concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use a qualified independent testing agency for preparing and reporting proposed mix designs.
  - 1. Do not use the Owner's field quality-control testing agency as the independent testing agency.
- B. Proportion mixes according to ACI 211.1 and ACI 301 to provide normal-weight concrete with the following properties:
  - 1. Compressive Strength (28-Day): 3000 psi
  - 2. Maximum Water-Cement Ratio at Point of Placement: 0.45
  - 3. Slump Limit at Point of Placement: 3 inches.
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content as follows with a tolerance of plus or minus 1-1/2 percent.
  - 1. Air Content: 5.5 percent for 1-1/2-inch maximum aggregate.
- D. Fiber Reinforcement: Add to mix at a rate of 1/5 lb per cu. yd., unless manufacturer recommends otherwise.
- E. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, project condition, weather, test results, or other circumstances warrant.

#### 2.8 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94.
  - 1. When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

## 2.9 JOINT MATERIALS

- A. Zip strip control joint manufactured by Superior Featherweight Tools, Inc. or approved equal.
- B. Performed Joint Fillers
  - 1. The cork type shall be in accordance with AASHTO M153.
  - 2. The bituminous fiber type shall be in accordance with AASHTO M213 with the bituminous content determined by AASHTO T164.
  - 3. The weathering test shall be deleted for either type of material.
- C. Roofing paper to be used in construction joints shall be composed of roofing felt saturated and coated on both sides with an asphaltic material. It shall not weight less than 39.8 lbs/square foot

and shall not crack when bent over 1/2 inch radius at room temperature.

# 2.10 JOINT SEALANTS

- A. Compatibility: Sealant fillers and all adjacent materials shall be compatible as demonstrated by sealant manufacturer testing.
- B. Colors Provide color of exposed joint sealants to comply with the following:
  - 1. Match colors of concrete.
- C. Cold Applied Joint Sealants shall be one part, polyurethane-base sealant for concrete pourable, chemically curing elastomeric formulation complying with the following requirements relative to formulation with ASTM C 920 for Type s, Grade NS, Class 25, and Uses indicated.

## 2.11 JOINT SEALANT BACKING

- A. General: Provide sealant backings of material and type that are nonstaining; are compatible with joint substrates; sealants, primers, and other joint fillers, and are approved for applications indicated by sealants manufacturer based on field experience and laboratory testing.
- B. Backer Rods for Cold Applied Sealants: Performed, compressible, resilient, nonwaxing, nonextruding strips of flexible, plastic foam of material indicated below and of size, shape, and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
  - 1. Closed cell polyethylene foam, nonabsorbent to liquid water and gas, and nonoutgassing in unruptured state.
  - 2. Proprietary, reticulated, closed-cell polymeric foam, nonoutgassing, with a density of 2.5 pcf and tensile strength of 35 psi per ASTM D 1623, and with water absorption less than 0.02 gram/cubic centimeter per ASTM C 1083.
  - 3. Either material indicated above.
- C. Bond Breaker Type: Polyethylene tape of other plastic tape as recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint filler materials or joint surfaces at back of joint where such adhesions would result in sealant failure. Provide self-adhesive tape where applicable.

## PART 3 EXECUTION

## 3.1 SURFACE PREPARATION

- A. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Do not begin paving work until such conditions have been corrected and are ready to receive paving.
- B. Remove loose material from compacted subbase immediately before placing concrete.
- 3.2 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for paving to required lines, grades, and elevations. Install forms to allow continuous progress of work and so that forms can remain in pace at least 24 hours after concrete placement
- B. Check completed formwork and screeds for grade and alignment to following tolerances:
  - 1. Top of Forms: Not more than 1/2 inch in 10 feet.
  - 2. Vertical Face on Longitudinal Axis: Not more than 1/2 inch in 10 feet.
- C. Clean forms after each use and coat with form release agent as required to ensure separation from concrete without damage.

# 3.3 PLACING REINFORCEMENT

- A. General: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars" for placing and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain maximum cover to reinforcement.
- D. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh and laces splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

# 3.4 JOINTS

- A. General: Construct contraction, construction, and isolation joints true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to the centerline, unless indicated otherwise.
- B. Contraction joints: Provide weakened-plane contraction joints, sectioning concrete into areas as shown on Drawings. Construct contraction joints for a depth equal to at least 1/4 of the concrete thickness, as follows:
  - 1. Tooled Joints: Form contraction joints in fresh concrete by grooving and finishing each edge of joint with a radiused jointer tool.
  - 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8 inch wide joints into hardened concrete when cutting action will not tear, abrade, or otherwise damage surface and before development of random contraction cracks.
  - 3. Inserts: Form contraction joints by inserting premolded plastic, hardboard, or fiberboard strips into fresh concrete until top surface of strip is flush with paving surface. Radius each joint edge with a jointer tool. Carefully remove strips or caps of two-piece assemblies after concrete has hardened. Clean groove of loose debris.
- C. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than 1/2 hour, unless paving terminates

at isolation joints.

- 1. Provide performed galvanized steel or plastic keyway-section forms or bulkhead forms with key, unless indicated otherwise. Embed keys at least 1-1/2 inches into concrete.
- 2. Continue reinforcement across construction joints unless indicated otherwise. Do not continue reinforcement through sides of strip paving unless indicated.
- 3. Provide tie bars at sides of paving strips where indicated.
- 4. Use bonding agent one existing concrete surfaces that will be joined with fresh concrete.
- D. Isolation Joints: Form isolation joints of preformed joint filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
  - 1. Locate expansion joints at intervals of 40 feet, unless indicated otherwise.
  - 2. Extend joint filler full width and depth of joint, not less than <sup>1</sup>/<sub>2</sub> inch or more than 1 inch below finished surface where joint sealant is indicated. Place top of joint filler flush with finished concrete surface when no joint sealant is required.
  - 3. Furnish joint filler in one-piece lengths for full width being placed wherever possible. Where more than one length is required, lace or clip joint filler sections together.
  - 4. Protect top edge of joint filler during concrete placement with a metal, plastic, or other temporary preformed cap. Remove protection cap after concrete has been placed on both sides of joint.
- E. Walks shall be constructed to match existing concrete at existing road tie-ins.
  - 1. Expansion joints between building and pavement shall be cork.
  - 2. Pavements shall be separated from curbs by a construction joint using felt roofing paper material.
  - 3. "Zip Strip" control joint to be installed at a maximum of 24' and between existing walks and new concrete.
  - 4. Saw cut control joints are not permitted.
  - 5. Install dowel bars and support assemblies at joints where indicated. Lubricate or asphaltcoat one half of dowel length to prevent concrete bonding to one side of joint.

# 3.5 JOINT SEALANT INSTALLATION

- A. Clean out joints before installing joint sealants to comply with recommendations of manufacturer.
- B. Comply with Joint Manufacturer printing installation instructions and recommendations of ASTM C 962 for use of joint sealants.
- C. Immediately after sealant application and prior to time skinning or curing begins, tool sealants to a smooth, uniform bead to eliminate air pockets and to ensure contact and adhesion of sealant with sides of joint.
  - 1. Do not use tooling agent that discolor sealants or adjacent surface or are not approved by the sealant manufacturer.
  - 2. Protect joint sealants during and after curing period from contact with contaminating substances or from damage resulting from construction operations or other causes so they are without deterioration at final acceptance.

## 3.6 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete framework installation, reinforcing steel, and item to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove ice, snow, or frost from subbase surface and reinforcing before placing concrete. Do not place concrete on surfaces that are frozen.
- C. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.
- D. Comply with requirements with ACI 304R for measuring, mixing, transporting, and placing concrete.
- E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
  - 1. When concrete placing is interrupted for more than 1/2 hour, place a construction joint.
- F. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- G. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidation concrete complying with ACI 309R.
  - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcing, dowels, and joint devices.
- H. Screed paved surfaces with a straightedge and strike off. Use bull floats or darbies to form a smooth surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces prior to beginning finishing operations.
- I. Place concrete in two operations; strike off initial pour for entire width of placement and to the required finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.
  - 1. Remove and replace portions of bottom layer of concrete that have been placed more than 15 minutes without being covered by top layer or use bonding agency if acceptable to Architect.
- J. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutter to required cross section, lines, grade, finish and jointing as specified for formed concrete. If results are not acceptable, remove and replace with formed concrete.

- K. Slip Form Pavers: When automatic machine placement is used for paving, submit revised mix design and laboratory test results that meet or exceed requirements. Produce paving to required thickness, lines, grades, finish, and jointing as required for formed paving.
  - 1. Compact subbase and prepared subgrade of sufficient width to prevent displacement of pave machine during operation.
- L. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
- M. Cold Weather Placement: Comply with provision of ACI 306R and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
  - 1. Concrete placement shall begin only when the ambient air and surface temperature is at least  $40 \square F$  and rising and discontinued anytime the temperature falls below  $40 \square F$ . Placing concrete on a frozen base is prohibited.
  - 2. Do not use frozen materials or materials containing ice or snow.
  - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agent or chemical accelerators unless otherwise accepted in mix designs.
- N. Hot Weather Placement: Place concrete complying with ACI 305R and as specified when hot weather conditions exist.
  - 1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 70 □ F. Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to concrete is Contractor's option.
  - 2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperation immediately before embedding in concrete.
  - 3. Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft sport, or dry areas.

# 3.7 CONCRETE FINISHING

- A. Float Finish: Begin floating when bleed water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units. Finish surfaces to true planes within a tolerance of 1/4 inch in 10 feet as determined by a 10-foot-long straightedge placed anywhere on the surface in any direction. Cut down high spots and fill low spots. Refloat surface immediately to a uniform granular texture.
  - 1. Burlap Finish: Drag a seamless strip of damp burlap across concrete, perpendicular to line of traffic, to provide a uniform gritty texture finish.
  - 2. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across concrete surface perpendicular to line of traffic to provide a uniform fine line texture finish.
- B. Final Tooling: Tool edges of paving, gutter, curbs, and joints formed in fresh concrete with a

jointing tool to the following radius. Repeat tooling of edges and joints after applying surface finishes. Eliminate tool marks on concrete surfaces.

1. Radius: 3/8 inch

## 3.8 CONCRETE PROTECTION AND CURING

- A. General: Following texturing and edging, the concrete shall be cured for a minimum of 72 hours. Comply with the recommendations of ACI 306R for cold weather protection and ACI 305R for hot weather protection during curing.
- B. Evaporation Control: In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply according to manufacturer's instruction after screeding and bull floating, but before floating.
- C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
  - 1. Moisture-Curing: Keep surfaces continuously moist for not less than 7 days with the following materials:
    - a. Water.
    - b. Continuous water-fog spray.
    - c. Absorptive cover, water saturated, and keep continuously wet. Cover concrete surfaces and edges with a 12-inch lap over adjacent absorptive covers.
  - 2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
  - 3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.

# 3.9 FIELD QUALITY CONTROL TESTING

- A. The Owner will employ a qualified testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement. Sampling and testing for quality control may include the following:
  - 1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
    - a. Slump: ASTM C 143; one test at point of placement for each compressivestrength test but no less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.
    - b. Air Content: ASTM C 231, pressure method; one test for each compressivestrength test but no less than one test for each day's pour of each type of airentrained concrete.

- c. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is  $40 \square$  F and below and when  $80 \square$  F and above, and one test for each set of compressive-strength specimens.
- d. Compression Test Specimens: ASTM C 31; one set of four standard cylinders for each compressive-strength test, unless directed otherwise. Mold and store cylinders for laboratory-cured test specimens except when field-cured test specimens are required.
- e. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd. But less than 25 cu. yd., plus one set for each additional 50 cu. yd. Test one specimen at 7 days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.
- 2. When frequency of testing will provide fewer than five strength tests for a given class of concrete, conduct testing from at least five randomly selected batches or from each batch if fewer than five are used.
- 3. When total quantity of a given class of concrete is less than 50 cu. yd., Architect may waive strength testing if adequate evidence of satisfactory strength is provided.
- 4. When strength of field-cured cylinders is less than 85 percent of companion laboratorycured cylinders, evaluate current operation and provide corrective procedures for protecting and curing the in-place concrete.
- 5. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test results falls below specified compressive strength by more than 500 psi.
- B. Test results will be reported in writing to Architect, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive strength tests shall contain the Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in paving, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day and 28-day tests.
- C. Nondestructive Testing: Impact hammer sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.
- D. Additional Tests: The testing agency will make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by Architect. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

# 3.10 REPAIRS AND PROTECTION

- A. Remove and replace concrete paving that is broken, damaged, or defective, or does not meet the requirements of this Section.
- B. Drill test cores where directed by Architect when necessary, to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with Portland cement concrete bonded to paving with epoxy adhesive.
- C. Protect concrete from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface

stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep concrete paving not more than 2 days prior to date scheduled for Substantial Completion inspections.

# END OF SECTION

## SECTION 32 31 00 – CHAIN LINK FENCES & GATES

#### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. General Conditions of the Baltimore County Board of Education's Specifications for Site Development.
- C. Baltimore County Department of Public Works Standard Details for Construction dated February 2007 and as amended.
- D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

#### 1.2 DESCRIPTION

- A. This Section includes the following:
  - 1. Galvanized-steel chain link fabric vinyl coated (black)
  - 2. Galvanized-steel framework.

## 1.3 RELATED SECTIONS

- A. Section 312300: Excavating, Filling & Grading
- B. Section 03: Cast-In-Place Concrete

## 1.4 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data in the form of manufacturer's technical data, specifications, and installation instructions for fence and gateposts, fabric, gates, gate operators, and accessories.
- C. Shop drawings showing location of fence, gates, each post, and details of post installation, extension arms, gate swing, hardware, and accessories.
- D. Samples for verification of PVC color in form of 6-inch lengths of actual fabric wire to be used in color selected.
  - 1. Include similar samples of polymer coating applied on posts, rails, and accessories in color selected.

#### 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has at least three years' experience and has completed at least five chain link fence projects with same material and of similar scope to that indicated for this Project with a successful construction record of in-service performance.
- B. Single-Source Responsibility: Obtain chain link fences and gates, including accessories, fittings, and fastenings, from a single source.

#### 1.6 **PROJECT CONDITIONS**

A. Field Measurements: Verify layout information for fences and gates shown on the Drawings in relation to the property survey and existing structures. Verify dimensions by field measurements.

#### PART 2 PRODUCTS

## 2.1 FABRIC

- A. Selvage: Knuckled on both selvages.
- B. Steel Chain-Link Fence Fabric: Fabricated in one-piece widths for fencing 12 feet and less in height to comply with Chain Link Fence Manufacturers Institute (CLFMI) "Product Manual" and with requirements indicated below:
  - 1. Mesh and Wire Size: 1-inch and 2-inch mesh, 0.148-inch diameter (9 gage).
  - 2. Coating: ASTM A 817, Type 2, Class 1, zinc-coated (galvanized) applied after weaving.
  - 3. Finish: Manufacturer's standard thermally bonded polyvinyl chloride (PVC) plastic resin finish over fabric, not less than 10 mil (0.010") thick. Black color complying with ASTM F668, Type 2B.

## 2.2 FRAMING

A. Round member sizes are given in actual outside diameter (OD) to the nearest thousandth of inches. Round fence posts and rails are often referred to in ASTM standard specifications by nominal pipe sizes (NPS) or the equivalent trade sizes in inches. The following indicates these equivalents all measured in inches:

Actual	NPS	Trade
OD	Size	Size
1 215	1	1 2/0
1.315	1	1-3/8
1.660	1-1/4	1-5/8
1.900	1-1/2	2
2.375	2	2-1/2
2.875	2-1/2	3
3.500	3	3-1/2
4.000	3-1/2	4
6.625	6	6-5/8

B. Type I Round Posts: Standard weight (schedule 40) galvanized-steel pipe conforming to ASTM F 1083, according to heavy industrial requirements of ASTM F 669, Group IA, with minimum yield strength of 25,000 psi, not less than 1.8 oz. of zinc per sq. ft. Type A coating inside and outside according to ASTM F 1234, as determined by ASTM A 90, and weights per foot as follows:

Weight	NPS
<u>(lb/ft)</u>	Size
1.68	1
2.27	1-1/8
2.72	1-1/2
3.65	2
5.79	2-1/2
7.58	3
9.11	3-1/2
8.97	6
28.55	8
	Weight ( <u>lb/ft</u> ) 1.68 2.27 2.72 3.65 5.79 7.58 9.11 8.97 28.55

- C. Type II Round Posts: Cold-formed, electric-welded steel pipe conforming to heavy industrial requirements of ASTM F 669, Group IC, with minimum yield strength of 50,000 psi, either protective coating system below according to ASTM F 1234, and weights per foot as follows:
  - 1. Coatings: Type B outside with a minimum of 0.9 oz. of zinc per sq. ft. after welding, a chromate conversion coating and a clear polymer overcoat. Type B inside with a minimum of 0.9 oz. of zinc per sq. ft. or Type D inside with a minimum 0.3-mil-thick, 81-percent zinc-pigmented nominal coating.
  - 2. Coatings: Type C inside and outside with not less than 0.9 oz. of zinc-5 percent aluminum-mischmetal alloy per sq. ft.

Actual OD	Weight (lb/ft)	NPS <u>Size</u>
1.315	1.35	1
1.660	1.84	1-1/4
1.900	2.28	1 - 1/2
2.375	3.12	2
2.875	4.64	2-1/2
3.500	5.71	3
4.000	6.56	3-1/2

D. Roll-Formed Steel: Rolled form steel shapes (e.g., C section) produced from structural-quality steel conforming to ASTM A 570, grade 45, or ASTM A 446, grade D, galvanized, conforming to heavy industrial requirements of ASTM F 669, Group II, with a minimum yield strength of 45,000 psi. Protective coating system according to ASTM F 1234, Type A, hot-dip galvanized with a minimum of 2.0 oz. of zinc per sq. ft. according to ASTM A 123, 4.0 oz. of zinc per sq. ft. according to ASTM A 525; or Type C, a minimum of 1.0 oz. of zinc-5 percent aluminum-mischmetal alloy per sq. ft.

according to ASTM A 875.

- E. Roll-Formed Steel: Hot-rolled steel shape H section with a minimum yield strength of 45,000 psi conforming to ASTM F 669, group III. Protective coating system according to ASTM F 1234, Type A, hot-dip galvanized with a minimum of 2.0 oz. of zinc per sq. ft. of according to ASTM A 123, or 4.0 oz. of zinc per sq. ft. according to ASTM A 525.
- F. Supplemental Color Coating: In addition to above metallic coatings, provide posts and rails with manufacturer's standard polymer coating according to ASTM F 1234, 10-mil minimum polyvinyl chloride (PVC) or 3-mil minimum polyester plastic resin finish applied to exterior surfaces and, except for tubular shapes, to exposed interior surfaces. Color to match chain link fabric.
- G. Top Rails: Manufacturer's longest lengths (17 to 21 feet) with swedged-end or expansion-type coupling, approximately 6 inches long for joining. Provide rail ends or other means for attaching top rail securely to each gate corner, pull, and end post.
  - 1. Roll-Formed Steel: 1.660 inch OD SS40 steel pipe, weighing 1.83 lbs/lf.
- H. Steel Posts:
  - 1. Roll-Formed Line Posts: 2.5-inch OD SS40 hot galvanized, steel pipe, weighing 3.17 lbs/lf.
  - Roll-Formed End, and Corner Posts: 3.0-inch OD SS40 hot galvanized, steel 2. pipe, weighing 4.64 lbs/lf.
- I. Swing Gate Posts: Furnish posts to support single gate leaf, or one leaf of a doublegate installation, according to ASTM F 900, sized as follows for steel pipe posts: 1.
  - Steel posts:
    - Up to and including 6 Feet: 2.875-inch OD pipe weighing at least 5.79 a. lbs/ft.
    - Over 6 to 13 Feet: 4.000-inch OD pipe weighing at least 10.79 lbs/ft. b.

#### 2.3 FITTINGS AND ACCESSORIES

- A. Material: Comply with ASTM F 626. Mill-finished aluminum or galvanized iron or steel to suit manufacturer's standards.
  - 1. Steel and Iron: Unless specified otherwise, hot-dip galvanize pressed steel or cast-iron fence fittings and accessories with at least 1.2 oz. zinc per sq. ft. as determined by ASTM A 90.
- B. Post and Line Caps: Supply cone type caps for terminal post, and loop type for line posts.
- C. Post Brace Assembly: Manufacturer's standard adjustable brace. Use material specified below for brace, and truss to line posts with 3/8-inch-diameter rod and adjustable tightener. Provide manufacturer's standard galvanized-steel cap for each end.
  - Roll-Formed Steel: 1-1/4-by-1-5/8-inch C section weighing a minimum of 1.40 1.

lb per linear ft.

- D. Bottom and Center Rail: Same material as top rail. Provide manufacturer's standard galvanized-steel, cast-iron or cast-aluminum cap for each end.
- E. Tension Bars: High carbon steel with a minimum length 2 inches less than the full height of fabric, a minimum cross section of 3/16 inch, and a minimum of 1.2 oz. of zinc coating per sq. ft. Provide one bar for each gate and end post, and two for each corner and pull post, except where fabric is integrally woven into the post.
- F. Brace Bands: 12 gauge thickness x 3/4 inch wide, pressed steel.
- G. Page self-lock bands 10 inches on center at post and rail. The Contractor shall not make substitutions.
- H. Vinyl Coating
  - 1. Fencing fabric, framing and accessories including ties, posts, rails, gate frames and fasteners shall be vinyl coated at the factory.
  - 2. Color: Black
  - 3. Thickness of vinyl coating:
    - a. Fabric: .006 min., .010 max.; ends of wire shall also be coated.
    - b. Framing: 10 to 14 mils
    - c. Accessories: Wire .018": other accessories 10 to 14 mils
- I. Coating: Polyvinyl chloride continuously and permanently bonded before fabrication by the thermal fusion process under pressure of at least 5000 psi; with the following properties:
  - 1. Specific gravity, ASTM D792-66 (1975): Approximately 1.30
  - 2. Durometer hardness; ASTM D2240-75: Approximately 90
  - 3. Mandrel bend 10 x Mandrel: For vinyl-clad wire, 5 RPM, 5 lb. weight; -20 deg. C
  - 4. Compression cut resistance: 1500 pounds
  - 5. Accelerated aging test, ASTM D1499-64 (1971): 1500 hours
  - 6. Weatherometer test, ASTM G23-69 (1975): 1000 hours without cracking, blistering or loss of adhesion
  - 7. Salt spray (unscored samples), Federal Test Standard 141, Method 6061: 5000 hours without deterioration of coating or metal corrosion
- J. Swing Gates: Comply with ASTM F 900.
  - 1. Steel: Gates up to 10 feet wide (per panel):
    - a. Up to 6 Feet High: Fabricate perimeter frames of 1.660-inch minimum OD Type I or II steel pipe.
    - b. 6 Feet to 10 Feet High: Fabricate perimeter frames of 1.990 inch OD Type I or II steel pipe.
  - 2. Gate Hardware: Provide galvanized hardware and accessories for each gate according to the following:
    - a. Hinges: Size and material to suit gate size, non-lift-off type, offset to permit 180-degree gate opening. Provide 1-1/2 pair of hinges for each leaf over 6-foot nominal height.
    - b. Latch: Forked type or plunger-bar type to permit operation from either

side of gate, with padlock eye as an integral part of latch.

- c. Keeper: Provide a keeper for vehicle gates that automatically engages gate leaf and holds it in the open position until manually released.
- d. Gate Stops: Provide gate stops for double gates consisting of mushroomtype flush plate with anchors, set in concrete, and designed to engage a center drop rod or plunger bar. Include a locking device and padlock eyes as an integral part of the latch, permitting both gate leaves to be locked with a single padlock.

#### PART 3 EXECUTION

#### 3.1 INSTALLATION

- A. General: Install fence to comply with ASTM F 567. Do not begin installation and erection before final grading is completed, unless otherwise permitted.
  - 1. Apply fabric to outside of framework. Install fencing on boundary lines inside of property line established by survey as required by Division 1.
- B. Excavation: Drill or hand-excavate (using post-hole digger) holes for posts to diameters and spacings indicated, in firm, undisturbed or compacted soil.
  - 1. If not indicated on Drawings, excavate holes for each post to minimum diameter recommended by fence manufacturer, but not less than four times the largest cross section of post.
  - 2. Unless otherwise indicated, excavate hole depths approximately 3 inches lower than post bottom, with bottom of posts set not less than 32 inches below finish grade surface.
- C. Setting Posts: Center and align posts in holes 3 inches above bottom of excavation. Space a maximum of 10 feet o.c., unless otherwise indicated.
  - 1. Protect portion of posts above ground from concrete splatter. Place concrete around posts and vibrate or tamp for consolidation. Check each post for vertical and top alignment, and hold in position during placement and finishing operations.
    - a. Unless otherwise indicated, extend concrete footings 2 inches above grade and trowel to a crown to shed water.
- D. Top Rails: Run rail continuously through line post caps, bending to radius for curved runs and at other posts terminating into rail end attached to posts or post caps fabricated to receive rail. Provide expansion couplings as recommended by fencing manufacturer.
- E. Center Rails: Install center rails in one piece between posts and flush with post on fabric side, using rail ends and special offset fittings where necessary.
- F. Bottom Rails: Install center rails in one piece between posts and flush with post on fabric side, using rail ends and special offset fittings where necessary.
- G. Brace Assemblies: Install braces at end and gateposts and at both sides of corner and

pull posts. Locate horizontal braces at midheight of fabric on fences with top rail and at two-thirds fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

- Bottom Tension Wire: Install tension wire within 6 inches of bottom of fabric before stretching fabric and tie to each post with not less than same gage and type of wire. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter (11-gage) hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c.
- I. Top Tension Wire: Install tension wire through post cap loops before stretching fabric. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter (11-gage) hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c.
- J. Fabric: Leave approximately 2 inches between finish grade and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Install fabric on security side of fence, and anchor to framework so that fabric remains under tension after pulling force is released.
- K. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not over 15 inches o.c.
  - 1. Maximum Spacing: Tie fabric to line posts 12 inches o.c. and to rails and braces 24 inches o.c.
- L. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts for added security.

## 3.2 GATE INSTALLATION

A. Install gates plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary. Install gates according to manufacturer's instructions, plumb, level, and secure.

## 3.3 PROJECT CLOSEOUT

A. All materials used for temporary fencing shall remain the property of the Contractor and shall be removed from the Owner's property.

# **END OF SECTION**

#### SECTION 32 90 00 - PLANTING

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. General Conditions and Sections 3 and 12 of the Baltimore County Board of Education's Specifications for Site Development.
- C. Baltimore County Department of Public Works Standard Details for Construction dated 2007 and as amended.
- D. Baltimore County Landscape Manual dated August 7, 2000 and as amended.
- E. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

#### 1.2 SUMMARY

- A. This Section includes the following:
  - 1. Trees
  - 2. Shrubs
  - 3. Ground covers
  - 4. Plants
  - 5. Lawns
  - 6. Sod
  - 7. Topsoil and soil amendments
  - 8. Fertilizers and mulches
  - 9. Stakes and guys
  - 10. Landscape edgings
  - 11. Transplanting of existing trees and shrubs
- B. Related Sections:
  - 1. Section 311000: Site Clearing.
  - 2. Section 312300: Excavating and Filling

## 1.3 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. LEED Submittals:
  - 1. Product Data for Credit MR 5: For regional materials, documentation indicating location of manufacture and location of extraction or recovery of primary raw materials. Include statement indicating cost of each product with regional material

content.

- C. Product certificates signed by manufacturers certifying that their products comply with specified and Department of Agriculture requirements.
  - 1. Manufacturer's certified analysis for standard products.
  - 2. Analysis for other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
  - 3. Label data substantiating that plants, trees, shrubs, and planting materials comply with specified requirements.
- D. Certification of grass seed from seed vendor for each grass-seed mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
  - 1. Certification of each seed mixture for sod, identifying sod source, including name and telephone number of supplier.
- E. Samples of each of the following:
  - 1. 5 lbs. of mineral mulch for each color and texture of stone required for Project, in labeled plastic bags.
  - 2. Edging materials and accessories to verify color selected.
  - 3. Softball Field Infield Mix: Contractor must supply 1 cubic yard of dry weight material of ballfield infield mix, at no cost to the Baltimore County Public Schools to sample. The samples will be used to determine compliance with the specifications. If sample is in compliance with the specifications, Baltimore County Public Schools will provide written approval of acceptance of the ballfield infield mix material. The approved sample of the ballfield infield mix material shall be representative of the quality of material to be provided throughout the contract.
- F. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and address of architects and owners, and other information specified.
- G. Material test reports from qualified independent testing agency indicating and interpreting test results relative to compliance of the following materials with requirements indicated.
  - 1. Analysis of existing surface soil.
  - 2. Analysis of imported topsoil.
- H. Planting schedule indicating anticipated dates and locations for each type of planting.
  Planting schedule shall also include a construction plan and schedule showing locations or locations for storage of trees to be relocated and dates proposed for digging and replanting of trees to be relocated.

I. Maintenance instructions recommending procedures to be established by Owner for maintenance of landscaping during an entire year. Submit before expiration of required maintenance periods.

# 1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced Installer who has completed landscaping work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment.
  - 1. Installer's Field Supervision: Require Installer to maintain an experienced fulltime supervisor on the Project site during times that landscaping is in progress.
- B. Testing Agency Qualifications: To qualify for acceptance, an independent testing agency must demonstrate to Architect's satisfaction, based on evaluation of agency-submitted criteria conforming to ASTM E 699, that it has the experience and capability to satisfactorily conduct the testing indicated without delaying the Work.
- C. Provide number one quality, size, genus, species, and variety of trees and shrubs indicated, complying with applicable requirements of ANSI Z60.1 "American Standard for Nursery Stock."
- D. Topsoil Analysis: Furnish a soil analysis made by a qualified independent soil-testing agency stating that topsoil has an organic content by weight, of not less that 4.0 percent, a ph range of 6.0-7.0, and shall not have soluble salts greater that 500 parts per million. Before delivery the topsoil location shall be made known. Each truckload delivered shall be accompanied with an accurate weight verification delivery ticket.
  - 1. Report suitability of topsoil for growth of applicable planting material. State recommended quantities of nitrogen, phosphorus, and potash nutrients and any limestone, aluminum sulfate, or other soil amendments to be added to produce satisfactory topsoil.
  - 2. Soil Testing is required for every 50 cubic yards of material that will be used on site.
  - 3. Topsoil must be installed within 2 months of testing.
- E. Measurements: Measure trees and shrubs according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches above ground for trees up to 4-inch caliper size, and 12 inches above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.
- F. Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 1 Section "Project Meetings."
- G. Seed Certification: All grass seed shall be certified by the Department of Agriculture and delivered to the site with appropriate tags attached to each seed bag. Tags shall be removed by authorized representative of Baltimore County Public Schools.
- 1.5 DELIVERY, STORAGE, AND HANDLING

- A. No trees or shrubs shall be delivered or planted on the site until all construction is completed, unless approved by the Owner.
- B. Packaged Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site.
- C. Seed: Deliver seed in original sealed, labeled, and undamaged containers.
- D. Sod: Time delivery so that sod will be placed within 24 hours after stripping. Protect sod against drying and breaking of rolled strips.
- E. Trees and Shrubs: Deliver freshly dug trees and shrubs. Do not prune before delivery, except as approved by Architect. Protect bark, branches, and root systems from sunscald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy natural shape. Provide protective covering during delivery. Do not drop trees and shrubs during delivery.
- F. Handle balled and burlapped stock by the root ball.
- G. Deliver trees, shrubs, ground covers, and plants after preparations for planting have been completed and install immediately. If planting is delayed more than 6 hours after delivery, set planting materials in shade, protect from weather and mechanical damage, and keep roots moist.
  - 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
  - 2. Do not remove container-grown stock from containers before time of planting.
  - 3. Water root systems of trees and shrubs stored on site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

## 1.6 PROJECT CONDITIONS

- A. Utilities: Determine location of above grade and underground utilities and perform work in a manner, which will avoid damage. Hand excavate, as required. Maintain grade stakes until removal is mutually agreed upon by parties concerned.
- B. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Architect before planting.
- C. No frozen sod shall be used, and no sod shall be placed upon frozen soil.

## 1.7 COORDINATION AND SCHEDULING

- A. Coordinate installation of planting materials during normal planting seasons (see Section 3.2 "Planting Seasons") for each type of plant material required.
- B. Athletic fields shall be constructed during the earliest phases of the construction, after installation of the sediment controls, in order to allow turf grasses to mature.

## 1.8 WARRANTY

- A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
- B. Special Warranty: Warrant the following living planting materials for a period of one year after County acceptance of building, against defects including death and unsatisfactory growth. If landscaping is installed after occupancy of building occurs, warranty shall begin after inspection and acceptance of work. Defects resulting from abnormal weather conditions unusual for warranty period, or incidents beyond the contractor's control are not covered by this warranty.
  - 1. Trees
  - 2. Shrubs
  - 3. Ground covers
  - 4. Plants
  - 5. Sod
- C. Replacement shall be during the next planting season. Material and the method of replacement shall be the same as specified for the original planting. All replacements will be inspected for acceptance as per these specifications.
- D. Replace planting materials that are more than 25 percent dead or in an unhealthy condition at end of warranty period. Unacceptable plant and tree material shall be removed from the site and replaced by the Contractor at his own expense.
- E. All replacements shall have a two-year guarantee. The Contractor shall continue to make replacements until a plant or tree shows vigorous and healthy growth for a period of one year from the date of acceptance by the Owner.
- F. Warranty lawns through specified lawn maintenance period.

## 1.9 TREE, SHRUB AND GROUND COVER MAINTENANCE

A. Maintain trees and shrubs by pruning, cultivating, watering, weeding, fertilizing, restoring, planting saucers, tightening and repairing stakes and guy supports, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees and shrubs free of insects and disease. Restore or replace damaged tree wrappings. Maintain trees and shrubs until final acceptance and written release.

## 1.10 LAWN MAINTENANCE

- A. Begin maintenance of lawns immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:
  - 1. Seeded Lawns: 60 days after date of acceptance of building.
    - a. When full maintenance period has not elapsed before end of planting season, or if lawn is not fully established at that time, continue

maintenance during next planting season.

- B. Maintain and establish lawns by watering, fertilizing, weeding, mowing, trimming and other operations. Bare spots which exist after three (3) weeks of favorable growing weather shall be recultivated, reseeded, raked, and rolled as specified in Section 3.5 "Lawn Planting Preparation." Mulching shall be with peat moss. Reseeding of bare spots shall be done as many times as necessary to establish a 95% coverage as determined by the Owner.
- C. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawns uniformly moist to a depth of 4 inches.
  - 1. Water lawn at the minimum rate of 1 inch per week.
- D. Mow lawns as soon as there is enough top growth to cut with mower set at specified height for principal species planted. Repeat mowing as required to maintain specified height without cutting more than 40 percent of the grass height. Remove no more than 40 percent of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet.
- E. Post-fertilization: Apply fertilizer to lawn after first mowing and when grass is dry.
  - 1. During the fall apply 10-10-10 fertilizer in three (3) equal applications which will provide a total of 2-22 lbs. of actual nitrogen per 1,000 s.f. Fertilizer shall be granular form and be 50% organic and contain at least 25% of nitrogen in slow release form.
  - 2. A cosmatic fertilizer application shall be made in mid March of 0.5 lbs. per 1,000 s.f. of slow release nitrogen.
  - 3. Apply pre-emergent crabgrass control the following spring between April 1st through 15th and follow that with an application of post emergent crabgrass control in early June as needed and apply post emergent broadleaf weed control as needed between May 15th and June 15th.
- F. Final Acceptance of Lawns: Final acceptance of lawns is contingent upon the establishment of a uniform stand of the specified turfgrass at the end of the warranty/maintenance period and shall be in strict compliance with these specifications and without evidence of excessive weed or crabgrass infestation.
  - 1. The Contractor shall submit a written request to the Owner for final inspection of the established turf.
  - 2. The request shall be received at least ten (10) calendar days before the anticipated date of inspection and the turfgrass shall be cut immediately prior to the final inspection.
  - 3. Coverage of the specified turfgrass shall be no less than 95% and weed infestation shall not be greater than 5% at the time of final inspection.
- G. Periodical sampling of soil shall be performed in order to monitor and maintain pH. A minimum of two tests are required.

#### PART 2 PRODUCTS

## 2.1 TREE AND SHRUB MATERIAL

- A. General: Furnish no. 1 grade nursery-grown trees and shrubs conforming to ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sunscald, injuries, abrasions, and disfigurement. Provide trees and shrubs harvested within 500 mile radius of Project Site.
- B. Grade: Provide trees and shrubs of sizes and grades conforming to ANSI Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.
- C. Where trees and shrubs are not planted in clearly defined groups, label each tree and shrub with securely attached, waterproof tag bearing legible designation of botanical and common name.
- D. Where trees and shrubs are planted in clearly defined groups, label at least 1 tree and 1 shrub, in each group, of each variety and caliper with a securely attached, waterproof tag bearing legible designation of botanical and common name.

#### 2.2 SHADE AND FLOWERING TREES

- A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, conforming to ANSI Z60.1 for type of trees required.
  - 1. Branching Height: 1/3 to 1/2 of tree height.
- B. Small Trees: Small upright or spreading type, branched or pruned naturally according to species and type, and with relationship of caliper, height, and branching recommended by ANSI Z60.1, and stem form as specified.
- C. Provide balled and burlapped trees.

## 2.3 DECIDUOUS SHRUBS

- A. Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI 60.1 for type, shape, and height of shrub.
- B. Provide balled and burlapped deciduous shrubs.
  - 1. Container-grown deciduous shrubs will be acceptable in lieu of balled and burlapped deciduous shrubs subject to meeting ANSI Z60.1 limitations for container stock.

#### 2.4 CONIFEROUS EVERGREENS

A. Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, conforming to ANSI Z60.1.

- B. Provide balled and burlapped coniferous evergreens.
  - 1. Container-grown coniferous evergreens will be acceptable in lieu of balled and burlapped coniferous evergreens subject to meeting ANSI Z60.1 limitations for container stock.

#### 2.5 BROADLEAF EVERGREENS

- A. Form and Size: Normal-quality, well-balanced, broadleaf evergreens, of type, height, spread, and shape required, conforming to ANSI Z60.1.
- B. Provide balled and burlapped broadleaf evergreens.
  - 1. Container-grown broadleaf evergreens will be acceptable in lieu of balled and burlapped broadleaf evergreens subject to meeting ANSI Z60.1 limitations for container stock.

#### 2.6 GROUND COVERS AND PLANTS

A. Provide ground covers and plants established and well rooted in removable containers or integral peat pots and with not less than the minimum number and length of runners required by ANSI Z60.1 for the pot size indicated. Provide ground covers and plants harvested within 500 mile radius of Project Site.

## 2.7 GRASS MATERIALS

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with the Association of Official Seed Analysts' "Rules for Testing Seeds" for purity and germination tolerances. Provide seeds harvested within 500 mile radius of Project Site.
  - 1. Seed Mixture: Provide seed of grass species and varieties, proportions by weight, and minimum percentages of purity, germination, and maximum percentage of weed seed as indicated in Seed Mixtures Schedule at the end of this Section.
- B. Seed shall be packed in 50-lbs. net weight in new, clean, poly woven bags, tightlywoven to prevent leaking and contamination. Each container shall have an accurate analysis tag, and a certification tag permanently affixed to it.
- C. All seed shall be delivered within 48 hours after the seed is mixed and tagged, and installed prior to date listed on State Certification.

## 2.8 SOD

- A. Turf Sod: Provide strongly rooted sod, not less than 2 years old and free of weeds and undesirable native grasses. Provide only sod capable of growth and development when planted (viable, not dormant).
  - 1. Mixture to conform to seed mix, see paragraph 3.22.
  - 2. Sod shall be machine cut at a uniform soil thickness of 3/4 inch, plus or minus

1/4 inch, at the time of cutting. Measurement for thickness shall exclude top growth and thatch.

- 3. Mowing Height: Height of grass blade not to exceed 3 inches.
- 4. Pad Size: Individual pieces of sod shall be cut to the supplier's standard width and length. Maximum allowable deviation from standard widths and lengths shall be 5%. Broken pads and torn or uneven ends will not be acceptable.
- 5. Strength of Sod Sections: Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape when suspended vertically from a firm grasp on the upper 10% of the selection.
- 6. Moisture Content: Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.
- 7. Time Limitations: Sod shall be harvested, delivered and installed within a period of 24 hours. Sod not transplanted within this period shall be inspected and approved or rejected by the inspection officer or representative prior to its installation.
- 8. No sod shall be placed between June 1<sup>st</sup> and August 15<sup>th</sup>, nor any time when the temperature is below 40° F.

# 2.9 TOPSOIL

- A. Topsoil: ASTM D 5268, pH range of 6.0 to 7, 4.0 percent organic material minimum, free of stones 3/8 inch or larger in any dimension, roots, plants, sod, clay lumps, and other extraneous materials harmful to plant growth.
  - 1. Topsoil Source: Topsoil shall be screened prior to placement so that 100% passes through a #4 sieve. Clean topsoil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth. Verify through testing, the suitability of surface soil to produce topsoil meeting these specified requirements and amend when necessary. See section 1.4 for testing requirements. If topsoil does not have the properties specified, the Contractor shall add amendments to the topsoil as necessary to bring it to compliance with these specifications. The contractor is solely responsible for providing a minimum of 6" of topsoil over all non-mechanically stabilized areas within the project's limit of disturbance as base bid. The required topsoil may be provided through re-use of existing soil on site, importing of soil from off-site, or a combination of re-use and importing. When topsoil quantities from the site are insufficient to meet the project requirements, Contractor shall provide additional and supplemental via imported topsoil as part of the base bid.
    - a. Imported topsoil: Imported topsoil shall be screened utilizing a #4 sieve size prior to delivery and placement. Topsoil shall be indigenous natural friable loam of uniform composition, obtained from an area, which has never been stripped, possessing characteristics of the best soils of the vicinity, which produce heavy growth of crops, grass and other vegetation. Topsoil shall be of uniform composition with no subsoil, clay lumps stones, roots or similar objects and be free of any parts (seed, rhizomes, roots etc.) of Johnson grass, Canada Thistle, Bermuda grass, Poison Ivy or other noxious weeds and litter or any other material substances which may be harmful to plant growth or a hindrance to planting or maintenance operations, and also contain no rocks over ½", no glass, and/or no metal. Imported topsoil shall contain 20-75% sand, 10-60% silt, 5-30% clay and have 4-10% organic matter as determined

by soil composition tests of the Organic Carbon, 6A Chemical Analysis Method described in the Department of Agriculture Soil Survey Investigation Report No.1 dated April 1984. Contractor shall have topsoil tested by a certified testing agency in accordance with USDA Cooperative Extension Service Guidelines. Testing certification shall attest that tested samples meet all specification requirements. The contractor shall pay cost of topsoil testing.

- 2. Organic matter: Topsoil shall have an organic content, by weight, of not less than 4.0 percent.
- 3. Soluble salts: Topsoil shall not have soluble salts greater than 500 parts per million.
- 4. Origin: Before delivery the source of the topsoil shall be made known.
- 5. Screening: All topsoil, whether from on-site or off-site source shall be screened prior to placement.
- 6. Depth of topsoil for lawn areas shall be 6" minimum. Random sampling will be taken by Owner's representative after topsoil is distributed and graded to assure minimum 6" depth of topsoil has been achieved after compaction.
- 7. Depth of topsoil for field areas as shown on landscape plans shall be 6" minimum. The 6" of topsoil on the athletic field areas must meet all requirements listed above.

## 2.10 SOIL AMENDMENTS

- A. Lime: ASTM C 602, Class T, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent, with a minimum 99 percent passing a No. 8 sieve and a minimum 75 percent passing a No. 60 sieve.
  - 1. Provide lime in the form of dolomitic limestone.
- B. Aluminum Sulfate: Commercial grade, unadulterated.
- C. Peat Humus: Finely divided or granular texture, with a pH range of 6 to 7.5, composed of partially decomposed moss peat (other than sphagnum), peat humus, or reed-sedge peat.
- D. Peat Humus: For acid-tolerant trees and shrubs, provide moss peat, with a pH range of 3.2 to 4.5, coarse fibrous texture, medium-divided sphagnum moss peat or reed-sedge peat. It shall analyze to at least 90% organic matter and contain not more than 60% moisture. Spaghnum type of peat moss is not acceptable.
- E. Water: Potable.

## 2.11 FERTILIZER

- A. Bonemeal: Commercial, raw, finely ground; minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- B. Superphosphate: Commercial, phosphate mixture, soluble; minimum of 20 percent available phosphoric acid.
- C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character,

consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of ureaform, phosphorous, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

## 2.12 MULCHES

A. Organic Mulch: Organic mulch, free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of shredded hardwood.

## 2.13 WEED-CONTROL BARRIERS

- A. Nonwoven Fabric: Polypropylene or polyester fabric, 3 oz. per sq. yd. minimum.
- B. Composite Fabric: Woven, needle-punched Polypropylene substrate bonded to a nonwoven Polypropylene fabric, 4.8 oz per sq. yd.

#### 2.14 EROSION-CONTROL MATERIALS

- A. Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.
- B. Fiber Mesh: Biodegradable twisted jute or spun-coir mesh, 0.92 lb. per sq. yd. minimum, with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

## 2.15 STAKES AND GUYS

- A. Guy Stakes shall be oak, locust, white cedar, or approved equal. Sound hardwood of uniform size, decay free, straight, and 1-1/2" square by 2 feet long.
- B. Upright stakes shall be oak, locust, white cedar, or approved equal. Sound hardwood of uniform size, decay free, straight and not less than 1-1/2" or more than 2-1/4" in width. Length as required for proper tree staking per details.
- C. Staking Wire shall be No. 12 gauge galvanized annealed wire.
- D. Guying Hose shall be 1/2" ID fabric bearing garden hose or an approved equal guying material. Guying hose shall be uniform in color.
- E. Deadman shall be redwood, cedar, or approved equal sound hardwood of uniform size, decay free, in good condition and 6" by 6" by 3 feet long.

## PART 3 EXECUTION

## 3.1 EXAMINATION

A. Examine areas to receive landscaping for compliance with requirements and for conditions affecting performance of work of this Section. Do not proceed with

installation until unsatisfactory conditions have been corrected.

## 3.2 PLANTINGS SEASONS

- A. All planting shall be performed during the regular planting season for various types of plant material as follows:
  - 1. Deciduous trees and shrubs are to be planted during late fall (October 1 through November 15) and early spring (March through mid-May).
  - 2. Evergreen trees and shrubs are to be planted during fall (August through September) and early spring (March through mid-May).

## 3.3 PREPARATION

A. The location of all planting beds shall be staked out by the Contractor prior to planting and such location stakes shall be approved by the Baltimore County Public Schools before planting operations will be permitted to proceed.

#### 3.4 PLANTING SOIL PREPARATION

- A. Before mixing, clean topsoil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth.
- B. Mix soil amendments and fertilizers with topsoil at rates indicated. Delay mixing fertilizer if planting does not follow placing of planting soil within a few days.
- C. For tree pit or trench backfill, mix planting soil before backfilling and stockpile at site.
- D. For planting beds and lawns, mix planting soil either prior to planting or apply on surface of topsoil and mix thoroughly before planting.
  - 1. Mix lime with dry soil prior to mixing fertilizer. Prevent lime from contacting roots of acid-tolerant plants.
  - 2. Apply phosphoric acid fertilizer, other than that constituting a portion of complete fertilizers, directly to subgrade before applying planting soil and tilling.

## 3.5 LAWN PLANTING PREPARATION

- A. Limit subgrade preparation to areas that will be planted in the immediate future.
- B. Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous materials.
- C. Spread planting soil mixture to depth required to meet thickness, grades, and elevations shown, after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen.
  - 1. Place approximately 1/2 the thickness of planting soil mixture required. Work into top of loosened subgrade to create a transition layer and then place remainder of planting soil mixture.

- D. Grade lawn and grass areas to a smooth, even surface with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future. Remove trash, debris, stones larger than 1/2 inch in any dimension, and other objects that may interfere with planting or maintenance operations.
- E. Moisten prepared lawn areas before planting when soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- F. Restore prepared areas if eroded or otherwise disturbed after fine grading and before planting.

#### 3.6 GROUND COVER AND PLANT BED PREPARATION

- A. Remove soil to a minimum depth of 18 inches below finished grade and 24 inches beyond perimeter of the proposed planting bed and dispose offsite. Replace with prepared planting soil mixture.
- B. Final grades for landscaping beds shall be 6" above existing ground level.

## 3.7 EXCAVATION FOR TREES AND SHRUBS

- A. Pits and Trenches: Excavate with vertical sides and with bottom of excavation slightly raised at center to assist drainage. Loosen hard subsoil in bottom of excavation.
  - 1. Balled and Burlapped Trees and Shrubs: Excavate approximately 2 to 3 times as wide as ball diameter and equal to ball depth, plus the following setting layer depth:
    - a. Setting Layer: Allow 6-8 inches of planting soil.
  - 2. Where drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.
- B. Preparation of Shrub Beds: All landscape beds shall have existing soil removed to a depth of 18" below grade and two feet beyond its perimeter.
- C. Subsoil excavated from the plant pits shall be removed from the site unless otherwise notified, in writing by the Owner. Do not mix with planting soil or use as backfill.
- D. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
  - 1. Hardpan Layer: Drill 6-inch diameter holes into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.
- E. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.
- F. Fill excavations with water and allow to percolate out, before placing setting layer and positioning trees and shrubs.

## 3.8 PLANTING TREES AND SHRUBS

- A. Set balled and burlapped stock plumb and in center of pit or trench with top ball raised above adjacent finish grades as indicated.
  - 1. Place stock on setting layer of compacted planting soil.
  - 2. Remove burlap and wire baskets from tops of balls and partially from sides, but do not remove from under balls. Remove pallets, if any, before setting. Do not use planting stock if ball is cracked or broken before or during planting operation. All burlap, ropes, staples, and other items used in balling and burlapping shall be removed from the site by the Contractor.
  - 3. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately ½ backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill. No air pockets shall be left about the roots.
- B. Set container-grown stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.
  - 1. Carefully remove containers so as not to damage root balls.
  - 2. Score roots of container plants with a sharp knife, 4 to 5 times, 1" deep around the perimeter of the plant.
  - 3. Place stock on setting layer of compacted planting soil.
  - 4. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately ½ backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill. No air pockets shall be left about the roots.
- C. Dish and tamp top of backfill to form a 3-inch high mound around the rim of the pit. Do not cover top of root ball with backfill.

# 3.9 TREE AND SHRUB PRUNING

A. Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Unless otherwise directed by Architect, do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are size after pruning. Pruning shall be done with clean sharp instruments. All injured tree and shrub roots shall be pruned to make clean ends before planting.

## 3.10 TREE AND SHRUB GUYING AND STAKING

- A. All trees shall be supported immediately after planting. Wires shall be encased in fabric bearing hose as necessary to prevent contact with the bark of the tree and shall be placed around the trunk in a single loop. Rubber hose and wire shall not be placed in such as manner as to pull apart at a crotch of the tree. Wire shall be tightened and kept taut by using turnbuckles.
- B. Staking trees of less than 3" caliper: All trees shall be staked as follows: Trees shall be

supported in an upright position by two stakes as shown on the plans. The stakes shall be spaced approximately 12" from the trunk and in the case of balled and burlapped trees outside the perimeter of the ball. Stakes shall be driven vertically into the ground to a depth of at least 2 to 3 feet and shall not be twisted or pulled in such a manner as to cause injury to the ball or roots. The tree shall be wired to each stake, near the top, with two strands of wire.

- C. Guying trees more than 3" caliper shall be guyed as follows: Trees shall be supported in an upright position by three guys equally spaced around the tree. Each guy shall consist of two strands of wire and be attached to the tree trunk at an angle of 60° at 2/5 of the height of the tree. The guys shall be anchored at the ground in one of the following methods:
  - 1. Stakes which have been driven into the ground at an angle away from the tree so that the tops of the anchor stakes are below finished grade.
  - 2. Deadman placed at least three feet below finished grade.

# 3.11 PLANTING GROUND COVER AND PLANTS

- A. Space ground cover and plants as indicated.
- B. Space ground cover and plants not more than 24 inches apart.
- C. Dig holes large enough to allow spreading of roots, and backfill with planting soil. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water. Water thoroughly after planting, take care not to cover plant crowns with wet soil.

## 3.12 MULCHING

- A. Mulch backfilled surfaces of pits, trenches, planted areas, and other areas indicated.
- B. Organic Mulch: Apply the following average thickness of organic mulch and finish level with adjacent finish grades. Do not place mulch against trunks or stems.
  - 1. Thickness: 3 inches.
- C. Mulch shall be applied within two days after planting of plant or landscape bed.
- D. A sample of the mulch shall be approved by the Baltimore County Public Schools before installation.
- E. After raking the surface smooth and even, the mulch shall be thoroughly soaked for its full depth.

# 3.13 SEEDING NEW LAWNS

A. Sow seed with a spreader or a seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in 2 directions at right angles to each other.

- 1. Do not use wet seed or seed that is moldy or otherwise damaged in transit or storage.
- B. Sow seed at the following rates:
  - 1. Seeding Rate: 8 to 9 lbs per 1000 sq. ft.
- C. Rake seed lightly into top 1/8 inch of topsoil, roll lightly, and water with fine spray.
- D. Protect seeded slopes exceeding 1:4 against erosion with erosion-control blankets installed and stapled according to manufacturer's recommendations.
- E. Protect seeded slopes exceeding 1:6 against erosion with jute or coir-fiber erosioncontrol mesh installed and stapled according to manufacturer's recommendations.
- F. Protect seeded areas with slopes less than 1:6 against erosion by spreading straw mulch after completion of seeding operations. Spread uniformly at a minimum rate of 2 tons per acre to form a continuous blanket 12 inches loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.
  - 1. Anchor straw mulch by crimping into topsoil by suitable mechanical equipment.
  - 2. Anchor straw mulch by spraying with nitro-cellulose tackifier at the rate of 10 to 13 gal. per 1000 sq. ft. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.
- G. Protect seeded areas against hot, dry weather or drying winds by applying peat mulch within 24 hours after completion of seeding operations. Soak and scatter uniformly to a depth of 3/16 inch thick and roll to a smooth surface.

## 3.14 HYDROSEEDING NEW LAWNS

- A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogenous slurry suitable for hydraulic application.
  - 1. Mix slurry with nonasphaltic tackifier.
  - 2. Apply slurry uniformly to all areas to be seeded in a 1-step process. Apply mulch at the minimum rate of 1500 lb per acre dry weight but not less than the rate required to obtain specified seed-sowing rate.

# 3.15 RECONDITIONING LAWNS

- A. Recondition existing lawn areas damaged by Contractor's operations, including storage of materials or equipment and movement of vehicles. Also recondition lawn areas where settlement or washouts occur or where minor regarding is required.
- B. Remove sod and vegetation from diseased or unsatisfactory lawn areas; do not bury

into soil. Remove topsoil containing foreign materials resulting from Contractor's operations, including oil drippings, fuel spills, stone, gravel, and other construction materials, and replace with new topsoil.

- C. Where substantial lawn remains, mow, dethatch, core aerate, and rake. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergent herbicides.
- D. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of it off the Owner's property.
- E. Till stripped, bare, and compacted areas thoroughly to a depth of 6 inches.
- F. Apply required soil amendments and initial fertilizers and mix thoroughly into top 4 inches of soil. Provide new planting soil as required to fill low spots and meet new finish grades.
- G. Apply seed and protect with straw mulch as required for new lawns.
- H. Water newly planted areas and keep moist until new grass is established.

# 3.16 SODDING

- A. Installation Procedures for Sod:
  - 1. Moistening the Soil: During periods of high temperature, after all unevenness in the soil surface has been corrected, the soil shall be lightly irrigated immediately prior to laying the sod.
  - 2. Starter Strip: The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and tightly against each other. Lateral joints shall be staggered to promote more uniform growth and strength. Care shall be exercised to insure that the sod is not stretched or overlapped and that all joints are butted tightly in order to prevent voids which would cause air drying of the roots.
  - 3. Sloping Surfaces: On sloping areas 3:1 or steeper, or where erosion may be a problem, sod shall be laid parallel to the contours of the slope (perpendicular to the flow of water), with staggered joints, and secured by at least two (2) non treated pine or coniferous wood stakes spaced not more than two (2) feet apart. Stakes shall be driven flush with top of the sod. No metal staples or pegs may be used. When placing sod in drainage ditches, the length of the strip shall be laid parallel to the direction of the flow of the water.
  - 4. Watering and Rolling: The landscape contractor shall lightly water sod during installation to prevent excessive drying. As sodding is completed in any one section, the entire area shall be rolled with a 1/2 ton roller properly leveled. It shall then be thoroughly irrigated so that the underside of the new sod pad and soil immediately below the sod are thoroughly wet (to a depth of 2-4"). Watering shall be accomplished as necessary until the sod is established or until acceptance of the work.

## 3.17 INSTALLATION OF EDGINGS

A. Steel Edging: Install steel edging where indicated according to manufacturer's

recommendations. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.

## 3.18 INSTALLATION OF MISCELLANEOUS MATERIALS

- A. Apply antidesiccant using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage.
  - 1. When deciduous trees or shrubs are moved in full-leaf, spray with antidesiccant at nursery before moving and again 2 weeks after planting.

#### 3.19 CLEANUP AND PROTECTION

- A. During the course of planting, excess waste material shall be continuously and promptly removed, lawn areas kept clean, and all reasonable precautions shall be taken to avoid damage to existing structures, plants, and grass areas.
- B. Existing grass areas, which have been injured by this work, shall be regraded to the original grade. When completed the entire area shall be neat and clean to the satisfaction of Baltimore County Public Schools.
- C. Immediately after all pruning, staking, and mulching have been completed; the Contractor shall remove all branches, excavated soil, and construction debris.

#### 3.20 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Promptly remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the Owner's property.

#### 3.21 PLANTING SOIL AMENDMENTS SCHEDULE

- A. Tree Pits or Trenches: Provide soil amendments in not less than the following quantities:
  - 1. Ratio of loose peat humus to topsoil by volume: 1:4.
  - 2. Commercial fertilizer in amounts recommended in soils report from a qualified soil-testing agency. Fertilizer shall be mixed evenly into the backfill mix.
- B. Ground Cover and Planting Beds: Provide soil amendments in not less than the following quantities:
  - 1. Ratio of loose peat humus to topsoil by volume: 1:4.
  - 2. Commercial fertilizer in amounts recommended in soils report from a qualified soil-testing agency. Fertilizer shall be spread evenly over the area to be planted and cultivated into the soil mix to a depth of six (6) inches minimum.
- C. Lawns:
  - 1. Spread four (4) inches of topsoil over finished subgrade unless otherwise indicated.
  - 2. Apply lime, fertilizer, and other soil amendments in amounts recommended in
soils report from a qualified soil-testing agency.

- 3. Apply 10-22-22 analysis granular fertilizer (50% UFN<sub>2</sub>) at a rate of twenty three (23) pounds per 1000 square feet.
- 4. Apply granular limestone at a rate of one hundred thirty (130) pounds per 1000 square feet.

# 3.2 SEED MIXTURES SCHEDULE

A. Seed mixes shall be composed of the following varieties according to use and tested to the following minimum percentages of purity and germination.

GRASS SEED MIXTURES					
Use	Irrigated play fields and general areas	Non-irrigated playing fields	Maintenance seeding		
Product	LESCO Premium Athletic Mix	LESCO Team Mates Plus mix	LESCO Eagle Blend plus Blue		
LESCO #	001365	019586	011942		
Mixture	70% premium Kentucky Bluegrass 30% premium turf-type perennial ryegrass	<ul> <li>70% premium turf-type tall fescues</li> <li>20% premium turf-type perennial ryegrass</li> <li>10% premium Kentucky Bluegrass</li> </ul>	75% premium turf-type perennial ryegrass 25% premium Kentucky Bluegrass		
Rate/ 1000 s.f.	4 lbs.	8 lbs.	6 lbs.		

# B. NOTES:

- 1. Improved varieties of each species are required.
- 2. Tall fescue mix is to contain any two (2) certified varieties from the latest issue of the
  - University of Maryland Memorandum No. 77, dated April 1992. (K-31 is not acceptable)
- 3. Kentucky Bluegrass shall contain 3 certified varieties selected from the following list: Baron, Cheri, Columbia, Monopoly, Ram 1 and Victa.
- 4. All seed must be free of all prohibited and restricted noxious weeds in accordance with Maryland law.
- 5. Seed lots must be blended and certified as per the general certification specifications of the Maryland Department of Agriculture.
- 6. Seed filling must comply with the Maryland Seed and Regulations law.
- 7. All seed must be certified with complete and accurate analysis tags attached to each container.

8. Seed mixes for SWM planting areas are to comply with approved SWM drawings.

9. Tags shall be removed by an authorized representative of Baltimore County Public Schools.

# **END OF SECTION**

# SECTION 329100 - MAINTENANCE OF TURF AND PLANTS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Baltimore County Department of Public Works Standard Details for Construction dated 2007 and as amended.
- C. Baltimore County Landscape Manual dated August 7, 2000 and as amended.
- D. Acceptable growth completion for turf, see Specification SECTION 32 90 00 PLANTING, Section 1.10.F.3

# 1.2 SUMMARY

- A. Supply all labor, materials, gasoline, oil, equipment, and supplies to maintain the lawn for the time period as specified in part 3.1 of this section and Section 329000.
- B. Maintain lawns by watering, fertilizing, weeding, mowing, trimming and other operations such as rolling, regrading and replanting as required to establish a smooth, acceptable lawn, free of eroded or bare areas.

# 1.3 SUBMITTALS

- A. Within 14 days of Notice to Proceed the Contractor shall submit a complete list of equipment to be reviewed by the Construction Manager.
- B. Within 14 days of Notice to Proceed, the Contractor shall submit a complete Maintenance Schedule to be reviewed by the Construction Manager.

## 1.4 EXISTING CONDITIONS

A. It will be the responsibility of the Contractor to visit the site and be thoroughly familiar with its configuration and dimensions.

## PART 2 - PRODUCTS

- 2.1 EQUIPMENT
  - A. The Contractor must furnish a list of machinery that he will use for the work above.
    - 1. This equipment will be inspected by the Construction Manager or his authorized representative before the contract is approved in order to determine whether it is adequate.

- 2. All equipment must meet all OSHA and MOSHA standards and be equipped with turf type tires.
- B. The Contractor shall maintain the cutting edge of all mowing equipment in sharp condition and proper adjustment.
  - 1. All mowing equipment shall be maintained in accordance with manufacturers instructions and shall meet safety requirements specified herein.
  - 2. Equipment guards, shield and mufflers shall be kept intact and capable of performing their intended functions.
- 2.2 SOURCE QUALITY CONTROL
  - A. Use of subcontractors is permissible, however, each subcontractor and their equipment shall be approved in advance by the Construction Manager.
  - B. The Contractor will be responsible for ensuring that subcontractors comply with the provisions of this contract.
  - C. All herbicide/pesticide applicators must be licensed/certified by the MD Department of Agriculture in the category specified for the type of work being performed.

# PART 3 - EXECUTION

## 3.1 PREPARATION

- A. Maintenance of lawns shall begin immediately after installation, and continue until acceptance of work. Warranty and maintenance period shall begin upon written acceptance of work and continue for two (2) growing seasons (two (2) years).
- B. The Contractor shall notify the Construction Manager by 2:00 p.m. the day before each site will be cut. Contractor will notify the Construction Manager before 7:30 a.m. if he is not able to cut that day.
- C. The Contractor shall not mow over debris and is required to pick up trash before mowing.
- D. Never allow the grass to grow taller than 3.75 4" tall before being mowed back to 2.5" tall. Turf shall not be mowed shorter than 2.5" tall. Repeat mowing as required for maintaining specific height without mowing more than 30% of the grass leaf blade (height) at any single mowing.
- E. All finishing work around and in obstacles such as trees, drainage ditches, storm drains, manhole covers, fences, buildings, parking lots, and curb and gutters, including removal of grass and weeds in cracks etc.
  - 1. This work shall be completed during the time the grass is cut.

- 2. Contractors are required to sweep or blow grass clippings off all walks and curbs.
- 3. If the Contractor is licensed and insured, Roundup may be used if approved by the Owner and must be applied in accordance with all applicable Baltimore County Public Schools and Maryland Department of Agriculture standards for notification and posting of the property. Spraying may be done on Saturday and Sunday, and shall not be performed Monday through Friday between the hours of 7:00 am and 3:30 pm, during school hours.
- 4. A deduction to contract price will be made if punch list items are not corrected.
- 5. Contractor will have 3 working days, including Saturday to correct deficiencies after notice has been given.
- 6. Areas will be reinspected by the Construction Manager to determine if work has been satisfactorily corrected.
- F. The Contractor must take all precautions necessary to avoid damaging obstacles such as trees, plants, fences, signs, drain covers, sewer clean outs, lights, turf, etc.
  - 1. Any damage caused by the Contractor's improper work will be repaired by the Contractor to the satisfaction of the Construction Manager.
  - 2. If damages are not repaired within 10 days the Owner will have the damages repaired at the Contractor's expense.
- G. The Contractor or his employees are not to enter the school building except to check in or out unless on official business.
- H. Warrant the living planting materials for a period of one year after inspection by the Owner and Engineer and written acceptance of work by the Owner. Defects resulting in abnormal weather conditions unusual for warranty period, or incidents beyond the contractor's control are not covered by this warranty provided ALL requirements of this contract have been met. The Owners acceptance of the building does not constitute acceptance of the turfgrass or change any warranty or maintenance periods.

# 3.2 SAFETY

- A. Any barricades or protective equipment required by the Contractor to make the work site safe shall be his responsibility.
- B. The Contractor shall take every precaution while working on school grounds to insure the safety of students, school personnel, or the public.
  - 1. The Contractor shall request the assistance of the Principal to move students to other play areas so that the turf can be cut.

C. Keys will be removed or equipment will be inoperable when not being attended by its operator.

# 3.3 AUTHORIZATION

- A. All work shall be inspected by the Construction Manager.
- B. All changes to the contract, whether additive or deductive, shall be in writing and shall be signed by the Purchasing Officer.

# END OF SECTION

### SECTION 33 10 00 WATER UTILITIES

#### PART 1 GENERAL

### 1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. General Conditions of the Baltimore County Board of Education's Specifications for Site Development.
- C. Baltimore County Department of Public Works Standard Details for Construction dated 2007 and as amended.
- D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

### 1.2 SUMMARY

- A. This Section includes water systems piping for potable water service and fire protection service outside the building.
- B. Related Specifications: The following standard specifications are made a part of this specification to the extent referenced herein.
  - 1. National Fire Protection Association "Standard for Installation of Private Fire Supply Mains and Their Appurtenances NFPA 24".

## C. Related Sections:

- 1. Section 312300: Excavating and Filling.
- 2. Refer to sections relating to fire protections systems and water distribution systems in Division 22.

### 1.3 SYSTEM PERFORMANCE REQUIREMENTS

- A. Minimum Pressure Rating: Except where otherwise indicated, the following are minimum pressure requirements for water system piping.
  - 1. Underground Piping: 280 psig with an actual operating pressure of 125 psig.
  - 2. All materials shall be in accordance with the requirements of the Baltimore County Plumbing Code and the Baltimore County Department of Public Works.

### 1.4 SUBMITTALS

A. General: Submit the following according to Conditions of the Contract and Division I Specification Sections.

- B. Product data for the following:
  - 1. Identification materials and devices.
- C. Coordination drawings showing pipe sizes and elevations. Include details for connections, anchors, and reaction backing. Show other piping in same trench and clearances from water system piping. Indicate interface and spatial relationship between piping and proximate structures.
- D. Record drawings at Project closeout of installed water system piping and products according to Division 1 Section "Project Closeout".
- E. Test reports specified in "Field Quality Control" Article in Part 3.

### 1.5 QUALITY ASSURANCE

- A. Comply with standards of authorities having jurisdiction for fire protection systems. Include materials, hose threads, installation, and testing.
- B. Comply with standards of authorities having jurisdiction for potable water piping and plumbing systems. Include materials, installation, testing, and disinfection.
- C. Comply with NFPA 24 "Standards for the Installation of Private Fire Service Mains and Their Appurtenances" for materials, installations, tests and flushing.
- D. Listing and Labeling: Provide equipment and accessories that are listed and labeled.
  - 1. The Terms "Listed and Labeled": As defined in "National Electrical Code," Article 100.
  - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- E. Product Options: Water systems specialties and accessories are based on specific types, manufacturers, and model indicated. Components by other manufacturers but having equal performance characteristics may be considered, provided deviations in dimensions, operation, and other characteristics do not change design concept or intended performance as judged by Architect. The burden of proof of equality of products is on Contractor. Refer to Division 1 Section "Product Substitutions."

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling, to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.
- C. Protect flanges, fittings, and piping specialties from moisture and dirt.

D. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

## 1.7 PROJECT CONDITIONS

- A. Site Information: Data in subsurface investigation repots was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as representations or warranties of accuracy or continuity between soil bores. The Owner, Architect or Engineer will not be responsible for interpretations or conclusions drawn from this data by the Contractor.
  - 1. Additional test bores and other exploratory operations may be performed by the Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.
- B. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by the Architect and then only after acceptable temporary utility services have been provided. If existing utilities are indicated to be abandoned, the Contractor shall remove such utility, if necessary, at no additional cost to the Owner.
  - 1. Provide a minimum 48-hours notice to the Architect and receive written notice to proceed before interrupting any utility.
- C. Should uncharted or incorrectly charted, piping, or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.
- D. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights. Open trench excavations within the limits of the State right-of-way shall be protected in accordance with the requirements of applicable permits. Open excavation within other roadways shall be plated and shall be posted with warning devices in accordance with the <u>Manual on Uniform Traffic Control Devices.</u>
  - 1. Perform excavation by hand within dripline of large trees to remain. Protect root systems from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with moistened burlap.
  - 2. Work which affects the public right-of-way shall be in accordance with the Baltimore County Department of Public Works requirements and regulations.

# 1.8 SEQUENCING AND SCHEDULING

- A. Coordinate with pipe materials, sizes, entry locations, and pressure requirements of building fire protection systems piping.
- B. Coordinate with pipe materials, sizes, and entry locations, and pressure requirements

of building water distribution systems piping.

- C. Coordinate with other utility work.
- D. Coordinate electrical requirements of actual equipment furnished with requirements specified in Division 26.

## PART 2 PRODUCTS

# 2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with the requirements of Baltimore City, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Drilling Machine Corporation Stops:
    - a. Ford Meter Box Co., Inc.
    - b. Hays Div., Romac Industries.
    - c. Mueller Co., Grinnell Corp.
  - 2. Bronze Corporation Stops and Valves:
    - a. Ford Meter Box Co., Inc.
    - b. Hays Div., Romac Industries.
    - c. A.Y. McDonald Mfg. Co.
    - d. Mueller Co., Grinnell Corp.
  - 3. Tapping Valves:
    - a. A.P. Smith Manufacturing Company.
    - b. M & H Valve & Fittings Company
  - 4. Gate Valves:
    - a. A.P. Smith Manufacturing Company.
    - b. M & H Valve & Fittings Company.
  - 5. Dry-Barrel Fire Hydrants:
    - a. American Darling Valve Company Model B-62-B
    - b. Dresser Manufacturing Company Reliant Style 929
    - c. Kennedy Valve Company Guardian Model K-81
    - e. Mueller Co. A-463 Centurian
    - f. U.S. Pipe & Foundry Co. Smith Model H 205
  - 6. Drains:
    - a. Ancon, Inc.
    - b. Jones Manufacturing Co., Inc.
    - c. Josam Co.
    - d. Jay R. Smith Mfg. Co. Div., Smith Industries, Inc.
    - e. Wade Div., Tyler Pipe Subsid., Tyler Corp.
    - f. Zurn Hydromechanics Div., Zurn Industries, Inc.
  - 7. Detector Check Valves:
    - a. Ames Co., Inc.

- b. Hersey Products, Inc., Grinnell Corp.
- c. Kennedy Valve Div., McWane, Inc.
- d. Viking Corp.
- e. Watts Regulator Co.
- 8. Backflow Preventers:
  - a. Ames Co., Inc.
  - b. Cla-Val Co. Div., Griswold Industries.
  - c. Conbraco Industries, Inc.
  - d. Febco.
  - e. Hersey Products, Inc., Grinnell Corp.
  - f. Watts Regulator Co.
  - g. Wilkins Regulator Div., Zurn Industries, Inc.

## 2.2 PIPES AND TUBES

- A. Refer to Part 3 Article "Piping Applications" for identification of systems where pipe and tube materials specified below are used.
- B. Ductile-Iron Pipe: AWWA C151, Class 54.
  - 1. Lining: AWWA C104, cement mortar, seal coated.
  - 2. Gaskets, Glands, and Bolts and Nuts: AWWA C111.
  - 3. Mechanical-Joint-Type Pipe: AWWA C111, rubber gaskets, ductile retain- or glands, and steel bolts and nuts.
  - 4. Encasement: AWWA C105, polyethylene film tube.
- C. Copper Tube: ASTM B 88, Types K (ASTM B 88M, Types A and B), seamless water tube, annealed temper.

## 2.3 PIPE AND TUBE FITTINGS

- A. Refer to Part 3 Article "Piping Applications" for identification of systems where pipe and tube fitting materials specified below are used.
- B. Ductile-Iron Pipe Fittings Class D or Class 250: AWWA C110, ductile-iron, 250-psig (1725-kPa) minimum pressure rating; or AWWA C153, ductile-iron compact fittings, 350-psig (2400-kPa) pressure rating.
  - 1. Lining: AWWA C104, cement mortar.
  - 2. Gaskets: AWWA C111, rubber.
- C. Polyethylene Encasement: AWWA C105, 8-mils (2 mm) minimum thickness, tube or sheet.

## 2.4 JOINING MATERIALS

- A. Refer to Part 3 Article "Piping Applications" for identification of systems where joining materials specified below are used.
- B. Ductile-Iron Pipe and Ductile-Iron Fittings: The following materials apply:

1. Mechanical Joints: AWWA C111 ductile-iron retainer glands, high-strength steel bolts and nuts, and rubber gaskets.

# 2.5 PIPING SPECIALTIES

- A. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150-psig (1035-kPa) or 300-psig (2070-kPa) minimum pressure to suit system pressures.
- B. Dielectric-Flange Insulation Kits: Field-assembled companion-flange assembly, fullface or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
  - 1. Provide separate companion flanges and steel bolts and nuts for 150-psig (1035kPa) or 300-psig (2070-kPa) minimum working pressure to suit system pressures.

## 2.6 VALVES

- A. Valves shall be in accordance with the latest requirements of Baltimore County and Baltimore City.
- B. Valve Boxes: Concrete Sectional Vaults having frame and cover with lettering "Water Valve," in accordance with Baltimore County standards.
- C. Tapping Sleeve and Tapping Valve: Shall be in accordance with the latest requirements of Baltimore County and Baltimore City.
- D. Service Clamps and Corporation Stops: Complete assembly, including service clamp, corporation stop, and bolts and nuts. Use service clamp and stop compatible with drilling machine.
  - 1. Service Clamp: Cast iron or ductile iron with gasket and AWWA C800 threaded outlet for corporation stop, and threaded end straps.
  - 2. Corporation Stops: Bronze body and ground key plug, with AWWA C800 threaded inlet and outlet matching service piping material.
  - 3. Manifold: Copper with 2 to 4 inlets as required, with ends matching corporation stops and outlet matching service piping.

## 2.7 WATER METERS

- A. General: Provide water meter with registration in gallons.
- B. Domestic Water Meter: As approved by Baltimore City.
- C. Fire Service Water Meter: As approved by Baltimore City.

## 2.8 PITS

- A. Concrete: Portland cement mix, 3000 psi (20.7 MPa).
  - 1. Cement: ASTM C 150, Type I.

- 2. Fine Aggregate: ASTM C 33, sand.
- 3. Coarse Aggregate: ASTM C 33, crushed gravel.
- 4. Water: Potable.
- B. Reinforcement: Steel conforming to the following:
  - 1. Fabric: ASTM A 185, welded wire fabric, plain.
  - 2. Reinforcement Bars: ASTM A 615, Grade 60 (ASTM A 615, Grade 400), deformed.
  - 3. Ladder: ASTM A 36 (ASTM A 36M), steel or polyethylene-encased steel steps.
  - 4. Manhole: ASTM A 48, Class 35, gray-iron, 24-inch (610-mm) minimum diameter traffic frame and cover, of size and weight indicated.
  - 5. Manhole: ASTM A 536, Grade 60-40-18, ductile-iron, 24-inch (610-mm) minimum diameter traffic frame and cover, of size and weight indicated.
  - 6. Drain: ASME A112.21.1M, cast-iron area drain, of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

## 2.9 FIRE HYDRANTS

- A. General: "Traffic Model", cast-iron body, compression-type valve, opening against pressure and closing with pressure, 6-inch (DN 150) mechanical joint inlet, 150-psig (1035-kPa) working pressure.
- B. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
- C. Operating and Cap Nuts: Pentagon 1-3/8 inch (3.5 cm) point to flat.
- D. Direction of Opening: Open hydrant valve by turning operating nut to the left, or counterclockwise. Show direction of the opening on the bonnet with a raised arrow.
- E. Finish: Sherwin Williams, Kem L-F65, E-36, Safety Orange Lead Free Industrial Enamel or approved equal.
- F. Dry-Barrel Fire Hydrants: UL 246, FM-approved, two 2-1/2 inch (6.35 cm) and one 4-1/2 inch (11.4 cm) outlets, 5-inch (12.7 cm) min. main valve, drain valve, and 6-inch mechanical joint inlet and a flanged connection on the stand pipe end.

## 2.10 ANCHORAGES AND BUTTRESSES

- A. General: All anchorages and buttresses shall be in conformance with the Baltimore County Specifications and Standard Details.
- B. Concrete Reaction Backing: Portland cement mix, 3000 psi.
  - 1. Cement: ASTM C 150, Type I.
  - 2. Fine Aggregate: ASTM C 33, sand.
  - 3. Coarse Aggregate: ASTM C 33, crushed gravel.

4. Water: Potable

# 2.11 IDENTIFICATION

A. Metallic-Lined Plastic Underground Warning Tapes: polyethylene plastic tape with metallic core, 6 inches wide, by 4 mils thick, solid blue in color with continuously printed caption in black letters "CAUTION - WATER LINE BURIED BELOW".

### PART 3 EXECUTION

## 3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section 312300.

### 3.2 SERVICE ENTRANCE PIPING

- A. Extend water system piping from the existing public main to a point within 5' of the proposed building.
  - 1. Terminate water system piping from the proposed public main to a point within 5' of the proposed buildings for fire protection.
- B. Water distribution systems and fire protection systems are specified in Division 15 Sections. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Basic Mechanical Materials and Methods".

# 3.3 PIPING APPLICATIONS

- A. Refer to Part 2 of this Section for detailed specifications for pipe and fittings products listed below. Use pipe, tube, fittings, and joining methods according to the following applications. Piping in pits and inside building may be joined with flanges or couplings, instead of joints indicated, for grooved-end AWWA-size piping.
- B. Use pipe, tube, fittings, and joining methods according to following applications:
  - 1. 4 inches (DN 100) to 8 inches (DN 200): Class D or Class 250, ductile-iron pipe, ductile-iron compact fittings, and mechanical joints with retainer glands.

### 3.4 JOINT CONSTRUCTION

- A. Ductile-Iron Piping Gasketed Joints: Construct joints according to AWWA C600.
- B. Flanged Joints: Align flanges and install gaskets. Assemble joints by sequencing bolt tightening. Use lubricant on bolt threads.
- C. Threaded Joints: Thread pipes with tapered pipe threads according to ASME B1.20.1, apply tape or joint compound, and apply wrench to valve ends into which pipes are being threaded.

D. Dissimilar Materials Piping Joints: Construct joints using adapters that are compatible with both piping materials, outside diameters, and system working pressure. Refer to "Piping Systems - Common Requirements" Article for joining piping of dissimilar metals.

# 3.5 PIPING SYSTEMS - COMMON REQUIREMENTS:

- A. Installation: Installation shall be in accordance with the Baltimore County Specifications; NFPA 24; the Baltimore County Plumbing Code; and the written recommendations of the pipe manufacturer, except that in the case where there are conflicts among the provision of the various installation requirements, the more stringent or restrictive requirements shall govern.
- B. General Locations and Arrangements: Drawings indicate general locations and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated except where deviations to layout are approved on coordination drawings.
- C. Install components having pressure rating equal to or greater than system rated pressure (200 psig).
- D. Install piping free of sags and bends.
- E. Install fittings for changes in direction.
- F. Piping Connections: Except as otherwise indicated, making piping connections as specified below.
  - 1. Install flanges, in piping 2-1/2 inches and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
  - 2. Install dielectric fittings to connect piping of dissimilar metals.

# 3.6 PIPING INSTALLATION

- A. Comply with requirements of NFPA 24 for materials and installation.
  - 1. Bury piping at minimum depth of 48 inches below finished grade, and not less than 18 inches below average local frost depth.

## 3.7 ANCHORAGE INSTALLATION:

- A. Anchorages: Install anchorages for tees, plugs/caps, and bends. Include anchorages for the following piping systems:
  - 1. Gasketed-Joint, Ductile-Iron Piping: According to AWWA C600.
- B. Apply full coat of asphalt or other acceptable corrosion retarding to surfaces of installed ferrous anchorage devices.

C. Anchorage blocks shall be constructed of a poured reinforced concrete pad, which partially encapsulates the fitting and prevents any relative movement between the straight section of the fitting and the branch section.

## 3.8 IDENTIFICATION INSTALLATION

A. Install continuous plastic underground warning tape during back filling of trench for underground water service piping. Locate 6 inches to 8 inches below finished grade, directly over piping.

### 3.9 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after thrust blocks have hardened sufficiently. Fill pipeline 24 hours prior to testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests: Test at not less than 2 times operating pressure for 2 hours.
  - 1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 1000 joints. Remake leaking joints with new materials and repeat test until leakage is within above limits.

#### 3.10 CLEANING

- A. Clean and disinfect water distribution piping as follows:
  - 1. Purge new water distribution piping systems and parts of existing systems that have been altered, extended, or repaired prior to use.
  - 2. Use purging and disinfecting procedures prescribed by Baltimore County Specifications and NFPA.
- B. Prepare reports for purging and disinfecting activities.

## **END OF SECTION**

## SECTION 33 30 00 – SANITARY SEWERAGE UTILITIES

### PART 1 GENERAL

### 1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. General Conditions of the Baltimore County Board of Education's Specifications for Site Development.
- C. Baltimore County Department of Public Works Standard Details for Construction dated 2007 and as amended.
- D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

### 1.2 SUMMARY

- A. This Section includes sanitary sewage disposal systems five feet (5') outside the building.
- B. Related Sections:
  - 1. Section 312300; Excavating and Filling.
  - 2. Section 03; Cast-In-Place Concrete.
  - 3. Refer to sections relating to plumbing piping and drainage and vent systems in Division 22.

## 1.3 DEFINITIONS

- A. Wastewater: Sewage, water or other liquid requiring disposal.
- B. Sewage Piping: System of pipe, fittings, and appurtenances for gravity flow of wastewater.

#### 1.4 SYSTEM PERFORMANCE REQUIREMENTS

A. Solid Piping Rating: At least equal to system operating pressure.

## 1.5 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Shop drawings for the following precast, reinforced concrete structures, including

manhole openings, covers, pipe connections, and accessories.

C. Coordination drawings showing piping, underground structures, and other utilities. Indicate size and invert elevations of piping and structures.

## 1.6 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with provisions of the local health department and authorities having jurisdiction.
- B. Product Options: Drawings indicate sizes, profiles, connections and dimensional requirements of septic system components. Manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Product Substitutions."

# 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic pipe or fittings in direct sunlight.
- B. Protect pipe, pipefittings, and seals from dirt and damage.
- C. Handle pre-cast concrete structures according to manufacturers rigging instructions.

# 1.8 PROJECT CONDITIONS

- A. Site Information Data in subsurface investigation reports was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as representations or warranties of accuracy or continuity between soil borings. The Owner, Architect or Engineers will not be responsible for interpretations or conclusions drawn from this data by the Contractor.
  - 1. Additional test borings and other exploratory operations may be performed by the Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.
- B. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by the Architect and then only after acceptable temporary utility services have been provided. If existing utilities are indicated to be abandoned, the Contractor shall remove such utility, if necessary, at no additional cost to the Owner.
  - 1. Provide a minimum 48-hours notice to the Architect and receive written notice to proceed before interrupting any utility.

## PART 2 PRODUCTS

## 2.1 PIPES AND FITTINGS

A. Refer to Part 3 "Piping Applications" Article for identification of systems where

piping materials specified below are used.

- B. Polyvinyl Chloride (PVC) Sewer Pipe and Fittings: ASTM D 3034, SDR 26, nonperforated, for solvent-cement or elastomeric gasket joints.
  - 1. Solvent Cement: ASTM D 2564.
  - 2. Gaskets: ASTM F 477, elastomeric seal.
- C. Sleeve-Type Couplings: Rubber or elastomeric sleeve and band assembly fabricated to match outside diameters of pipes to be joined.
  - 1. Sleeves for Plastic Pipe: ASTM F 477, elastomeric seal.
  - 2. Bands: Stainless steel, at least one at each pipe insert.
- D. Gasket-Type Couplings: Rubber or elastomeric compression gasket, made to match outside diameter of smaller pipe and inside diameter or hub or adjoining larger pipe.
  - 1. Gaskets for Plastic Pipe: ASTM F 477, elastomeric seal.
  - 2. Gaskets for Dissimilar Pipes: Compatible with pipe materials being joined.

# 2.2 CLEANOUTS

A. Description: ASME A112.36.2M, with round, flanged, cast-iron housing, and secured scoriated, medium-dry loading class, cast-iron cover. Include cast-iron ferrule and countersunk brass cleanout plug.

## 2.3 MANHOLES

- A. Precast Concrete Manholes: ASTM C 478, precast reinforce concrete, of depth indicated, with provision for rubber gasket joints, and frame and cover; all in accordance with Baltimore County Standard Details. Include indented top design with lettering, equivalent to the following cast into cover:
  - 1. Sanitary Sewer Piping Systems: Sanitary Sewer

## PART 3 EXECUTION

## 3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section 312300 "Excavating and Filling".
- 3.2 IDENTIFICATION
  - A. Identification materials and their installation are specified in Division 31 Section "Excavating and Filling". Arrange for installation of green warning tapes directly over piping (including absorption field piping), at outside edges of underground structures, and at outside edges of seepage pits.

1. Use detectable warning tape over edges of underground structures, edges of seepage pits, and over nonferrous piping.

## 3.3 GENERAL INSTALLATION

- A. Installation: Installation shall be in accordance with the requirements of the Baltimore County Specifications, and in accordance with the Drawings.
- B. Where installation details are not shown on the Drawings, installation shall be in accordance with the Baltimore County Standard Details.
- C. Termination: Terminate piping 5' from building foundation in location as indicated. Provide temporary pipe plug for piping extension into building by work of Division 22.

## 3.4 PIPING APPLICATIONS

- A. Refer to Part 2 of this Section for detailed specifications for pipe and fitting products listed below.
- B. Use pipe, tube, fittings, and joining methods according to the following applications.
  - 1. Solid Piping: Polyvinyl Chloride (PVC), non-perforated sewer pipe and fittings and solvent-cemented or gasketed joints.

## 3.5 PIPE JOINT CONSTRUCTION AND INSTALLATION

- A Join and install polyvinyl chloride (PVC) pipe as follows:
  - 1. Join solvent-cement type pipe and fitting with solvent cement according to ASTM D 2855 and ASTM F402.
  - 2. Join gasketed pipe and fittings with elastromeric seals according to ASTM D 3212.
  - 3. Install solid piping according to ASTM D 2321.

## 3.6 CLEANOUT INSTALLATION

- A. Install cleanouts and extension for mapping to cleanout at grade as indicated. Set cleanout housing and cover in concrete block 18 by 18 by 12 inches deep, except where location is in concrete paving. Set top of cleanout 1 inch above surrounding earth grade, or flush with grade when installed in paving.
- B. Cleanout installed in paving shall have countersunk lid.
- C. Refer to Division 3 Section "Cast-in-Place Concrete" for formwork, reinforcing and concrete.
- 3.7 CONNECTIONS

A. Install standard manhole over existing sanitary sewer and connect proposed sanitary.

# 3.8 FIELD QUALITY CONTROL

- A. System Tests: After installation, pipe shall be inspected visually for deflections and misaligned pipe sections.
  - 1. All sewers shall be tested in accordance with Category 3of the Baltimore County Specifications, except that Contractor shall supply all materials needed for testing.
  - 2. Additional Tests: Fill underground structures with water and let stand overnight. If water level recedes, locate and repair leaks and retest. Repeat tests and repair until there is no leakage.
  - 3. Cleaning: Clear interior of piping and structures of dirt and other superfluous materials as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of day or whenever work stops.

# END OF SECTION

## SECTION 33 40 00 - STORM DRAINAGE UTILITIES

#### PART 1 GENERAL

### 1.1 RELATED DOCUMENTS

- A. Requirements of the General Provisions apply to all work under this section.
- B. General Conditions and Section 4 of the Baltimore County Board of Education's Specifications for Site Development.
- C. Baltimore County Department of Public Works Standard Details for Construction dated 2007 and as amended.
- D. Throughout the specifications, types of materials may be specified by manufacturer's name and catalogue number in order to establish standards of quality and performance and not for the purpose of limiting competition. Alternate methods and/or materials may be submitted to the Architect for consideration. Those judged to be equal to that specified will receive written approval.

### 1.2 SUMMARY

- A. This Section includes drainage systems five feet (5') outside the building. Systems include the following:
  - 1. Storm drainage
  - 2. Stormwater Management Facility
- B. Related Sections:
  - 1. Section 312300; Excavating and Filling.
  - 2. Refer to sections relating to plumbing piping, drainage and vent systems and laboratory systems in Division 22.

### 1.3 DEFINITIONS

A. Drainage Piping: System of pipe, fittings, and appurtenances for gravity flow of storm drainage.

#### 1.4 PERFORMANCE REQUIREMENTS:

- A. Gravity-Flow, Nonpressure-Piping Pressure Ratings: At least equal to system test pressure.
- B. Stormwater Management Permit: Stormwater management facilities shall be constructed in accordance with the approved drawings and the provisions of the Stormwater Management Permit. The Owner will obtain the Stormwater Management Permit prior to construction of the facility.
- C. Certification of Completed Facilities: As-Built Plans and Certifications are required

for the stormwater management facilities. In order to properly prepare these documents, this stormwater management facility must be inspected by a Registered Professional Engineer at specific stages of the construction. The Contractor shall notify the Owner at least five (5) working days prior to starting work on this stormwater management facility. The Contractor shall provide an As-built survey of the stormwater management facility signed and sealed by a Registered Surveyor in hard copy as well as CADD format. Preparation and processing of the As-Built Plans and Certification will be the responsibility of the Owner.

## 1.5 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for the following:
  - 1. Cleanouts.
- C. Shop drawings for precast concrete manholes and other structures. Include frames, covers and grates.
- D. Shop drawings for the various types of piping.
- E. Shop drawings for cast-in-place concrete or field-erected masonry manholes and other structures. Include frames, covers and grates.
- F. Reports and calculations for design mixes for each class of cast-in-place concrete.
- G. Inspection and test reports specified in the "Field Quality Control" Article.

### 1.6 QUALITY ASSURANCE

- A. Environmental Agency Compliance: Comply with regulations pertaining to sanitary sewerage and storm drainage systems.
- B. Utility Compliance: Comply with regulations pertaining to sanitary sewerage and storm drainage systems. Include standards of water and other utilities where appropriate.
- C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of system components and are based on specific manufacturer types indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Product Substitutions".

# 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic structures in direct sunlight.
- B. Do not store plastic pipe or fittings in direct sunlight.

- C. Protect pipe, pipefittings, and seals from dirt and damage.
- D. Handle precast concrete manholes and other structures according to manufacturer's rigging instructions.
- E. Stone to be delivered and placed immediately in the water quality facility and protected from soil contamination.

## 1.8 PROJECT CONDITIONS

- A. Site Information: Data in subsurface investigation reports was used for the basis of the design. The data in the subsurface investigation report is not a part of the Contract. Conditions are not intended as presentations or warranties of accuracy or continuity between soil borings. The Owner, Architect or Engineers will not be responsible for interpretations or conclusions drawn from this data by the Contractor.
  - 1. Additional test borings and other exploratory operations may be performed by the Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.
- B. Locate existing structures and piping to be closed and abandoned.
- C. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted under the following conditions and then only after arranging to provide acceptable temporary utility services.
  - 1. Notify Architect not less than 48 hours in advance of proposed utility interruptions.
  - 2. Do not proceed with utility interruptions without receiving Architect's written permission.
- D. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

## 1.9 SEQUENCING AND SCHEDULING

- A. Coordinate with interior building drainage systems.
- B. Coordinate with other utility work.

## PART 2 PRODUCTS

# 2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1. Cleanouts
  - a. Ancon, Inc.
  - b. Jones Manufacturing Co., Inc.
  - c. Josam Co.
  - d. Rockford Sanitary Systems, Inc.
  - e. Jay R. Smith Mfg. Co. Div., Smith Industries, Inc.
  - f. Wade Div., Tyler Corp.
  - g. Zurn Industries, Inc., Hydromechanics Div.

# 2.2 PIPES AND FITTINGS

- A. High Density Polyethylene (HDPE) Pipe and Fittings Hancor Blue Seal Water Tight: As manufactured by Advanced Drainage Systems, Inc. or approved equal.
- B. Reinforced-Concrete Pipe and Fittings: ASTM C 76, Class IV, Wall B, for gasketed joints.
  - 1. Gaskets: ASTM C 443, rubber.
- C. High Density Polyethylene (HDPE) perforated pipe and fittings. Fittings Hancor Blue Seal Water Tight, as manufactured by Advanced Drainage Systems, Inc. or approved equal.

## 2.3 SPECIAL PIPE COUPLINGS AND FITTINGS

- A. Sleeve-Type Pipe Couplings: Rubber or elastomeric sleeve and band assembly fabricated to match outside diameters of pipes to be joined, for Nonpressure joints.
  - 1. Sleeves for Concrete Pipe: ASTM C 443 (ASTM C 443M), rubber.
  - 2. Sleeves for Plastic Pipe: ASTM F 477, elastomeric seal.
  - 3. Sleeves for Dissimilar Pipes: Compatible with pipe materials being joined.
  - 4. Bands: Stainless steel, at least one at each pipe insert.

## 2.4 MANHOLES

- A. Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for rubber gasket joints, and frame and cover, all in accordance with Baltimore County Standard Details. Include indented top design with lettering, equivalent to the following, cast into cover:
  - 1. Storm Drainage Piping Systems: "STORM DRAIN".

## 2.5 STORM DRAIN INLETS

A. General: Pre-cast reinforced concrete, or cast-in-place concrete complete with frames

and grates, all in accordance with Baltimore County Standard Details unless otherwise noted on the contract drawings.

# 2.6 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318, ACI 350R, and the following:
  - 1. Cement: ASTM C 150, Type II.
  - 2. Fine Aggregate: ASTM C 33, sand.
  - 3. Coarse Aggregate: ASTM C 33, crushed gravel.
  - 4. Water: Potable.

b.

- B. Structures: Portland-cement design mix, 4000 psi minimum, with 0.45 maximum water-cement ratio.
  - 1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
  - 2. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.
- C. Structure Channels and Benches: Factory or held formed from concrete. Portlandcement design mix, 4000-psi minimum, with 0.45 maximum water-cement ratio.
  - 1. Include channels and benches in manholes.
    - a. Manholes Channels: Concrete invert, formed to same width as connected piping, with height of the vertical sides to 3/4 of the pipe diameter. Form curved channels with smooth, uniform radius and slope.
      - (1) Invert Slope: 2.5 percent (1:40) through manhole.
      - Manhole Benches: Concrete, sloped to drain into channel.
        (a) Slope: 1 inch per foot (1:12).
      - Include channels and benches in storm drain inlets.
      - Storm Drain Inlet Channels: Concrete invert, formed to same width as connected piping, with height of the vertical sides to 3/4 of the pipe diameter. Form curved channels with smooth, uniform radius and slope.
        - (a) Invert Slope: 2.5 percent (1:40) through inlet.
      - (2) Storm Drain Inlet Benches: Concrete, sloped to drain into channel.
        - (b) Slope: 1 inch per foot (1:12).
  - 2. Ballast and Pipe Supports: Portland-cement design mix, 3000-psi minimum, with 0.58 maximum water-cement ratio.
    - a. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
    - b. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel.

# 2.7 PROTECTIVE COATINGS

- A. General: Include factory or field-applied protective coatings to structures and appurtenances according to the following:
- B. Coating: Apply 2-coats, coal-tar epoxy, 15-mil minimum thickness, except where otherwise indicated.

- 1. Manholes: On exterior surfaces.
- 2. Storm Drain Inlets: On exterior surfaces.

# 2.8 CLEANOUTS

- A. Description: ASME A112.36.2M, round, cast-iron housing with clamping device and found, secured, scoriated, cast-iron cover. Include cast-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug. Use units with top-loading classifications according to the following applications:
  - 1. Light Duty: In earth or grass, foot-traffic areas.
  - 2. Medium Duty: In paved, foot-traffic areas.
  - 3. Heavy Duty: In vehicle-traffic service areas.
- B. Pipe Fitting and Riser to Cleanout: ASTM A 74, service class, cast-iron soil pipe and fittings.

# 2.9 RIPRAP

A. Stone for riprap shall be uniformly graded from the smallest to the largest pieces as specified in the Contract Documents. The stone will be accepted upon visual inspection at the point of usage, and shall conform to the following:

CLASS OF RIPRAP	WEIGHT RANGES lb (kg)	APPROX. SIZE in. (mm)
0	1-33 (0.5 – 15)	2-7 (50-175)
Ι	2-150 (1-70)	3-12 (75-300)
II	20-700 (10-320)	6-20 (150-500)
III	40-2000 (20-910)	8-28 (200-700)

## 2.10 GEOTEXTILES

- A. Geotextiles shall conform to the class specified in the Contract Documents. The geotextile shall be manufactured from fibers consisting of long chain synthetic polymers, composed of a minimum 85 percent by weight of polyolephins, polyesters or polyamides. The geotextile shall resist deterioration from ultraviolet exposure. Geotextiles used in the construction of silt fence shall contain sufficient amounts of ultraviolet ray inhibitors and stabilizers to provide a minimum of 12 months of expected usable construction life at a temperature range of 0 to 120F (-18 to 49 C).
- B. All values specified are minimum or maximum roll values.

C. Classes SD, PE, SE, ST, F, and E Geotextiles shall have a 0.010 cm/sec minimum permeability when tested in conformance with D4491, and an apparent minimum elongation of 20 percent when tested for conformance with the grab tensile strength requirements specified below. Classes shall also conform to the following additional requirements:

GEOTEXTILE CLASS	MAXIMU M APPAREN T OPENING SIZE mm	GRAB TENSILE STRENGTH lb min.	BURST STRENGTH PSI min.	PUNCTURE STRENGTH lb
SD – Type I	0.43	250	500	90
SD – Type I	0.25	250	500	90
PE – Type I	0.43	250	320	90
PE – Type II	0.25	250	320	90
PE – Type III	0.22	250	320	90
SE	0.30	250	320	90
ST	0.15**	300	145	110
F	0.60	100	190	-
Е	0.30	90	145	30

SD – Subgrade Drainage

PE - Permanent Erosion Control

SE – Separation

ST - Stabilization

E – Filter Covering

F – Silt Fence

\*\* MINIMUM Apparent Opening Size

- Class F Geotextiles (Silt Fence) shall have a 50 lb/in. (8.8kN/m) minimum tensile strength and a D. 20 lb/in. (3.5kN/m) minimum tensile modulus when tested in conformance with D4595. The material shall also have a 0.3 gal/ft<sup>2</sup> (12.21/m<sup>2</sup>) per minute minimum flow rate and a 75 percent minimum filtering efficiency when tested in conformance with D 5141.
  - E. The properties shall be determined as follows:

TEST	METHOD
Apparent Opening Size	D 4751

Grab Tensile Strength	D 4632, Grab Test – 4 x 8 in. (100 x 200 mm) specimen, 1 x 2 in. (25 x 50 mm) clamps; 12 in. (300 mm)/minute strain rate both principal directions of geotextile.
Burst Strength	D3786
Puncture Strength	D 6241

Sewing of the geotextile will be allowed provided it conforms to the following:

- a) Seams shall be either "J" or "butterfly" type and shall utilize a lock stitch.
- b) Seams shall conform to the tensile strength requirements for the geotextile when tested

across the seam.

c) The thread for seaming shall be of equal or greater durability than the geotextile itself.

### PART 3 EXECUTION

## 3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section 312300-"Excavating and Filling".

## 3.2 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section 312300. Arrange for installation of green detectable warning tapes directly over piping and at outside edges of underground structures.

## 3.3 PIPING APPLICATIONS

- A. General: Include watertight, silttight, or soiltight joints, except where watertight or silttight joints are indicated.
- B. Refer to Part 2 of this Section for detailed specifications for pipe and fitting products listed below. Use pipe, fittings, and joining methods according to the following applications.
- C. Corrugated Polyethylene (HDPE), Hancor Blue Seal corrugated polyethylene pipe installed per manufacturers' specifications.
- C. Reinforced-concrete sewer pipe and fittings; rubber gaskets; and gasketed joints.

#### 3.4 SPECIAL PIPE COUPLING AND FITTING APPLICATIONS

A. Special Pipe Couplings: Use where indicated and where required to join piping and no other appropriate method is specified. Do not use instead of specified joining

#### methods.

- 1. Use the following pipe couplings for nonpressure applications:
  - a. Strait-pattern, sleeve type to join piping, of same size, with small difference in outside diameters.
  - b. Increaser/reducer-pattern, sleeve type to join piping of different sizes.
  - c. Gasket type to join piping of different sizes where annular space between smaller piping's outside diameter and larger piping's inside diameter permits installation.
  - d. Internal-expansion type to join piping with same inside diameter.
- B. Special Pipe Fittings: Use where indicated.
- 3.5 INSTALLATION, GENERAL
  - A. General Locations and Arrangements: Drawings (plans and details) indicate the general location and arrangement of underground drainage systems piping. Location and arrangement of piping layout take into account many design considerations. Install piping as indicated, to extent practical and in accordance with the requirements of the Baltimore County Specifications and in accordance with the pipe manufacturer's written instructions. Where installation details are not shown on the Drawings, installation shall be in accordance with the Baltimore County Standard Details.
  - B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's recommendations for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.
  - C. Use manholes for changes in direction.
  - D. Use proper size increasers, reducers, and couplings, where different sizes or materials of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited, except as indicated on the plans.
  - E. Install piping at constant slope between points and elevations indicated. Install straight piping runs at constant slope, not less than that specified, where slope is not indicated.
  - F. Extend piping and connect to building's storm drains, of sizes and in locations indicated. Terminate piping as indicated.
  - G. Install piping pitched down in direction of flow, at minimum slope of 1 percent (1:100) and 36-inch minimum cover, except where otherwise indicated.

## 3.6 PIPE JOINT CONSTRUCTION AND INSTALLATION

- A. General: Join and install pipe and fittings according to the following.
- B. Corrugated Polyethylene (HDPE) Plastic Pipe and Fittings: Join and install in accordance with manufacturer's instructions.

- C. Concrete Pipe and Fittings: Install according to ACPA "Concrete Pipe Handbook". Use the following seals:
  - 1. Round Pipe and Fittings: ASTM C 443 (ASTM C 443M), rubber gaskets.
- D. Join piping made of different materials or dimensions with couplings made for this application. Use couplings that are compatible with and fit both systems materials and dimensions.

## 3.7 MANHOLE INSTALLATION

- A. General: Install manholes, complete with accessories, as indicated.
- B. Form continuous concrete channels and benches between inlets and outlet, where indicated.
- C. Set tops of frames and covers flush with finished surface where manholes occur in pavements. Set tops 3 inches above finished surface elsewhere, except where otherwise indicated.
- D. Place precast concrete manhole sections as indicated, and install according to ASTM C 891.
  - 1. Provide rubber joint gasket complying with ASTM C 443, at joints of sections.
  - 2. Apply bituminous mastic coating at joints of sections.
- E. Construct cast-in-place manholes as indicated.

#### 3.8 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318, ACI 350R, and as indicated.

#### 3.9 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use castiron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.
- B. Set cleanout frames and covers in concrete paving with tops flush with Surface of paving.
- C. Cleanouts located in paving shall have countersunk lids.

## 3.10 CLOSING ABANDONED DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping that is

indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either of the following procedures:

- 1. Close open ends of piping with at least 8-inch-thick brick masonry bulkheads.
- 2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
- B. Abandoned Structures: Excavate around structure as required and use either of the following procedures:
  - 1. Remove structure and close open ends of remaining piping.
  - 2. Remove top of structure down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.
  - 3. Backfill to grade according to Division 31 "Excavating and Filling".

## 3.11 FIELD QUALITY CONTROL

- A. Clear interior of piping and structures of dirt and superfluous material as the work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.
  - 1. In large, accessible piping, brushes and brooms may be used for cleaning.
  - 2. Place plug in end of incomplete piping at end of day and whenever work stops.
  - 3. Flush piping between manholes and other structures, if required by authorities having jurisdiction, to remove collected debris.
- B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of the Project.
  - 1. Submit separate reports for each system inspection.
  - 2. Defects requiring correction include the following:
    - a. Alignment: Less than full diameter of inside of pipe is visual between structures.
    - b. Deflection: Flexible piping with deflection that prevents passage of a ball or cylinder of a size not less than 92.5 percent of piping diameter.
    - c. Crushed, broken, cracked, or otherwise damaged piping.
    - d. Infiltration: Water leakage into piping.
    - e. Exfiltration: Water leakage from or around piping.
  - 3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
  - 4. Reinspect and repeat procedures until results are satisfactory.
- C. Test new piping systems and parts of existing systems that have been altered,

extended, or repaired for leaks and defects.

- 1. Do not enclose, cover, or put into service before inspection and approval.
- 2. Test completed piping systems according to authorities having jurisdiction.
- 3. Schedule tests, and their inspections by authorities having jurisdiction, with at least 24 hours advance notice.
- 4. Submit separate reports for each test.
- 5. High density polyethylene "HDPE" pipe: Perform testing in accordance with manufacuturers recommendations.
- 6. Where authorities having jurisdiction do not have published procedures, perform tests as follows:
  - a. Storm Drainage: Perform hydrostatic test.
    - (1) Allowable leakage is a maximum of 200 gallons per inch nominal pipe size, for every mile of pipe, during a 24-hour period.
    - (2) Close openings in system and fill with water.
    - (3) Purge air and refill with water.
    - (4) Disconnect water supply.
    - (5) Test and inspect joints for leaks.
    - (6) Option: Test ductile-iron piping according to AWWA C600, Section 4 "Hydrostatic Testing". Use test pressure of at least 5 psig.
    - (7) Option: Test concrete piping according to ASTM C 969.
    - (8) Option: Test concrete arch piping and elliptical piping according to authorities having jurisdiction.
  - b. Storm Drainage: Perform hydrostatic test. Close openings in system and fill with water to not less than 10-foot head of water. Disconnect water supply. Water level must not drop for 15 minutes. Inspect joints for leaks.
    - (1) Option: Test concrete arch piping and elliptical piping according to authorities having jurisdiction.
  - c. Storm Drainage: Perform air test according to UNI-B-6.
    - (1) Option: Test round concrete piping, 24 inches and smaller, according to ASTM C 924.
    - (2) Option: Test concrete arch piping and elliptical piping according to authorities having jurisdiction.
- 7. Manholes: Perform hydraulic test according to ASTM C 969.
- 8. Leaks and loss in test pressure constitute defects that must be repaired.
- 9. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

# END OF SECTION