

## SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL 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. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories.
5. Precast concrete handholes.
6. Polymer concrete handholes and boxes with polymer concrete cover.
7. Fiberglass handholes and boxes with polymer concrete cover.
8. Fiberglass handholes and boxes.
9. High-density plastic boxes.

#### 1.3 DEFINITIONS

- A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
- B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- C. Duct Bank:
  1. Two or more ducts installed in parallel, with or without additional casing materials.
  2. Multiple duct banks.
- D. GRC: Galvanized rigid (steel) conduit.
- E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  1. Include duct-bank materials, including spacers and miscellaneous components.

2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include underground-line warning tape.
5. Include warning planks.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:
  - a. Include plans, elevations, sections, details, attachments to other work, and accessories.
  - b. Include duct entry provisions, including locations and duct sizes.
  - c. Include reinforcement details.
  - d. Include frame and cover design and manhole chimneys.
  - e. Include ladder details.
  - f. Include grounding details.
  - g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
  - h. Include joint details.
2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
  - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
  - b. Include duct entry provisions, including locations and duct sizes.
  - c. Include cover design.
  - d. Include grounding details.
  - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.
  1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
  2. Drawings shall be signed and sealed by a qualified professional engineer.
- B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- C. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.
- D. Source quality-control reports.
- E. Field quality-control reports.

## 1.6 MAINTENANCE MATERIALS SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

## 1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

## 1.8 FIELD 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 indicated:
  - 1. Notify Architect, Construction Manager, Owner no fewer than two weeks in advance of proposed interruption of electrical service.
  - 2. Do not proceed with interruption of electrical service without Architect's, written permission.
- B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

## PART 2 - PRODUCTS

### 2.1 METAL CONDUIT AND FITTINGS

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. Coated Steel Conduit: PVC-coated GRC.
  - 1. Comply with NEMA RN 1.
  - 2. Coating Thickness: 0.040 inch, minimum.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. AFC Cable Systems; a part of Atkore International.
  - 2. Allied Tube & Conduit; a part of Atkore International.
  - 3. Anamet Electrical, Inc.
  - 4. Calconduit.
  - 5. Electri-Flex Company.
  - 6. FSR Inc.
  - 7. Korkap.
  - 8. Opti-Com Manufacturing Network, Inc (OMNI).

9. O-Z/Gedney; a brand of Emerson Industrial Automation.
10. Perma-Cote.
11. Picoma Industries, Inc.
12. Plasti-Bond.
13. Republic Conduit.
14. Southwire Company.

D. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

## 2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ARNCO Corp.
2. Beck Manufacturing.
3. CANTEX INC.
4. CertainTeed Corporation.
5. Condux International, Inc.
6. Crown Line Plastics.
7. ElecSys, Inc.
8. Electri-Flex Company.
9. Endot Industries Inc.
10. IPEX USA LLC.
11. Lamson & Sessions.
12. Manhattan/CDT.
13. National Pipe & Plastics.
14. Opti-Com Manufacturing Network, Inc (OMNI).

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

## 2.3 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Allied Tube & Conduit; a part of Atkore International.
  - b. CANTEX INC.

- c. Carlon; a brand of Thomas & Betts Corporation.
  - d. IPEX USA LLC.
  - e. PenCell Plastics.
- B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 26 0553 "Identification for Electrical Systems."
- C. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.
- 1. Color: Red dye added to concrete during batching.
  - 2. Mark each plank with "ELECTRIC" in 2-inch-high, 3/8-inch-deep letters.

## 2.4 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
- 1. Tests of materials shall be performed by an independent testing agency.
  - 2. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
  - 3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.
- C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Division 31. Remove and stockpile topsoil for reapplication according to Division 31.

### 3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Electrical Cables More Than 600 V: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.
- B. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.
- C. Duct for Electrical Feeders 600 V and Less: Type EPC-80-PVC RNC, direct-buried unless otherwise indicated.
- D. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.
- E. Underground Ducts Crossing Driveways and Roadways: Type EPC-40 PVC RNC, encased in reinforced concrete.

### 3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
  - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-20 structural load rating.
  - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
  - 3. Cover design load shall not exceed the design load of the handhole or box.

### 3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Division 31 but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Replace area after construction vehicle traffic in immediate area is complete.
- C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top-soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 9219 "Seeding" and Section 32 9300 "Plants."
- E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 01 7000 "Execution and Closeout Requirements."

### 3.5 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct according to NEMA TCB 2.
- C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.
  - 1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.
- E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell, without reducing duct slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.
  - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to terminator spacing 10 feet from the terminator, without reducing duct line slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch.

- I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- K. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.
- L. Concrete-Encased Ducts and Duct Bank:
  - 1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified by division 31 for pipes less than 6 inches in nominal diameter.
  - 2. Width: Excavate trench 12 inches wider than duct on each side.
  - 3. Width: Excavate trench 3 inches wider than duct on each side.
  - 4. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
  - 5. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
  - 6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. 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.
  - 7. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
  - 8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
  - 9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
    - a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
      - 1) Stub-ups shall be minimum 6 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
    - c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.



- 1) Stub-ups shall be minimum 6 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
10. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. 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.
12. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
  - a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
  - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.
14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 3000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements by division 31 for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct on each side.
3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. 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.
8. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.

9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
  - a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
  - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be minimum 6 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
  - c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be minimum 6 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.
  - a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.
  - b. Place minimum 6 inches of engineered fill above concrete encasement of duct.
- N. Warning Planks: Bury warning planks approximately 12 inches above direct-buried duct, placing them 24 inches o.c. Align planks along the width and along the centerline of duct or duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.
- O. Underground-Line Warning Tape: Bury conducting underground line specified in Section 26 0553 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

### 3.6 INSTALLATION OF CONCRETE HANDHOLES, AND BOXES

- A. Precast Concrete Handhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
  2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
  3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- B. Elevations:
1. Install handholes with bottom below frost line. Contractor will verify frost line at this project and depth below grade.
  2. Handhole Covers: In paved areas and traffic ways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
  3. Where indicated, cast handhole cover frame integrally with handhole structure.
- C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
- D. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
  2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.
- E. Waterproofing: Apply waterproofing to exterior surfaces of handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 07 1300 "Sheet Waterproofing." After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
- F. Damp proofing: Apply damp proofing to exterior surfaces of and handholes after concrete has cured at least three days. Damp proofing materials and installation are specified in Section 07 1113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, damp proof joints and connections, and touch up abrasions and scars. Damp proof exterior of manhole chimneys after mortar has cured at least three days.
- G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
- H. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- I. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

### 3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and traffic ways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
- D. Install handholes and boxes with bottom below frost line. Contractor will verify frost line at this project site and dimension below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, non-deliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
  - 1. Concrete: 3000 psi, 28-day strength, complying with Section 03 3000 "Cast-in-Place Concrete," with a troweled finish.
  - 2. Dimensions: 10 inches wide by 12 inches deep.

### 3.8 GROUNDING

- A. Ground underground ducts and utility structures according to Section 26 0526 "Grounding and Bonding for Electrical Systems."

### 3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
  - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.

3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 0526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Prepare test and inspection reports.

### 3.10 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump.
  1. Sweep floor, removing dirt and debris.
  2. Remove foreign material.

END OF SECTION 26 0543

## SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

### 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. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

- B. Related Requirements:

1. Section 07 8400 "Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

### PART 2 - PRODUCTS

#### 2.1 SLEEVES

- A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

- C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- F. Sleeves for Rectangular Openings:
  - 1. Material: Galvanized sheet steel.
  - 2. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
    - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

## 2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 2. Pressure Plates: Carbon steel.
  - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

## 2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

## 2.4 GROUT

- A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## 2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
  - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

## PART 3 - EXECUTION

### 3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 9200 "Joint Sealants."
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
  - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
  - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
  - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.



- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

### 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install 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.

### 3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 26 0544

## SECTION 26 0550 - INSTALLATION COORDINATION

### PART 1 - GENERAL

#### 1.1 REQUIREMENTS

- A. See Division 21, Section 21 0549, Fire Protection and Electrical Installation Coordination.
- B. See Division 22, Section 22 0549, Plumbing & Electrical Installation Coordination.
- C. See Division 23, Section 23 0549, HVAC and Electrical Installation Coordination.
- D. See Mechanical Drawings for control requirements and for items requiring 120V power.

### PART 2 - PRODUCTS

Not applicable.

### PART 3 - EXECUTION

Not applicable.

END OF SECTION 26 0550

## SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL 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. Color and legend requirements for raceways, conductors, and warning labels and signs.
  - 2. Labels.
  - 3. Bands and tubes.
  - 4. Tapes and stencils.
  - 5. Tags.
  - 6. Signs.
  - 7. Cable ties.
  - 8. Paint for identification.
  - 9. Fasteners for labels and signs.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.
- D. Delegated-Design Submittal: For arc-flash hazard study.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1 and IEEE C2.
- B. Comply with NFPA 70.

- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Comply with NFPA 70E and Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
  - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.
- H. All boxes and enclosures, including transfer switches, generators and power panels, for emergency circuits shall be permanently marked so they will be identified as a component of the emergency circuit of system. NFPA 70, 700.9(A).

## 2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
  - 1. Black letters on an orange field.
  - 2. Legend: Indicate voltage and system or service type.
  - 3. Colors: As follows:
    - a. 120/208 Volt – Black.
    - b. 277/480 Volt – Blue.
    - c. Emergency 120/208 Volt – Black and orange.
    - d. Emergency 277/480 Volt – Blue and orange.
    - e. Fire-Alarm System: Red.
    - f. Fire-Suppression Supervisory and Control System: Red and yellow.
    - g. Combined Fire-Alarm and Security System: Red and blue.
    - h. Security System: Blue and yellow.
    - i. Mechanical and Electrical Supervisory System: Green and blue.
    - j. Data System: Green and yellow.
    - k. Television Systems: Green and White.
    - l. Sound/PA: Orange.
    - m. Telephone: Orange and yellow.
- B. Color-Coding for Phase and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit, conductors.
  - 1. Color shall be factory applied No. 12 AWG.
  - 2. Colors for 208/120-V Circuits:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.

3. Colors for 240-V Circuits:
    - a. Phase A: Black.
    - b. Phase B: Red.
  4. Colors for 480/277-V Circuits:
    - a. Phase A: Brown.
    - b. Phase B: Orange.
    - c. Phase C: Yellow.
  5. Color for Neutral: White.
  6. Color for Equipment Grounds: Green.
  7. Colors for Isolated Grounds: Green with white stripe.
- C. Raceways and Cables Carrying Circuits at More Than 600 V:
1. Black letters on an orange field.
  2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- D. Warning Label Colors:
1. Identify system voltage with black letters on an orange background.
- E. Warning labels and signs shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
  2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
- F. Equipment Identification Labels:
1. Black letters on a white field.
  2. Label all electrical distribution equipment down to 100A.

## 2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Brady Corporation.
    - b. Champion America.
    - c. emedco.
    - d. Grafoplast Wire Markers.
    - e. HellermannTyton.
    - f. LEM Products Inc.

- g. Marking Services, Inc.
  - h. Panduit Corp.
- B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Brady Corporation.
    - b. HellermannTyton.
    - c. Marking Services, Inc.
    - d. Panduit Corp.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. A'n D Cable Products.
    - b. Brady Corporation.
    - c. Brother International Corporation.
    - d. emedco.
    - e. Grafoplast Wire Markers.
    - f. Ideal Industries, Inc.
    - g. LEM Products Inc.
    - h. Marking Services, Inc.
    - i. Panduit Corp.
  - 2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
  - 3. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.
  - 4. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. A'n D Cable Products.
    - b. Brady Corporation.
    - c. Brother International Corporation.
    - d. emedco.
    - e. Grafoplast Wire Markers.
    - f. HellermannTyton.
    - g. Ideal Industries, Inc.

- h. LEM Products Inc.
- i. Marking Services, Inc.
- j. Panduit Corp.

2. Minimum Nominal Size:

- a. 1-1/2 by 6 inches for raceway and conductors.
- b. 3-1/2 by 5 inches for equipment.
- c. As required by authorities having jurisdiction.

## 2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Brady Corporation.
- b. HellermannTyton.
- c. Marking Services, Inc.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

- a. Brady Corporation.

## 2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Carlton Industries, LP.
- b. Champion America.
- c. HellermannTyton.
- d. Ideal Industries, Inc.
- e. Marking Services, Inc.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Brady Corporation.
  - b. Carlton Industries, LP.
  - c. emedco.
  
- C. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and is 12 inches wide. Stop stripes at legends.
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. HellermannTyton.
    - b. LEM Products Inc.
    - c. Marking Services, Inc.
  
- D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
  1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Carlton Industries, LP.
  
- E. Underground-Line Warning Tape:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Brady Corporation.
    - b. Ideal Industries, Inc.
    - c. LEM Products Inc.
    - d. Marking Services, Inc.
    - e. Reef Industries, Inc.
  
  2. Tape:
    - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
    - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
    - c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
  
  3. Color and Printing:
    - a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
    - b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE"



- c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
- 4. Tag: Type II:
  - a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
  - b. Width: 3 inches.
  - c. Thickness: 12 mils.
  - d. Weight: 36.1 lb/1000 sq. ft.
  - e. Tensile according to ASTM D 882: 400 lbf and 11,500 psi.
- F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

## 2.6 TAGS

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Brady Corporation.
    - b. Carlton Industries, LP.
    - c. emedco.
    - d. Marking Services, Inc.
- B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Brady Corporation.
    - b. Carlton Industries, LP.
    - c. emedco.
    - d. Grafoplast Wire Markers.
    - e. LEM Products Inc.
    - f. Marking Services, Inc.
    - g. Panduit Corp.
- C. Write-on Tags:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Carlton Industries, LP.

- b. LEM Products Inc.
- 2. Polyester Tags: 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment.
- 3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
- 4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

## 2.7 SIGNS

### A. Baked-Enamel Signs:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Carlton Industries, LP.
  - b. Champion America.
  - c. emedco.
- 2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
- 3. 1/4-inch grommets in corners for mounting.
- 4. Nominal Size: 7 by 10 inches.

### B. Metal-Backed Butyrate Signs:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Brady Corporation.
  - b. Champion America.
  - c. emedco.
- 2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
- 3. 1/4-inch grommets in corners for mounting.
- 4. Nominal Size: 10 by 14 inches.

### C. Laminated Acrylic or Melamine Plastic Signs:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Brady Corporation.
  - b. Carlton Industries, LP.
  - c. emedco.
- 2. Engraved legend.

3. Thickness:
  - a. For signs up to 20 sq. in., minimum 1/16 inch thick.
  - b. For signs larger than 20 sq. in., 1/8 inch thick.
  - c. Engraved legend with Black letters on white face.
  - d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
  - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

## 2.8 CABLE TIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. HellermannTyton.
  2. Ideal Industries, Inc.
  3. Marking Services, Inc.
- B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
  1. Minimum Width: 3/16 inch.
  2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
  3. Temperature Range: Minus 40 to plus 185 deg F.
  4. Color: Black, except where used for color-coding.
- C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
  1. Minimum Width: 3/16 inch.
  2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
  3. Temperature Range: Minus 40 to plus 185 deg F.
  4. Color: Black.
- D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
  1. Minimum Width: 3/16 inch.
  2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
  3. UL 94 Flame Rating: 94V-0.
  4. Temperature Range: Minus 50 to plus 284 deg F.
  5. Color: Black.

## 2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

### 3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
  - 1. Secure tight to surface of conductor, cable, or raceway.
- H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
  - 1. Secure tight to surface of conductor, cable, or raceway.
- I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- J. Stand-By Power Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

- K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
  - 1. "POWER."
  - 2. "STAND-BY POWER"
- M. Vinyl Wraparound Labels:
  - 1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
  - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.
- O. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.
- P. Self-Adhesive Labels:
  - 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
  - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
- Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.
- R. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.
- S. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
- T. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
  - 1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- U. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.
- V. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.
- W. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

X. Metal Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

Y. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

Z. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

AA. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

BB. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

CC. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

DD. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

### 3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch-high, black letters on 20-inch centers.
  - 1. Locate identification at changes in direction, at penetrations of walls and floors, and at 10-foot maximum intervals.
- D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
  - 1. "POWER."
- E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use snap-around color-coding bands to identify the phase.
  - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.
- G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.
- H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.
- I. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
- J. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
  - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
- K. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

- L. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:
  - 1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
  - 2. Wall surfaces directly external to raceways concealed within wall.
  - 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
  
- M. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
  
- N. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.
  
- O. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
  - 1. Apply to exterior of door, cover, or other access.
  - 2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
    - a. Power-transfer switches.
    - b. Controls with external control power connections.
  
- P. Arc Flash Warning Labeling: Self-adhesive labels.
  
- Q. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.
  
- R. Equipment Identification Labels:
  - 1. Install identification as follows:
  
  - 2. Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Except as otherwise indicated, provide a single line of text with 1/2-inch high lettering on 1-1/2-inch high label; where 2 lines of text are required, use lettering 2 inches high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment.  
 Example: *Panel 1H1 120/208V, 3-PH, 4-wire, AIC, Amperage, fed from panel MDR-CCT#4.*
  
  - 3. Indoor Equipment: Laminated acrylic or melamine plastic sign.
  - 4. Outdoor Equipment: Laminated acrylic or melamine sign.
  - 5. Equipment to Be Labeled:
    - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.



- b. Enclosures and electrical cabinets.
  - c. Access doors and panels for concealed electrical items.
  - d. Switchgear.
  - e. Switchboards.
  - f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
  - g. Substations.
  - h. Emergency system boxes and enclosures.
  - i. Motor-control centers.
  - j. Enclosed switches.
  - k. Enclosed circuit breakers.
  - l. Enclosed controllers.
  - m. Variable-speed controllers.
  - n. Push-button stations.
  - o. Power-transfer equipment.
  - p. Contactors.
  - q. Remote-controlled switches, dimmer modules, and control devices.
  - r. Battery-inverter units.
  - s. Battery racks.
  - t. Power-generating units.
  - u. Monitoring and control equipment.
  - v. UPS equipment.
6. Circuits: Apply identification labels of engraved plastic laminate on each switch and receptacle indicating panelboard and circuit number supplying receptacle. Handwrite circuit behind cover plate.
7. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

END OF SECTION 26 0553

## SECTION 26 0572 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

### 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 a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

#### 1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Short-circuit study input data, including completed computer program input data sheets.
  - 2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
    - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

- b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

## 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Short-Circuit Study Specialist.
- B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

## 1.6 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

## PART 2 - PRODUCTS

### 2.1 COMPUTER SOFTWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. CGI CYME.
  - 2. EDSA Micro Corporation.
  - 3. ESA Inc.
  - 4. Operation Technology, Inc.
  - 5. Power Analytics, Corporation.

- B. Comply with IEEE 399 and IEEE 551.
- C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

## 2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
  - 1. Protective device designations and ampere ratings.
  - 2. Cable size and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor and generator designations and kVA ratings.
  - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Comments and recommendations for system improvements, where needed.
- E. Protective Device Evaluation:
  - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
  - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
  - 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
  - 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
  - 5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.
- G. Short-Circuit Study Output:
  - 1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated fault-current magnitude and angle.
    - c. Fault-point X/R ratio.

- d. Equivalent impedance.
2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated symmetrical fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. Calculated asymmetrical fault currents:
      - 1) Based on fault-point X/R ratio.
      - 2) Based on calculated symmetrical value multiplied by 1.6.
      - 3) Based on calculated symmetrical value multiplied by 2.7.
  3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated symmetrical fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. No AC Decrement (NACD) ratio.
    - e. Equivalent impedance.
    - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Obtain all data necessary for the conduct of the study.
  1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
  2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
  1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  2. Obtain electrical power utility impedance at the service.
  3. Power sources and ties.

4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

### 3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
  1. To normal system low-voltage load buses where fault current is 10 kA or less.
  2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
  1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
  1. Electric utility's supply termination point.
  2. Incoming switchgear.
  3. Unit substation primary and secondary terminals.
  4. Low-voltage switchgear.

5. Motor-control centers.
6. Control panels.
7. Standby generators and automatic transfer switches.
8. Branch circuit panelboards.
9. Disconnect switches.

### 3.3 ADJUSTING

- A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

### 3.4 DEMONSTRATION

- A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION 26 0572

## SECTION 26 0573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

### 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 computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
  - 1. Study results shall be used to determine coordination of series-rated devices.

#### 1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Coordination-study input data, including completed computer program input data sheets.
  - 2. Study and equipment evaluation reports.
  - 3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.



- a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

## 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Coordination Study Specialist.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.
  1. In addition to items specified in Section 01 7800 "Closeout Submittals" include the following:
    - a. The following parts from the Protective Device Coordination Study Report:
      - 1) One-line diagram.
      - 2) Protective device coordination study.
      - 3) Time-current coordination curves.
    - b. Power system data.

## 1.7 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

## PART 2 - PRODUCTS

### 2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Software Developers:
  - 1. SKM
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
  - 1. Optional Features:
    - a. Arcing faults.
    - b. Simultaneous faults.
    - c. Explicit negative sequence.
    - d. Mutual coupling in zero sequence.

### 2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
  - 1. Protective device designations and ampere ratings.
  - 2. Cable size and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor and generator designations and kVA ratings.
  - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.

- E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."
- F. Protective Device Coordination Study:
  - 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
    - a. Phase and Ground Relays:
      - 1) Device tag.
      - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
      - 3) Recommendations on improved relaying systems, if applicable.
    - b. Circuit Breakers:
      - 1) Adjustable pickups and time delays (long time, short time, ground).
      - 2) Adjustable time-current characteristic.
      - 3) Adjustable instantaneous pickup.
      - 4) Recommendations on improved trip systems, if applicable.
    - c. Fuses: Show current rating, voltage, and class.
- G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
  - 1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
  - 2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
  - 3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
  - 4. Plot the following listed characteristic curves, as applicable:
    - a. Power utility's overcurrent protective device.
    - b. Medium-voltage equipment overcurrent relays.
    - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    - f. Cables and conductors damage curves.
    - g. Ground-fault protective devices.
    - h. Motor-starting characteristics and motor damage points.

- i. Generator short-circuit decrement curve and generator damage point.
  - j. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.
  6. Provide adequate time margins between device characteristics such that selective operation is achieved.
  7. Comments and recommendations for system improvements.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
  1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

### 3.2 PROTECTIVE DEVICE COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. The study shall be based on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
  1. To normal system low-voltage load buses where fault current is 10 kA or less.
  2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
    - a. Inrush current when first energized.
    - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
  2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- H. Motor Protection:
1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
  2. Select protection for motors served at voltages more than 600 V according to IEEE 620.
- I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- J. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.
- K. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
1. Electric utility's supply termination point.
  2. Switchgear.
  3. Low-voltage switchgear.
  4. Standby generators and automatic transfer switches.
  5. Branch circuit panelboards.
- M. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to short-circuit ratings.
  2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
  3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

### 3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

- A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
  - 1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
  - 2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
  - 3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

### 3.4 MOTOR-STARTING STUDY

- A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.
- B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

### 3.5 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the overcurrent protective device study.
  - 1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
  - 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  - 3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
- B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
  - 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  - 2. Electrical power utility impedance at the service.
  - 3. Power sources and ties.

4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
17. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
  - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
  - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
  - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
  - d. Generator thermal-damage curve.
  - e. Ratings, types, and settings of utility company's overcurrent protective devices.
  - f. Special overcurrent protective device settings or types stipulated by utility company.
  - g. Time-current-characteristic curves of devices indicated to be coordinated.
  - h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
  - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
  - j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
  - k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

### 3.6 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

### 3.7 DEMONSTRATION

- A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:
  - 1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
  - 2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
  - 3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 26 0573



## SECTION 26 0574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

### 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 a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

#### 1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Arc-flash study input data, including completed computer program input data sheets.
  - 2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
    - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary

submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Arc-Flash Study Specialist.
- B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

Commented [JMM1]:

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:
  - 1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
  - 2. Operation and Maintenance Procedures: In addition to items specified in Section 01 7800 "Closeout Submittals" provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

#### 1.7 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

## PART 2 - PRODUCTS

### 2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. CGI CYME.
  - 2. EDSA Micro Corporation.
  - 3. ESA Inc.
  - 4. Operation Technology, Inc.
  - 5. Power Analytics, Corporation.
- B. Comply with IEEE 1584 and NFPA 70E.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

### 2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
  - 1. Protective device designations and ampere ratings.
  - 2. Cable size and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor and generator designations and kVA ratings.
  - 5. Switchgear, switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."
- F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 0573 "Overcurrent Protective Device Coordination Study."
- G. Arc-Flash Study Output:
  - 1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.

- b. Calculated symmetrical fault-current magnitude and angle.
- c. Fault-point X/R ratio.
- d. No AC Decrement (NACD) ratio.
- e. Equivalent impedance.
- f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
- g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

- 1. Arcing fault magnitude.
- 2. Protective device clearing time.
- 3. Duration of arc.
- 4. Arc-flash boundary.
- 5. Working distance.
- 6. Incident energy.
- 7. Hazard risk category.
- 8. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

### 2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

- 1. Location designation.
- 2. Nominal voltage.
- 3. Flash protection boundary.
- 4. Hazard risk category.
- 5. Incident energy.
- 6. Working distance.
- 7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

### 3.2 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies:
  - 1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."
  - 2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 0573 "Overcurrent Protective Device Coordination Study."
- C. Calculate maximum and minimum contributions of fault-current size.
  - 1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
  - 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.
- F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
  - 1. Fault contribution from induction motors should not be considered beyond three to five cycles.
  - 2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

- H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
  - 1. When the circuit breaker is in a separate enclosure.
  - 2. When the line terminals of the circuit breaker are separate from the work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

### 3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
  - 1. Verify completeness of data supplied on the one-line diagram on Drawings "Arc-Flash Hazard Analysis" Article. Call discrepancies to the attention of Architect.
  - 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  - 3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.
- B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
  - 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  - 2. Obtain electrical power utility impedance at the service.
  - 3. Power sources and ties.
  - 4. Short-circuit current at each system bus, three phase and line-to-ground.
  - 5. Full-load current of all loads.
  - 6. Voltage level at each bus.
  - 7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
  - 8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
  - 9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
  - 10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
  - 11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
  - 12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
  - 13. Motor horsepower and NEMA MG 1 code letter designation.

14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

### 3.4 LABELING

- A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
  1. Motor-control center.
  2. Low-voltage switchboard.
  3. Switchgear.
  4. Medium-voltage switch.
  5. Control panel.

### 3.5 APPLICATION OF WARNING LABELS

- A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

### 3.6 DEMONSTRATION

- A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION26 0574

## SECTION 26 0800 - ELECTRICAL FACILITY STARTUP/COMMISSIONING

### PART 1 - GENERAL

#### 1.1 DESCRIPTION

##### A. Scope of Work

1. The Contractor is responsible to provide support required for start-up, testing, and commissioning. The commissioning process requires significant participation of Division 26 to ensure all portions of the work have been completed in a satisfactory and fully operational manner.

##### B. Minimum requirements for Contractor:

1. Start-up and testing of the equipment supplied.
2. Operate and maintain equipment and systems as required for commissioning tests.
3. Providing qualified personnel including equipment manufacturer's service technicians for participation with the commissioning team.
4. Provide equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements.
5. Provide operation and maintenance information and record drawings for verification, organization, and distribution.
6. Provide assistance to the Commissioning Authority (CA) to develop and edit equipment startup and testing schedules (Commissioning Matrix).
7. Provide training for the systems specified in this division with coordination by the Contract Administrator and Commissioning Authority.
8. Attend commissioning meetings.

#### 1.2 RELATED WORK

- A. All start-up and testing procedures and documentation requirements specified within Division 26.
- B. Allow sufficient time before final commissioning dates so that testing, adjusting and demonstration can be accomplished.
- C. Put all electrical gear into full operation only after all testing has been completed, and the Commissioning Authority has received the testing documentation.
- D. Provide labor and material to make corrections when required.



### 1.3 DEFINITIONS

- A. Point Verification Forms (PVF) are detailed installation and startup tracking documents developed by the Commissioning Authority and completed through a cooperative effort between the Contractor and the Commissioning Authority. The PVFs will track each point through installation, termination, and connection to the Facility Management System (FMS).
- B. Functional Performance Tests (FPT) are detailed testing procedure developed by the Commissioning Authority, and conducted through a cooperative effort between the Contractor and the Commissioning Authority. The FPTs will be detailed step by step procedures developed for each electrical system. The majority of electrical testing will be by the third party electrical testing firm. Commissioning Authority generated FPT's will be for systems such as lighting controls, dimmer controls, etc. Each FPT will have a clear acceptance criteria based in the contract documents which must be achieved before the system or sub-system is accepted by the Commissioning Authority and the Owner.
- C. The Commissioning Authority (CA) is a firm hired directly by the Owner to oversee the entire commissioning process.

### PART 2 - PRODUCTS

Not Applicable.

### PART 3 - EXECUTION

#### 3.1 WORK PRIOR TO COMMISSIONING

- A. Complete all phases of work so the system can be tested, adjusted, and energized. Division 26 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are fully functional and ready for testing and startup. This includes the complete installation of all equipment, materials, conduit, wire, supports, controls, etc., per the contract documents and related directives, clarifications, change orders, etc.
- B. A commissioning plan will be developed by the CA and approved by the commissioning team. Division 26 is obligated to assist the CA in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner. If Contractor initiated system changes have been made that alter the commissioning process, notify the Commissioning Authority and Contract Administrator for approval.
- C. Specific pre-commissioning responsibilities of Division 26 are as follows:
  - 1. Bring each system to a fully construction completed state.

2. Commissioning is intended to begin upon completion of a system. To support Partial Occupancy commissioning may proceed prior to the completion of systems, or sub-systems, and will be coordinated with the CA as equipment Early Run. Start of commissioning before system completion will not relieve Division 26 from completing those systems as per the schedule.

### 3.2 PARTICIPATION IN COMMISSIONING

- A. Provide skilled technicians to start up all systems within Division 26. These same technicians shall be made available to assist the CA in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested, coordinated by the CA, and tracked on the Commissioning Matrix. Division 26 will ensure that the qualified technician(s) are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.
- B. System problems and discrepancies may require additional technician time or reconstruction of systems and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.
- C. The Contract Administrator and CA reserve the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment or system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the commissioning team to complete the job.

### 3.3 WORK TO RESOLVE DEFICIENCIES

- A. In some systems, misadjustment, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Contract Administrator, with input from the Contractor, equipment supplier, and CA. Whereas all members will have input and the opportunity to discuss the work and resolve problems, the Contract Administrator will have final jurisdiction on the necessary work to be done to achieve performance.
- B. Corrective work shall be completed in a timely fashion to permit completion of the commissioning process according to the schedule. Experimentation to render system performance will be permitted. If the CA deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the CA will notify the Owner indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If deadlines pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

### 3.4 TRAINING

- A. Participate in the training of the Owner's engineering and maintenance staff, as required in Divisions 26, on each system and related components. Training, in part, will be conducted in a

classroom setting, with system and component documentation, and suitable classroom training aids.

- B. Training will be conducted by the Contractor and the equipment vendors.
- C. Training for the Commissioning Team members on the Commissioning Plan will be provided by the CA. All Commissioning Team members are required to attend this training.

### 3.5 SYSTEMS DOCUMENTATION

- A. In addition to the requirements of Division 26, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. Red-line all drawings on two sets. Include architectural floor plans, elevations and details, and the individual electrical systems in relation to actual building layout in Division 26 as-built drawings.
- B. Maintain as-built red-lines as required by Division 1. Given the size and complexity of this project, red-line drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining of drawings is considered essential and mandatory. Maintain these drawings in the construction trailer and make them available for inspection at any time.

### 3.6 MISCELLANEOUS SUPPORT

- A. Division 26 shall remove and replace covers of equipment, open access panels, etc., to permit Contractor, Contract Administrator, or CA to observe equipment and controllers provided.

END OF SECTION 26 0800

## SECTION 26 0880 - ELECTRICAL ACCEPTANCE TESTING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplemental General Conditions and Division 1 Specification Sections, apply to this Section.
- B. Refer to individual specification sections indicated below for tests to be performed and other requirements.

#### 1.2 QUALITY ASSURANCE

- A. The Contractor will be responsible for all Electrical Testing and perform the independent inspections, tests, adjustments and settings as specified herein and in other sections.
- B. The Electrical Testing will meet the requirements of NETA.
- C. The Contractor shall submit appropriate documentation to demonstrate that it satisfactorily complies with the National Electrical Testing Association.
  - 1. The Electrical Testing shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.
- D. The Electrical Testing shall utilize technicians who are regularly employed for testing services.
- E. Technicians performing these electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make an informed judgment on the continued serviceability or non-serviceability of the specific equipment. Technicians shall be certified in accordance with ANSI/NETA ETT-2000, Standard for Certification of Electrical Testing Technicians. Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.

#### 1.3 PERFORMANCE CRITERIA

- A. Perform acceptance testing, inspection, and calibration to assure that installed electrical systems and equipment, either Owner or Subcontractor supplied are:
  - 1. Installed in accordance with design Specifications and manufacturer's instructions,
  - 2. Ready to be energized,
  - 3. Operational and within industry and manufacturer's tolerances.

- B. Refer to each division 26 specification sections for equipment and systems to be inspected, tested and calibrated by the Electrical Testing Agency.

#### 1.4 REGULATORY REQUIREMENTS

- A. Make Inspections and tests in accordance with the applicable codes and standards of the following agencies except as provided otherwise herein:
  - 1. InterNational Electrical Testing Association – NETA ATS latest Edition: Acceptance Testing Specifications.
  - 2. ANSI/NETA ETT – 2000, Standard for the Certification of Electrical Testing Technicians
  - 3. National Fire Protection Association – NFPA.
    - a. ANSI/NFPA 70: National Electrical Code.
    - b. ANSI/NFP A 70B: Recommended Practice for Electrical Equipment Maintenance.
    - c. NFPA 70E: Electrical Safety Requirements for Employee Workplaces.
    - d. NFPA 99 & 101.
- B. Use the following references:
  - 1. Project design Specifications.
  - 2. Project ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY – refer to Sections 26 0572, 26 0573, and 26 0574.
  - 3. Manufacturer’s instruction manuals applicable to each particular apparatus.
  - 4. Project list of equipment to be inspected and tested.

#### 1.5 GENERAL REQUIREMENTS

- A. Safety and Precautions

This document does not include any procedures, including specific safety procedures. It is recognized that an overwhelming majority of the tests and inspections recommended in these specifications are potentially hazardous. Inherent in this determination is the prerequisite that individuals performing these tests be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved.

- 1. Safety practices shall include, but are not limited to, the following requirements:
  - a. Occupational Safety and Health Act.
  - b. Accident Prevention Manual for Industrial Operations, National Safety Council.
  - c. Applicable state and local safety operating procedures.
  - d. Owner’s safety practices.
  - e. ANSI/NFPA 70E, Electrical Safety Requirements for Employee Workplaces.
- 2. All tests shall be performed with apparatus de-energized except where otherwise specifically required.
- 3. The Electrical Testing Agency shall have a designated safety representative on the project to supervise operations with respect to safety.

## B. Suitability of Test Equipment

1. All test equipment shall be in good mechanical and electrical condition.
2. Split-core current transformers and clamp-on or tong-type ammeters require consideration of the following in regard to accuracy:
  - a. Position of the conductor within the core
  - b. Clean, tight fit of the core pole faces
  - c. Presence of external magnetic fields
  - d. Accuracy of the current transformer ratio in addition to the accuracy of the secondary meter.
3. Selection of metering equipment shall be based on knowledge of the waveform of the variable being measured. Digital multimeters may be average or RMS sensing and may include or exclude the dc component. When the variable contains harmonics or dc offset and, in general, any deviation from a pure sine wave, average sensing, RMS scaled meters may be misleading.
4. Field test metering used to check power system meter calibration must have accuracy higher than that of the instrument being checked.
5. Accuracy of metering in test equipment shall be appropriate for the test being performed but not in excess of two percent of the scale used.
6. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and tested equipment.

## C. Test Instrument Calibration

1. The Electrical Testing Agency shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.
2. The accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).
3. Instruments shall be calibrated in accordance with the following frequency schedule:
  - a. Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
  - b. Laboratory instruments: 12 months
  - c. Leased specialty equipment: 12 months where accuracy is guaranteed by lessor.
4. Dated calibration labels shall be visible on all test equipment.
5. Records, which show date and results of instruments calibrated or tested, shall be kept up-to-date.
6. Up-to-date instrument calibration instructions and procedures shall be maintained for each test instrument.
7. Calibrating standard shall be of higher accuracy than that of the instrument tested.

## D. Test Report

1. The test report shall include the following:
  - a. Summary of project.
  - b. Description of equipment tested.
  - c. Description of test.

- d. Test data.
  - e. Analysis and recommendations.
2. Test data records shall include the following minimum requirements:
- a. Identification of the testing organization.
  - b. Equipment identification.
  - c. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.
  - d. Date of inspections, tests, maintenance, and/or calibrations.
  - e. Identification of the testing technician.
  - f. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
  - g. Indication of expected results when calibrations are to be performed.
  - h. Indication of "as-found" and "as-left" results.
  - i. Sufficient spaces to allow all results and comments to be indicated.
3. The Electrical Testing Agency shall furnish a copy or copies of the complete report to the owner and Commissioning Authority as required in the acceptance contract.

## 1.6 SUBMITTALS

- A. Qualifications of the Electrical Testing Agency shall be submitted to the COMMISSIONING AUTHORITY for review with the electrical equipment submittals in accordance with Section 26 0500, "COMMON WORK RESULTS FOR ELECTRICAL, Submittals."

## PART 2 - PRODUCTS

Not Used.

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Set all adjustable circuit breaker trip settings in accordance with the trip setting report from the ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY.
- B. Test, inspect and calibrate the following electrical equipment in strict accordance with applicable sections of NETA ATS-2003.
  - 1. Electrical equipment shown on the electrical Drawings.
  - 2. Electrical equipment specified in all Division 26 Specifications for the Site.
  - 3. Electrical equipment furnished under other Divisions of the Specifications and connected under Division 26.
- C. Perform acceptance tests and inspections prior to energizing equipment, unless where energization is required to perform specified tests.

- D. Final acceptance will not occur before completion of the electrical acceptance tests, inspections and calibrations specified in this Section.

### 3.2 FIELD QUALITY CONTROL

- A. Standards: Comply with applicable standards of the InterNational Electrical Testing Association (NETA), including standard ATS.
- B. Acceptance Testing: After installing equipment and BEFORE electrical circuitry has been energized. Demonstrate product capability and compliance with requirements.

### 3.3 DIVISION OF RESPONSIBILITY

- A. The Electrical Testing Agency shall provide all material, equipment, labor and technical supervision to perform such tests and inspections as specified herein.
- B. The Electrical Testing Agency is responsible for programming all protective and alarming devices with the proper settings provided by the ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY. Settings shall not be changed or applied to any device without written authorization from the Owner.
- C. The Electrical Testing Agency shall notify the Contractor and Owner immediately upon the discovery of any defective equipment or incorrect system design or installation.
- D. The Electrical Testing Agency shall provide an experienced person on-site during energizing, with appropriate test equipment to provide assistance in the event of a malfunction during the system start-up process.

### 3.4 ACCEPTANCE TESTING PROCEDURES

- A. Testing and acceptance procedures for the equipment and systems listed in Part 1 shall be as described in the individual equipment specification sections listed above.

END OF SECTION 26 0880



## SECTION 26 0913 - LIGHTING CONTROL EQUIPMENT

### 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 types of lighting controls:
  - 1. Time switches.
  - 2. Lighting contactors.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
  - 1. Division 26, Section 26 0533, Raceway and Boxes for Electrical Systems, for general component identification and support requirements.
  - 2. Division 26, Section 26 0553, Identification for Electrical Systems, and general identification requirements.
  - 3. Division 26, Section 26 0800, Electrical Facility Startup / Commissioning, for turn-key startup of all programmable, networked, and/or software-based lighting control system(s).

#### 1.3 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 lighting control equipment and systems components, including dimensions and data on features and components. Include wiring diagrams and elevation views of front panels of control and indicating devices. Include data on ratings. For flush control panels, submit color and finish options for selection. Also include the following:
  - 1. Lists of ballast and lamp combinations compatible with dimmer systems, by manufacturer and catalog number.
  - 2. Sound data, including operational tests of dimming systems.
  - 3. Operational documentation for software.
- C. Shop Drawings detailing assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

- D. Wiring diagrams detailing specific systems tailored to this Project and differentiating between factory-installed and field-installed wiring.
- E. Field test reports indicating and interpreting test results specified in Part 3 of this Section.
- F. Maintenance data for lighting control equipment and systems components to include in the operation and maintenance manual specified in Division 1.
- G. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
- H. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
  - 1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
  - 2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.
- I. Software licenses and upgrades required by and installed for operation and programming of central lighting control panels "LCP's". Install software on the same personal computer "PC" workstation(s) as used for the monitoring and control as the Division 23 Facility Management System "FMS" / Energy Management System "EMS" / Building Automation System "BAS".

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- B. Software and Firmware Operational Documentation:
  - 1. Software operating and upgrade manuals.
  - 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
  - 3. Device address list.
  - 4. Printout of software application and graphic screens.

#### 1.5 QUALITY ASSURANCE

- A. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL where available.
- B. Comply with FCC Regulations of Part 15, Subpart J for Class A.
- C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

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 OSHA Regulation 1910.7.

#### 1.6 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: Submit a written warranty signed by manufacturer and Installer agreeing to replace programmable lighting control system components that fail in materials or workmanship within the specified warranty period.
- C. Warranty Period: 2 years from date of Substantial Completion.

#### 1.7 EXTRA MATERIALS

- A. Furnish extra products as described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents. Deliver extra materials to Owner.
  1. Relays: Single-pole mechanically held, 1 for every 4 installed. Furnish at least one of each type.
  2. Dimmer Modules: 1 for every 4 of each type and rating installed. Furnish at least one of each type.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, provide one of the products specified in on the drawings. Where no manufacturer is listed for the appropriate product category, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
  1. Contactors and Relays:
    - a. Square D Co.
    - b. Eaton Corporation
    - c. Siemens
  2. Time Switches:
    - a. NSi Industries / Tork, Inc.
    - b. Intermatic, Inc.

## 2.2 CONTACTORS AND RELAYS

- A. Comply with NEMA ICS 2.
- B. Description: Devices are electrically operated and mechanically held. Number of poles and ratings are as indicated. Coordinate rating of each unit with type of load served, including tungsten filament and inductive-type loads.
- C. Modular Single-Pole Relays: Split-coil, momentary-pulsed type, knockout mounting.
  - 1. Low-Voltage Leads: 5-pin plug connector.
  - 2. Pilot Contacts: Single pole.
  - 3. Rated Capacity: 20 A, 125 VAC for tungsten filaments, and 20 A, 277 VAC for ballasts.
  - 4. Endurance: 50,000 cycles at rated capacity.
- D. Modular Relay Panels: Steel cabinets, preassembled with modular single-pole relays, transformer power supplies, and associated components.
  - 1. Barriers separate low-voltage and line-voltage components.
  - 2. Cover: Hinged, lockable type.
  - 3. Directory: Mounted on back of door. Identifies relays and loads controlled.

## 2.3 TIME SWITCHES

- A. Time Switches: Solid-state programmable units with alphanumeric display conforming to UL 917. Include the following features:
- B. Time Switches: Electromechanical-dial type conforming to UL 917. Include the following features:
  - 1. Astronomic dial.
  - 2. Contacts: 2, rated 30 A at 277 VAC, except as otherwise indicated.
  - 3. Pilot-Duty Contacts: 2, rated 2 A at 240 V, except as otherwise indicated.
  - 4. Eight-Day Program: Uniquely programmable for each day of the week and holidays.
  - 5. Skip-day mode.

## 2.4 MANUAL SWITCHES AND PLATES

- A. Switches: Specification grade, modular, momentary push-button, low-voltage type.
  - 1. Color: White, except as otherwise indicated.
  - 2. Integral Pilot Light: Indicates when circuit is on. Use where indicated.
  - 3. Locator Light: Internal illumination helps locate switch in the dark. Use where indicated.
  - 4. Wall Plates: Match those specified in Division 26, Section 26 2726, Wiring Devices to materials, finish, and color. Use multigang plates where more than one switch is indicated at a location.
  - 5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install equipment according to manufacturers' written instructions.
- B. Mount control equipment according to manufacturers' instructions and Division 26, Section 26 2726, Wiring Devices.
- C. Mounting heights indicated are to bottom of unit for suspended items and to center of unit for wall-mounted ones.

### 3.2 CONTROL WIRING INSTALLATION

- A. Install wiring between control devices as specified in Division 26 Section 26 2726, Wiring Devices.
- B. Wiring Method: Install all wiring in raceway as specified in Division 26, Section 26 0533, Raceway and Boxes for Electrical Systems.
- C. Wiring Method: Install all wiring in raceway as specified in Division 26, Section 26 0533, Raceways and Boxes for Electrical Systems, except where run in accessible ceiling space, and gypsum board partitions.
- D. Bundle, train, and support wiring in enclosures.
- E. Grounding: Ground equipment. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### 3.3 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26, Section 26 0553, for Identification for Electrical Systems.
- B. Label each system control module with a unique designation. Make designations on elevated components readable from floor.

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to test, adjust, and program lighting control systems.
- B. Reports: Prepare written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.
- C. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible organization and person.

- D. Schedule visual and mechanical inspections and electrical tests with at least 7 days' advance notice.
- E. Visual and Operational Inspections: Include the following inspections.
  - 1. Inspect control components for defects and physical damage, NRTL labeling, and nameplate compliance with current Project Drawings.
  - 2. Check tightness of electrical connections with torque wrench calibrated within previous 6 months. Use manufacturers recommended torque values.
  - 3. Verify settings of photoelectric devices with photometer calibrated to National Institute for Science and Technology (NIST) standards within past 6 months.
  - 4. Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's instructions for routine functional operation.
- F. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following tests according to manufacturer's instructions:
  - 1. Continuity tests of circuits.
  - 2. Operational Tests: Set and operate controls to demonstrate controls in a methodical sequence that cues and reproduces actual operating functions. Include testing of dimming equipment and ambient-light, programmable, and occupancy controls under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
- G. Correct deficiencies disclosed by inspections and tests, make necessary adjustments, and retest deficient items. Verify that specified requirements are met.

### 3.5 ADJUSTING AND CLEANING

- A. Occupancy Adjustments: Upon request within 1 year of date of Substantial Completion, make up to 3 on-site visits to Project site to assist in adjusting light levels, making program changes, and adjusting sensors and controls.
- B. Repair scratches and mars of finish to match original finish. Clean equipment and devices internally and externally using methods and materials recommended by manufacturers.

### 3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Confirm correct communication wiring, initiate communications between panels, and program the lighting control system according to approved zone configuration schedules, time-of-day schedules, and input override assignments.

### 3.7 DEMONSTRATION

- A. Training: Provide services of a factory-authorized service representative to demonstrate programmable lighting control system and to train Owner's maintenance personnel.
  - 1. Train Owner's personnel to operate, service, maintain, adjust, and program equipment and system components. Allow at least 4 hours to conduct training. Schedule training with at least 7 days' advance notice. Use final approved operation and maintenance manual as a training aid throughout training. Use both classroom training and hands-on exercises.

END OF SECTION 26 0913

## SECTION 26 0923 - DIGITAL OCCUPANCY AND DAYLIGHT MANAGEMENT CONTROL SYSTEM

### PART 1 - GENERAL

#### 1.1 SUMMARY

##### A. Section Includes:

1. Digital Occupancy and Daylighting Sensor Control
2. Emergency Lighting Control (if applicable)

##### B. Related Section

1. Section 26 0913 – Lighting Control Equipment.
2. Section 26 2416 – Panelboards.
3. Section 26 2726 – Wiring Devices.
4. Section 26 5119 – LED Interior Lighting.
5. Section 26 0500 – Common Work Results

##### C. Control Intent – Control Intent includes, but is not limited to:

1. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.
2. Initial sensor and switching zones
3. Initial time switch settings
4. Task lighting and receptacle controls
5. Emergency Lighting control (if applicable)

#### 1.2 REFERENCES

- A. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE)
- B. Canadian Standards Association (CSA) ([www.csa.ca](http://www.csa.ca)).
- C. International Electrotechnical Commission ([www.iec.ch](http://www.iec.ch))
- D. International Organization for Standardization (ISO)
- E. National Electrical Manufacturers Association (NEMA) ([www.nema.org](http://www.nema.org))
- F. WD1 (R2005) - General Color Requirements for Wiring Devices.
- G. Underwriters Laboratories, Inc. (UL) ([www.ul.com](http://www.ul.com)):
  1. 916 – Energy Management Equipment.
  2. 924 – Emergency Lighting



H. International Building (IBC) Current Issue

1.3 SYSTEM DESCRIPTION & OPERATION

A. The Lighting Control and Automation system as defined under this section covers the following equipment:

1. Digital Room Controllers – Self configuring, digitally addressable one, two or three relays controllers with 0-10v control for ballasts (if applicable) and single relay application specific plug load controllers.
2. Digital Occupancy Sensors – Self configuring, digitally addressable and calibrated occupancy sensors with LCD screens and two way active Infra-Red (IR) configurations.
3. Digital Switches – Self configuring, digitally addressable push button switches, dimmers, and scene switches with two way active Infra-Red (IR) communications.
4. Analog and digital closed loop daylighting sensors - self-calibrating daylighting sensors that provide closed loop control to Room Controllers. Sensors and Room Controllers can provide single or multi-zone, on/off or dimming control for daylight harvesting.
5. Hand held remotes for room configuration – provides two way infrared communications to digital devices and allows complete configuration and reconfiguration of the device / room from 30 feet away. Unit to have Organic LED display, simple pushbutton interface, and allow send / receive / store of all room variables.
6. Hand held remotes for personal control – One, two, or four (scene) button remotes provide Infrared communications to a room. Remote controls will support ON/OFF, scene control and may be configured in the field to provide specific occupant requirements without special tools.
7. Digital Lighting Management (DLM) local network – Free topology, plug in wiring system (Cat 5e) for power and data to room devices.
8. Native BACnet Module (if applicable) – Provide MS/TP communications for Room to Room, or Room to Server communications.
9. Emergency Lighting Control Unit (ELCU)- allows any standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building

1.4 LIGHTING CONTROL APPLICATIONS

A. Unless relevant provisions of the applicable local Energy Codes are more stringent, provide a minimum application of lighting controls as follows:

1. Space Control Requirements – Provide occupancy/vacancy sensors with manual-on functionality in all spaces except toilet rooms, storerooms, library stacks, or other applications where hands-free operation is desirable and automatic-on occupancy sensors are more appropriate. Provide manual ON occupancy/vacancy sensors for any enclosed office, conference room, meeting room, open plan system and training room. For spaces with multiple occupants or where line-of-sight may be obscured, provide ceiling- or corner-mounted sensors with manual-on switches.
2. Bi-Level Lighting – Provide multi –level switched dimming controls in all spaces except toilet rooms, storerooms, library stacks, or applications where variable dimming is used.

3. Task Lighting / Plug Loads – Provide automatic shut off of non essential plug loads and task lighting in all spaces except toilet rooms and storerooms. Provide automatic ON of plug loads whenever spaces are occupied. For spaces with multiple occupants a single shut off consistent with the overhead lighting may be used for the area.
4. Daylighted Areas. All luminaries within 15’ of windows or within 7’ of skylights (the daylighted zone) shall be separately controlled from luminaires outside of daylighted zones. Luminaires closest to the daylight aperture shall be separately controlled from luminaires farther from the daylight aperture, within the daylight zone.
5. Daytime set points for total illumination (combined daylight and electric light) level that initiate dimming shall be programmed to be not less than 125% of the nighttime maintained designed illumination levels.
6. Multiple-leveled switched daylight harvesting controls may be utilized for areas marked on drawings.
7. Provide smooth and continuous daylight dimming for areas marked on drawings. Daylight system may be designed to turn off ambient lighting when daylight is at or above required lighting levels, only if system functions to turn lamps back on at dimmed level, rather than turning full-on prior to dimming.

B. Additional controls.

1. Provide occupancy/vacancy sensors for any enclosed office, conference room, meeting room, and training room. For spaces with multiple occupants or where line-of-sight may be obscured, provide ceiling- or corner-mounted with manual-on switches.
2. Conference, meeting, training, auditoriums, and multipurpose rooms shall have controls that allow for independent control of each local control zone. Rooms larger than 300 square feet shall instead have at least four (4) pre-set lighting scenes unless otherwise specified. Occupancy / vacancy sensors shall be provided to extinguish all lighting in the space.

## 1.5 SUBMITTALS

- A. Submittals Package: Submit the shop drawings, and the product data specified below at the same time as a package.
- B. Shop Drawings (For Sensor Systems):
  1. Composite wiring and/or schematic diagram of each control circuit as proposed to be installed (standard diagrams will not be accepted).
  2. Scale drawing for each area showing exact location of each sensor, switching module, and on-off-auto switch.
- C. Product Data: Catalog sheets, specifications and installation instructions.
- D. Include data for each device which:
  1. Indicates where sensor is proposed to be installed.
  2. Prove that the sensor is suitable for the proposed application.

## 1.6 QUALITY ASSURANCE

- A. Manufacturer: Minimum 10 years experience in manufacture of lighting controls.

## 1.7 PROJECT CONDITIONS

- A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
  - 1. Ambient temperature: 0° to 40° C (32° to 104° F).
  - 2. Relative humidity: Maximum 90 percent, non-condensing.

## 1.8 WARRANTY

- A. Provide a five year complete manufacturer's warranty on all products to be free of manufacturers' defects.

## 1.9 MAINTENANCE

- A. Spare Parts:
  - 1. Provide 1 of each product to be used for maintenance.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Acceptable Manufacturer:
  - 1. Watt Stopper
    - a. System: Digital Lighting Management (DLM)
- B. Substitutions:
  - 1. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by the design professional according to 01 6000 Product Requirements, Substitution Procedures. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.
  - 2. By using pre-approved substitutions, the contractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring. The contractor shall provide complete engineered shop drawings (including power wiring) with deviations for the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

## 2.2 SINGLE / DUAL RELAY WALL SWITCH VACANCY SENSORS

- A. PIR: Manual ON, Automatic OFF Wall switch type passive infrared occupancy sensor with built-in override control (off-auto). Furnish the Company's model which suits the electrical system parameters, and accommodates the square footage coverage and wattage requirement for each area (and type of lighting) controlled.
- B. Ultrasonic: Manual ON, Automatic OFF Wall switch type ultrasonic occupancy sensor with built-in override control (off-auto). Furnish the Company's model which suits the electrical system parameters, and accommodates the square footage coverage and wattage requirement for each area (and type of lighting) controlled.
- C. Dual technology: Manual ON, Automatic OFF Wall switch type dual technology, passive Infrared and ultrasonic occupancy sensor with built-in override control (off-auto). Furnish the Company's model which suits the electrical system parameters, and accommodates the square footage coverage and wattage requirement for each area (and type of lighting) controlled.

## 2.3 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR SYSTEM

- A. Wall or ceiling mounted (to suit installation) passive infrared, ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor. Furnish the Company's system which accommodates the square footage coverage requirements for each area controlled, utilizing Room Controller modules and accessories which suits the lighting and electrical system parameters.
- B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:
  - 1. Digital calibration and LCD entry for the following variables:
    - a. Sensitivity,
    - b. Time Delay
    - c. PIR, Ultrasonic or Dual Technology activation
    - d. Re-strike times.
    - e. Walk-through mode
  - 2. Two RJ-45 digital connections for DLM local network.
  - 3. Two-way infrared communications port to allow remote programming through hand held commissioning tool.
  - 4. Self contained push buttons for programming and control of room devices.
  - 5. Device Status LED's including:
    - a. Network Status LED to indicate data transmission
    - b. Power LED to indicate the device has power
    - c. LED for each sensor technology to indicate detected motion.
- C. Units will provide for digital calibration and commissioning and will not have any dip switches or potentiometers for field settings

- D. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required

## 2.4 DIGITAL WALL SWITCHES

- A. Low voltage (RJ-45) momentary push button switches in 1,2,3,4 and 8 button configuration, decorator opening. Wall switches will include the following features:
  - 1. Two way infrared communications port for use with personal and configuration remote controls.
  - 2. LED's for status, programming, and troubleshooting including:
    - a. One pilot LED for each button.
    - b. One locator LED per switch.
  - 3. Engraveable buttons
  - 4. Dimming switches shall include seven LED's to indicate load levels.
  - 5. Scene switches shall include pilot indication of scene selection.
  - 6. Device Status LED's including:
    - a. Network Status LED to indicate data transmission
    - b. Power LED to indicate the device has power
- B. Switches shall have two RJ-45 ports to allow connection to any other digital room device.
- C. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required to achieve multi-way switching

## 2.5 ROOM CONTROLLERS

- A. Room Controllers automatically bind the room loads to the connected devices in the space without any tools or configuration requirements. Room Controllers shall be provided to match the room lighting load and control requirements and sequences. The controllers will be simple to install and will not have screw type connections, dip switches, potentiometers or require special mounting or configuration. The control units will include the following features:
  - 1. Automatic room configuration to the most energy efficient sequence of operation based upon the devices in the room.
  - 2. One or two relay configuration
  - 3. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an Off-the-Shelf unit without requiring any configuration or setup.
  - 4. Device Status LED's including:
    - a. Network Status LED to indicate data transmission.
    - b. Power LED to indicate the device has power.
    - c. Load status.

5. Quick installation features including:
  - a. Standard junction box mounting.
  - b. Quick low voltage connections using standard RJ-45 patch cables.
  - c. Manual override and pilot indication for each load.
  - d. Universal voltage (120 – 277 VAC).
  - e. Zero cross circuitry.
  - f. Low power consumption, 150 ma switched power supply for sensors and switches.
  - g. Three RJ-45 DLM local network ports.
  - h. Enhanced Room Controllers shall include all the features of the Room Controller plus the following enhancements:
    - i. One, two or three relay configuration.
    - j. 250 ma switched power supply.
    - k. Four RJ-45 DLM local network ports.
    - l. One zero to 10 volt analog output per relay for control of dimmable ballasts.
  - m. Optional BACnet MS/TP communications port.
  - n. Current monitoring.
  - o. Plug Load Room Controllers provide dedicated control of plug loads within the space. The controllers plug into the DLM local network using the RJ-45 free topology network. The room controllers include the following features.
    - p. One relay configuration only.
    - q. Automatic ON/OFF configuration based upon room occupancy.
    - r. Default 30 minute (adjustable) additional time delay from lighting shut off to allow for electronic component use after an area is vacant.

## 2.6 DIGITAL PHOTOSENSORS

- A. Provide automatic daylight harvesting capabilities to the Room Controllers. The photo sensor / room controller configuration automatically configures the daylighting set points for ON/OFF or Dimming control. Using the automatic configuration replacing a photo sensor or room controller can be done without any special tools, programming or configuration. Photosensors include the following features:
  1. The digital photosensor shall utilize an internal photodiode that measures light in a 100 degree angle cutting the unwanted light from bright sources outside of this cone
  2. The digital photosensor shall be capable of turning lighting on and off or Raise / Lower depending on the binding to the Room Controller. Sensor range shall be from 1 - 1400fc.
  3. For ON/OFF daylight harvesting the controller provides a “hold on while occupied” feature that prohibits high levels from turning OFF the controlled lights as long as the space remains occupied.
  4. The sensor has a threaded nipple that mounts on a ceiling tile and for more challenging applications such as a side wall or hard rock ceiling the nipple pops off and the unit can be screwed down.

## 2.7 ROOM NETWORK

- A. The DLM local network is a free topology lighting control network and protocol designed to control a small area of a building. Digital room devices connect to the network using RJ-45

patch cords which provide both data and power to the sensors and switches. Features of the DLM local network include

1. Automatic configuration and binding of sensors, switches and lighting loads to the most energy efficient sequence of operation based upon the device attached.
2. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
3. Push and Learn configuration that can change the automatic binding process and load parameters by using only the digital devices in the room.
4. Two way infrared communications that allow load parameters, sensor configuration and binding operations to be configured through a hand held configuration tool up to 30 feet from any device

B. Support for the following devices within a room:

1. 64 loads within the room
2. 64 switches
3. 6 occupancy sensors
4. Maximum of 800 milliamps of power for sensors, switches and auxiliary devices.

## 2.8 EMERGENCY LIGHTING

A. Emergency Lighting Control Unit – A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include

1. 120 - 277 volts, 50/60 Hz, 20 amp ballast rating
2. Push to test button
3. Auxiliary contact for test / Fire Alarm system

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. When using wire other than RJ-45 connections provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements

B. Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated.

C. Calibrate all sensor time delays and sensitivity to guarantee proper coverage of occupants and energy savings.

1. Adjust time delay so that controlled area remains lighted for 5 minutes after occupant leaves area.

- D. Provide written or computer generated documentation on the commissioning of the system including room by room description including:
  - 1. Sensor parameters, time delays, sensitivities, daylighting set points.
  - 2. Sequence of operation, manual ON, Auto OFF, etc.
  - 3. Load Parameters - blink warning, etc.
- E. Re-commissioning – After 30 days from occupancy re-calibrate all sensors time delays and sensitivities to meet the Owner’s Project Requirements. Provide a detailed report to the Architect / Owner of re-commissioning activity.
- F. Spare Parts – Provide to Owner ten (10) spare units of each device and cable used in this system.

END OF SECTION 26 0923



## SECTION 26 2213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

### 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 distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
  - 2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.
- B. Shop Drawings:
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
  - 3. Include diagrams for power, signal, and control wiring.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
  - 4. Certification: Indicate that equipment meets Project seismic requirements.

- C. Source quality-control reports.
- D. Field quality-control reports.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

#### 1.6 QUALITY ASSURANCE

- A. Testing Qualifications: Accredited by NETA.
  - 1. Contractors Testing Field Supervisor: Certified by NETA to supervise on-site testing.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.
  - 1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.
- B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.
- C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.
- D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Acme Electric Corporation.
  - 2. Controlled Power Company; an Emerson company.
  - 3. Dongan Electric Manufacturing Company.
  - 4. Eaton.
  - 5. Federal Pacific.
  - 6. General Electric Company.
  - 7. Hammond Power Solutions Inc.
  - 8. Jefferson Electric, Inc.

9. Lincoln Electric Products Co., Inc.
10. Mag-Tran; a division of Quality Transformer & Electronics.
11. Marcus Transformer LTD.
12. MGM Transformer Company.
13. Micron Industries Corporation.
14. Mirus International Inc.
15. Square D

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

## 2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."

## 2.3 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

## 2.4 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces per project seismic requirements.

C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.

3. Grounded to enclosure.
- D. Coils: Continuous windings without splices except for taps.
1. Coil Material: Copper.
  2. Internal Coil Connections: Brazed or pressure type.
  3. Terminal Connections: Bolted.
- E. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
- F. Enclosure: Ventilated.
1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
  2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
  3. Wiring Compartment: Sized for conduit entry and wiring installation.
  4. Finish: Comply with NEMA 250.
    - a. Finish Color: ANSI 49 gray weather-resistant enamel.
- G. Enclosure: Ventilated.
1. NEMA 250, Type 3R: Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
  2. Wiring Compartment: Sized for conduit entry and wiring installation.
  3. Finish: Comply with NEMA 250.
    - a. Finish Color: ANSI 49 gray weather-resistant enamel.
- H. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.
- I. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- J. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity. See "Insulation Ratings" Article in the Evaluations for discussion of insulation classes. See "Energy Considerations" Article in the Evaluations for discussion of relative efficiencies. Temperature rise of 115 or 80 deg C only applies to transformers 15 kVA and larger.
- K. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- L. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- M. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

- N. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
  - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
  - 2. Indicate value of K-factor on transformer nameplate.
  - 3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.
- O. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize inter-winding capacitance.
  - 1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
  - 2. Include special terminal for grounding the shield.
- P. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.
- Q. Wall Brackets: Manufacturer's standard brackets.
- R. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
  - 1. 9.00 kVA and Less: 40dBA.
  - 2. 9.01 to 30.00 kVA: 45dBA.
  - 3. 30.01 to 50.00 kVA: 45 dBA for K-factors of 4dBA.
  - 4. 50.01 to 150.00 kVA: 50 dBA for K-factors of 4dBA.
  - 5. 150.01 to 300.00 kVA: 55 dBA for K-factors of 4dBA.

## 2.5 IDENTIFICATION

- A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 0553 "Identification for Electrical Systems."
- B. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 26 0553 "Identification for Electrical Systems."

## 2.6 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
  - 1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
  - 2. Ratio tests at rated voltage connections and at all tap connections.
  - 3. Phase relation and polarity tests at rated voltage connections.
  - 4. No load losses, and excitation current and rated voltage at rated voltage connections.

5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:
  - a. High-voltage to ground.
  - b. Low-voltage to ground.
  - c. High-voltage to low-voltage.
9. Temperature tests.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Install wall-mounted transformers level and plumb with wall brackets fabricated from design drawings signed and sealed by a licensed structural engineer.
  1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
  2. Brace wall-mounted transformers as specified in project's seismic criteria.
- B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

- C. Construct concrete bases according to Section 03 3000 "Cast-in-Place Concrete" or Section 03 3053 "Miscellaneous Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 26 0529 "Hangers and Supports for Electrical Systems."
  - 1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- D. Secure transformer to concrete base according to manufacturer's written instructions.
- E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

### 3.3 CONNECTIONS

- A. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

### 3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:
  - 1. Visual and Mechanical Inspection.
    - a. Inspect physical and mechanical condition.
    - b. Inspect anchorage, alignment, and grounding.
    - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    - d. Verify the unit is clean.
    - e. Perform specific inspections and mechanical tests recommended by manufacturer.
    - f. Verify that as-left tap connections are as specified.
    - g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:
  - a. Measure resistance at each winding, tap, and bolted connection.
  - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
  - c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
  - d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
  
- C. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:
  1. Visual and Mechanical Inspection:
    - a. Inspect physical and mechanical condition.
    - b. Inspect anchorage, alignment, and grounding.
    - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    - d. Verify the unit is clean.
    - e. Perform specific inspections and mechanical tests recommended by manufacturer.
    - f. Verify that as-left tap connections are as specified.
    - g. Verify the presence of surge arresters and that their ratings are as specified.
  
  2. Electrical Tests:
    - a. Measure resistance at each winding, tap, and bolted connection.
    - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
    - c. Perform power-factor or dissipation-factor tests on all windings.
    - d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
    - e. Perform an excitation-current test on each phase.
    - f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
    - g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
  
- D. Remove and replace units that do not pass tests or inspections and retest as specified above.
  
- E. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
  1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.



2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
  3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
- F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

### 3.5 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

### 3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 2213

## SECTION 26 2413 - SWITCHBOARDS

### 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. Service and distribution switchboards rated 600 V and less.
  - 2. Surge protection devices.
  - 3. Disconnecting and overcurrent protective devices.
  - 4. Instrumentation.
  - 5. Control power.
  - 6. Accessory components and features.
  - 7. Identification.
  - 8. Mimic bus.

#### 1.3 RELATED SECTIONS

- A. Section 26 0574 "Overcurrent Protective Device Arc-Flash Study" for arc-flash study and arc-flash label requirements.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
  - 1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
  - 2. Detail enclosure types for types other than NEMA 250, Type 1.
  - 3. Detail bus configuration, current, and voltage ratings.
  - 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
  - 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
  - 6. Detail utility company's metering provisions with indication of approval by utility company.

7. Include evidence of NRTL listing for series rating of installed devices.
  8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
  10. Include diagram and details of proposed mimic bus.
  11. Include schematic and wiring diagrams for power, signal, and control wiring.
- C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
- D. Delegated Design Submittal:
1. For arc-flash hazard study.
  2. For arc-flash labels.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field Quality-Control Reports:
1. Test procedures used.
  2. Test results that comply with requirements.
  3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 01 7800 "Closeout Submittals" include the following:
    - a. Routine maintenance requirements for switchboards and all installed components.
    - b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

- c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
  - 2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
  - 3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
  - 4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
  - 5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
  - 6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

#### 1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.
- B. Testing Qualifications: NETA or an NRTL.
  - 1. Testing Field Supervisor: Certified by NETA.

#### 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and connect factory-installed space heaters to temporary electrical service to prevent condensation.
- C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

#### 1.10 FIELD CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards 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.
  2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
    - a. Ambient Temperature: Not exceeding 104 deg F.
    - b. Altitude: Will equal the project site altitude.
- C. Unusual Service Conditions: NEMA PB 2, as follows:
1. Ambient temperatures within limits specified.
  2. Will equal the project site altitude.
- D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Architect, Construction Manager no fewer than 14 days in advance of proposed interruption of electric service.
  2. Indicate method of providing temporary electric service.
  3. Do not proceed with interruption of electric service without Architect's, Construction Manager's, and Owner's written permission.
  4. Comply with NFPA 70E.

#### 1.11 COORDINATION

- A. Coordinate layout and installation of switchboards 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.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

#### 1.12 WARRANTY

- A. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: Five years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
  - 2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

### 2.2 SWITCHBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Square D
  - 2. Siemens
  - 3. Eaton
  - 4. G.E.
- B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- 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.
- D. 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.
- E. Comply with NEMA PB 2.
- F. Comply with NFPA 70.
- G. Comply with UL 891.
- H. Front-Connected, Front-Accessible Switchboards:
  - 1. Main Devices: Panel mounted.
  - 2. Branch Devices: Panel mounted.
  - 3. Sections front and rear aligned.
- I. Front- and Side-Accessible Switchboards:
  - 1. Main Devices: Fixed, individually mounted.
  - 2. Branch Devices: Panel mounted.

3. Section Alignment: Front aligned.
- J. Front- and Rear-Accessible Switchboards:
1. Main Devices: Fixed, individually mounted.
  2. Branch Devices: Panel and fixed, individually mounted.
  3. Sections front aligned.
- K. Nominal System Voltage: 480Y/277 V and 208Y/120 V.
- L. Main-Bus Continuous: Amps as indicated on one-line diagram.
- M. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces per project's seismic requirements.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- N. Indoor Enclosures: Steel, NEMA 250, Type 1.
- O. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- P. Barriers: Between adjacent switchboard sections.
- Q. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.
- R. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
  2. Space-Heater Power Source: Transformer, factory installed in switchboard.
- S. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.
- T. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

- U. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.
- V. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- W. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- X. Pull Box on Top of Switchboard:
  1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
  2. Set back from front to clear circuit-breaker removal mechanism.
  3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
  4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
  5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- Y. Buses and Connections: Three phase, four wire unless otherwise indicated.
  1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
  2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
  3. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
  4. Copper feeder circuit-breaker line connections.
  5. Tin-plated aluminum feeder circuit-breaker line connections.
  6. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
  7. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
  8. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
  9. Disconnect Links:
    - a. Isolate neutral bus from incoming neutral conductors.
    - b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
  10. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.



- 11. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- Z. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- AA. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
- BB. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

### 2.3 SURGE PROTECTION DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Advanced Protection Technologies Inc. (APT).
  - 2. Eaton.
  - 3. General Electric Company.
  - 4. SIEMENS Industry, Inc.; Energy Management Division.
- B. SPDs: Comply with UL 1449, Type 2.
- C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.
- D. Features and Accessories:
  - 1. Integral disconnect switch.
  - 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
  - 3. Indicator light display for protection status.
  - 4. Form-C contacts rated at 5A and 250-V ac one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
  - 5. Surge counter.
- E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 250kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
  - 2. Line to Ground: 1200 V for 480Y/277 V and 1200 V for 208Y/120 V.
  - 3. Line to Line: 2000 V for 480Y/277 V and 1000 V for 208Y/120 V.

- G. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 700 V.
  - 2. Line to Ground: 1000 V.
  - 3. Line to Line: 1000 V.
- H. SCCR: Equal or exceed 250 kA.
- I. Nominal Rating: 20 kA.

## 2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
  - 1. 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 A and larger.
  - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  - 3. Electronic trip circuit breakers with 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 adjustments.
    - d. Ground-fault pickup level, time delay, and I squared t response.
  - 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
  - 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
  - 6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
  - 7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
  - 8. MCCB Features and Accessories:
    - a. Standard frame sizes, trip ratings, and number of poles.
    - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
    - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    - e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

- f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
  - g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
  - h. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
  - i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- B. Insulated-Case Circuit Breaker (ICCB): 80percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
- 1. Fixed circuit-breaker mounting.
  - 2. Two-step, stored-energy closing.
  - 3. Standard function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Time adjustments for long- and short-time pickup.
    - c. Ground-fault pickup level, time delay, and I squared t response.
  - 4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
  - 5. Remote trip indication and control.
  - 6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
  - 7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
  - 8. Control Voltage: 120-V ac.
- C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Boltswitch, Inc.
    - b. Eaton.
    - c. SIEMENS Industry, Inc.; Energy Management Division.
  - 2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
  - 3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
    - a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.

- b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
- 4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
- 5. Service-Rated Switches: Labeled for use as service equipment.
- 6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
  - a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  - b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
  - c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
  - d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
- 7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
- D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- E. Fuses are specified in Section 26 2813 "Fuses."

## 2.5 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, and the following:
  - 1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, tapped secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
  - 2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
  - 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
  - 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
  - 1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
    - a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
    - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
    - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.

- d. Megawatts: Plus or minus 1 percent.
  - e. Megavars: Plus or minus 1 percent.
  - f. Power Factor: Plus or minus 1 percent.
  - g. Frequency: Plus or minus 0.1 percent.
  - h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
  - i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
  - j. Contact devices to operate remote impulse-totalizing demand meter.
- 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
- C. Analog Meters:
- 1. Meters: 4-inch diameter or 6 inches square, flush or semiflush, with anti-parallax 250-degree scales and external zero adjustment.
- D. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
- E. Instrument Switches: Rotary type with off position.
- 1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
  - 2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.
- F. Ammeters: 2-1/2-inch minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.
- G. Watt-Hour Meters and Wattmeters:
- 1. Comply with ANSI C12.1.
  - 2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
  - 3. Suitable for connection to three- and four-wire circuits.
  - 4. Potential indicating lamps.
  - 5. Adjustments for light and full load, phase balance, and power factor.
  - 6. Four-dial clock register.
  - 7. Integral demand indicator.
  - 8. Contact devices to operate remote impulse-totalizing demand meter.
  - 9. Ratchets to prevent reverse rotation.
  - 10. Removable meter with drawout test plug.
  - 11. Semiflush mounted case with matching cover.
  - 12. Appropriate multiplier tag.
- H. Impulse-Totalizing Demand Meter:
- 1. Comply with ANSI C12.1.
  - 2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
  - 3. Cyclometer.

4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording five-minute integrated demand of totalized system.

## 2.6 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
- B. Control Circuits: 120-V ac, supplied from remote branch circuit.
- C. Control Circuits: 24V dc.
- D. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
- E. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- F. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

## 2.7 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
- D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
- E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.
- F. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with the project's seismic or manufacturer's instructions.

## 2.8 IDENTIFICATION

- A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
  - 1. Nameplate: At least 0.032-inch-thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.
- B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.
  - 1. Nameplate: At least 0.0625-inch-thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.
- C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.
- D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
- E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- F. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
  - 1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
  - 2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
  - 3. Protect from moisture, dust, dirt, and debris during storage and installation.
  - 4. Install temporary heating during storage per manufacturer's instructions.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 03 3000 "Cast-in-Place Concrete."
  - 1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
  - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
  - 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 5. Install anchor bolts to elevations required for proper attachment to switchboards.
  - 6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
- D. Comply with mounting and anchoring requirements for this project's seismic criteria.
- E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- F. Install filler plates in unused spaces of panel-mounted sections.
- G. Install overcurrent protective devices, surge protection devices, and instrumentation.
  - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- H. Install spare-fuse cabinet.
- I. Comply with NECA 1.

### 3.3 CONNECTIONS

- A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.
- B. Support and secure conductors within the switchboard according to NFPA 70.
- C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.



### 3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Acceptance Testing:
    - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    - b. Test continuity of each circuit.
  - 2. Test ground-fault protection of equipment for service equipment per NFPA 70.
  - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - 5. 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 switchboard. Remove front panels so joints and connections are accessible to portable scanner.
    - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
    - c. Instruments and Equipment:
      - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Switchboard will be considered defective if it does not pass tests and inspections.

- C. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Overcurrent Protective Device Coordination Study."

### 3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service

### 3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION 26 2413

## SECTION 26 2416 - PANELBOARDS

### 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. Distribution panelboards.
  - 2. Lighting and appliance branch-circuit panelboards.
  - 3. Load centers.
  - 4. Electronic-grade panelboards.

#### 1.3 DEFINITIONS

- A. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. HID: High-intensity discharge.
- E. MCCB: Molded-case circuit breaker.
- F. SPD: Surge protective device.
- G. VPR: Voltage protection rating.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard.
  - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
  - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details.

2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7800 "Closeout Submittals" 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 that allows adjustments.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- 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. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
  3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
  4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

## 1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

## 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

## 1.10 FIELD CONDITIONS

- A. Environmental Limitations:

- 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards 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.
- 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - a. Ambient Temperature: Not exceeding minus 22 deg. F to plus 104 deg. F.
  - b. Altitude: Not exceeding this project site elevation in feet.

- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

- 1. Ambient temperatures within limits specified.
- 2. Not exceeding this project site elevation in feet.

- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

- 1. Notify Architect, Construction Manager, and Owner no fewer than 14 days in advance of proposed interruption of electric service.
- 2. Do not proceed with interruption of electric service without Architect's, Construction Manager's, and Owner's written permission.
- 3. Comply with NFPA 70E.

## 1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

- 1. Panelboard Warranty Period: 24 months from date of Substantial Completion.

- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
  - 1. SPD Warranty Period: Five years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. 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.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.
- F. Enclosures: Flush and Surface-mounted, dead-front cabinets.
  - 1. Rated for environmental conditions at installed location.
    - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    - b. Outdoor Locations: NEMA 250, Type 3R.
    - c. Kitchen/Wash-Down Areas: NEMA 250, Type 4X.
    - d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
    - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
  - 2. Height: 84 inches maximum.
  - 3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
  - 4. Door in Door: Door within trim cover. Trims shall cover all live parts and shall have no exposed hardware. Inner door will be keyed lockable. Provide a minimum of two keys per panel, keyed the same.
  - 5. Skirt for Surface-Mounted Panelboards: Same gauge and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
  - 6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
  - 7. Finishes:

- a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
- b. Back Boxes: Same finish as panels and trim.
- c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:

- 1. Location: Convertible between top and bottom.
- 2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

- 1. Material: Hard-drawn copper, 98 percent conductivity.
  - a. Plating shall run entire length of bus.
  - b. Bus shall be fully rated the entire length.
- 2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
- 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
- 4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
- 5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
- 6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
- 7. Split Bus: Vertical buses divided into individual vertical sections.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

- 1. Material: Hard-drawn copper, 98 percent conductivity.
- 2. Terminations shall allow use of 75 deg C rated conductors without derating.
- 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
- 4. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
- 5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
- 6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- 7. Sub feed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

8. Gutter-Tap Lugs: Compression type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
  9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.
  - K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
    1. Percentage of Future Space Capacity: 20 percent.
  - L. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
    1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
    2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.
  - M. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
    1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
    2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

## 2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
- B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.



## 2.3 POWER PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Square D
  - 2. Siemens
  - 3. Eaton
  - 4. G.E.
- B. Panelboards: NEMA PB 1, distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
  - 1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker or Lugs only as indicated on plans.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger than 125 A: Bolt-on circuit breakers.
- G. Branch Overcurrent Protective Devices: Fused switches.
- H. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
  - 1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
  - 2. External Control-Power Source: 24-V control circuit.

## 2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Square D
  - 2. Siemens
  - 3. Eaton
  - 4. G.E.
- B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
  - 1. Thermal-Magnetic Circuit Breakers:
    - a. Inverse time-current element for low-level overloads.
    - b. Instantaneous magnetic trip element for short circuits.
    - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:
  - a. RMS sensing.
  - b. Field-replaceable rating plug or electronic trip.
  - c. Digital display of settings, trip targets, and indicated metering displays.
  - d. Multi-button keypad to access programmable functions and monitored data.
  - e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
  - f. Integral test jack for connection to portable test set or laptop computer.
  - g. Field-Adjustable Settings:
    - 1) Instantaneous trip.
    - 2) Long- and short-time pickup levels.
    - 3) Long and short time adjustments.
    - 4) Ground-fault pickup level, time delay, and I squared T response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.
9. MCCB Features and Accessories:
  - a. Standard frame sizes, trip ratings, and number of poles.
  - b. Breaker handle indicates tripped status.
  - c. UL listed for reverse connection without restrictive line or load ratings.
  - d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
  - e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
  - f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  - g. Shunt Trip: 24-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
  - h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
  - i. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
  - j. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
  - k. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
  - l. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

- m. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
  - n. Multipole units enclosed in a factory assembled to operate as a single unit.
  - o. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
  - p. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- 1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."
  - 2. Fused Switch Features and Accessories:
    - a. Standard ampere ratings and number of poles.
    - b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.
    - c. Auxiliary Contacts: Two normally open and normally closed contact(s) that operate with switch handle operation.

## 2.5 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.
  - 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.
- D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
  - 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

## 2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- 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.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NEMA PB 1.1.
- D. Equipment Mounting:
  - 1. Install panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete."
  - 2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
  - 3. Comply with requirements for seismic control devices per this project's seismic criteria.
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Comply with mounting and anchoring requirements per this project's seismic criteria.
- G. Mount top of trim 90 inches above finished floor unless otherwise indicated.

- H. Mount panelboard cabinet plumb and rigid without distortion of box.
- I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- J. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.
- K. Install overcurrent protective devices and controllers not already factory installed.
  - 1. Set field-adjustable, circuit-breaker trip ranges.
  - 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- M. Install filler plates in unused spaces.
- N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- O. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- P. Mount spare fuse cabinet in accessible location.

### 3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 0553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 26 0553 "Identification for Electrical Systems" identifying source of remote circuit.

### 3.4 FIELD QUALITY CONTROL

#### A. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. 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 panelboard. Remove front panels so joints and connections are accessible to portable scanner.
  - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
  - c. Instruments and Equipment:
    - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

B. Panelboards will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 2416

## SECTION 26 2726 - WIRING DEVICES

### 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. Straight-blade convenience, hospital-grade, isolated-ground, and tamper-resistant receptacles.
2. USB charger devices.
3. GFCI receptacles.
4. SPD receptacles.
5. Twist-locking receptacles.
6. Pendant cord-connector devices.
7. Cord and plug sets.
8. Toggle switches.
9. Decorator-style convenience.
10. Residential devices.
11. Wall plates.
12. Floor service outlets.
13. Prefabricated multi-outlet assemblies.

#### 1.3 DEFINITIONS

- A. Abbreviations of Manufacturers' Names:

1. Cooper: Cooper Wiring Devices; Division of Cooper Industries, Inc.
2. Hubbell: Hubbell Incorporated: Wiring Devices-Kellems.
3. Leviton: Leviton Mfg. Company, Inc.
4. Pass & Seymour: Pass& Seymour/Legrand.

- B. BAS: Building automation system.

- C. EMI: Electromagnetic interference.

- D. GFCI: Ground-fault circuit interrupter.

- E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

- F. RFI: Radio-frequency interference.

- G. SPD: Surge protective device.



- H. UTP: Unshielded twisted pair. ACTION SUBMITTALS
- I. Product Data: For each type of product.
- J. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- K. Samples: One for each type of device and wall plate specified, in each color specified.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

#### 1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.
  - 2. Poke-Through, Fire-Rated Closure Plugs: One for every 10 floor service outlets installed, but no fewer than two.
  - 3. SPD Receptacles: One for every 10 of each type installed, but no fewer than two of each type.

### PART 2 - PRODUCTS

#### 2.1 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
  - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
  - 2. Devices shall comply with the requirements in this Section.
- D. Devices for Owner-Furnished Equipment:
  - 1. Receptacles: Match plug configurations.

2. Cord and Plug Sets: Match equipment requirements.
- E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

## 2.2 STRAIGHT-BLADE RECEPTACLES

- A. Duplex Convenience Receptacles: 125 V, 20 A, heavy-duty type; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton (Arrow Hart).
    - b. Hubbell Incorporated; Wiring Device-Kellems.
    - c. Leviton Manufacturing Co., Inc.
- B. Tamper-Resistant Convenience Receptacles: 125 V, 20 A, heavy-duty type; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
1. Provide tamper resistant devices in throughout school and in dormitory.
  2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton (Arrow Hart).
    - b. Hubbell Incorporated; Wiring Device-Kellems.
    - c. Leviton Manufacturing Co., Inc.

## 2.3 USB CHARGER DEVICES

- A. Tamper-Resistant, USB Charger Receptacles: 12 V dc, 2.0 A, USB Type A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1310, and FS W-C-596.
1. Provide tamper resistant devices in throughout school and in dormitory.
  2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton (Arrow Hart).
    - b. Hubbell Incorporated; Wiring Device-Kellems.
    - c. Leviton Manufacturing Co., Inc.
  3. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
  4. USB Receptacles: Single, Type A.
  5. Line Voltage Receptacles: Single, two pole, three wire, and self-grounding.

## 2.4 GFCI RECEPTACLES

### A. General Description:

1. 125 V, 20 A, heavy-duty type, straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

### B. Duplex GFCI Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Eaton (Arrow Hart).
  - b. Hubbell Incorporated; Wiring Device-Kellems.
  - c. Leviton Manufacturing Co., Inc.

### C. Tamper-Resistant, Duplex GFCI Convenience Receptacles:

1. Provide tamper resistant devices in throughout school and in dormitory.
2. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - a. Hubbell Incorporated; Wiring Device-Kellems.

## 2.5 TWIST-LOCKING RECEPTACLES

### A. Twist-Lock, Single Convenience Receptacles: 125 V, 20 A, heavy-duty type; comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Eaton (Arrow Hart).
  - b. Hubbell Incorporated; Wiring Device-Kellems.
  - c. Leviton Manufacturing Co., Inc.

## 2.6 CORD AND PLUG SETS

### A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

## 2.7 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A, heavy-duty type:

1. Single Pole:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) Eaton (Arrow Hart).
- 2) Hubbell Incorporated; Wiring Device-Kellems.
- 3) Leviton Manufacturing Co., Inc.

2. Two Pole:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) Eaton (Arrow Hart).
- 2) Hubbell Incorporated; Wiring Device-Kellems.
- 3) Leviton Manufacturing Co., Inc.

3. Three Way:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) Eaton (Arrow Hart).
- 2) Hubbell Incorporated; Wiring Device-Kellems.
- 3) Leviton Manufacturing Co., Inc.

4. Four Way:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) Eaton (Arrow Hart).
- 2) Hubbell Incorporated; Wiring Device-Kellems.
- 3) Leviton Manufacturing Co., Inc.

C. Pilot-Light Switches: 120/277 V, 20 A, heavy-duty type.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).

- b. Hubbell Incorporated; Wiring Device-Kellems.
  - c. Leviton Manufacturing Co., Inc.
- 2. Description: Single pole, with LED-lighted handle, illuminated when switch is off.
- D. Key-Operated Switches: 120/277 V, 20 A, heavy-duty type.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton (Arrow Hart).
    - b. Hubbell Incorporated; Wiring Device-Kellems.
    - c. Leviton Manufacturing Co., Inc.
  - 2. Description: Single pole, with factory-supplied key in lieu of switch handle.
- E. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A, heavy-duty type; for use with mechanically held lighting contactors.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton (Arrow Hart).
    - b. Hubbell Incorporated; Wiring Device-Kellems.
    - c. Leviton Manufacturing Co., Inc.
- F. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A, heavy-duty type; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton (Arrow Hart).
    - b. Hubbell Incorporated; Wiring Device-Kellems.
    - c. Leviton Manufacturing Co., Inc.

## 2.8 WALL PLATES

- A. Single and combination types shall match corresponding wiring devices.
  - 1. Plate-Securing Screws: Metal with head color to match plate finish.
  - 2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
  - 3. Material for Unfinished Spaces: Galvanized steel
  - 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

- C. Wall plates shall be 0.040-inch smooth metal, except in the kitchens and restrooms, where cover plates shall be 0.302-inch stainless steel.

## 2.9 PREFABRICATED MULTIOUTLET ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Wiremold, Legrand
- B. Description:
  - 1. Two-piece surface metal raceway, with factory-wired multi-outlet harness.
  - 2. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- C. Raceway Material: Metal, with manufacturer's standard finish.
- D. Multioutlet Harness:
  - 1. Receptacles: 15-A, 125-V, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
  - 2. Receptacle Spacing: As indicated on plans.
  - 3. Wiring: No. 12 AWG solid, Type THHN copper, multiple circuit, connecting alternating receptacles.

## 2.10 FINISHES

- A. Device Color:
  - 1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
  - 2. Wiring Devices Connected to Stand-by Power System: Red.
  - 3. SPD Devices: Blue.
- B. Wall Plate Color: Match device color.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
  - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
  - a. Cut back and pigtail, or replace all damaged conductors.
  - b. Straighten conductors that remain and remove corrosion and foreign matter.
  - c. Pigtailling existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
10. Receptacles located in common areas, such as corridors, gymnasiums, cafeterias, and the like, shall be high-abuse type.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

- G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.
- H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

### 3.2 GFCI RECEPTACLES

- A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

### 3.3 IDENTIFICATION

- A. Comply with Section 26 0553 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

### 3.4 FIELD QUALITY CONTROL

- A. Test Instruments: Use instruments that comply with UL 1436.
- B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Test Instruments: Use instruments that comply with UL 1436.
  - 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- D. Tests for Convenience Receptacles:
  - 1. Line Voltage: Acceptable range is 105 to 132 V.
  - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
  - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
  - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
  - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
  - 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- E. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.



- F. Wiring device will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

END OF SECTION 26 2726

## SECTION 26 2813 - FUSES

### 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. Cartridge fuses rated 600 V ac and less for use in the following:
  - a. Control circuits.
  - b. Panelboards.
  - c. Switchboards.
  - d. Enclosed controllers.
  - e. Enclosed switches.
2. Spare-fuse cabinets.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
  1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
    - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
  2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
  3. Current-limitation curves for fuses with current-limiting characteristics.
  4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software.
  5. Coordination charts and tables and related data.
  6. Fuse sizes for elevator feeders and elevator disconnect switches.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7000 "Execution and Closeout Requirements," and/or Section 01 7800 "Closeout Submittals" include the following:
1. Ambient temperature adjustment information.
  2. Current-limitation curves for fuses with current-limiting characteristics.
  3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software.
  4. Coordination charts and tables and related data.

#### 1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

#### 1.6 FIELD CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F temperature or more than 100 deg F temperature, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bussmann, an Eaton business.
  2. Edison; a brand of Bussmann by Eaton.
  3. Littelfuse, Inc.
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

#### 2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
1. Type RK-1: 250 and or 600-V, zero- to 600-A rating, 200 kAIC, time delay.

2. Type RK-5: 250 and or 600-V, zero- to 600-A rating, 200 kAIC, time delay.
  3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
  4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, fast acting.
  5. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
  6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
  7. Type T: 250-V, zero- to 1200-A, 600-V, zero- to 800-A rating, 200 kAIC, very fast acting.
- B. 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.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

### 2.3 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum. Cabinet will be able to hold all required spare fuses.
  2. Finish: Gray, baked enamel.
  3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
  4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.
  5. Provide three spare fuses for each fuse size installed and store them in the fuse cabinet.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 FUSE APPLICATIONS

#### A. Cartridge Fuses:

1. Feeders: Class L, fast acting, Class RK1, fast acting, lass RK1, time delay.
2. Motor Branch Circuits: Class RK1, Class CC, motor duty, time delay.
3. Large Motor Branch (601-4000 A): Class L, time delay.
4. Power Electronics Circuits: Class T, fast acting.
5. Other Branch Circuits: Class RK1, time delay, Class RK5, time delay, Class J, fast acting, Class J, time delay, Class CC, fast acting.
6. Control Transformer Circuits: Class CC, time delay, control transformer duty.
7. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

### 3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Architect.

### 3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 2813

## SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Fusible switches.
  - 2. Nonfusible switches.
  - 3. Receptacle switches.
  - 4. Shunt trip switches.
  - 5. Molded-case circuit breakers (MCCBs).
  - 6. Molded-case switches.
  - 7. Enclosures.

#### 1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
  - 1. Enclosure types and details for types other than NEMA 250, Type 1.
  - 2. Current and voltage ratings.
  - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
  - 4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
  - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
  - 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF format.

- B. Shop Drawings: For enclosed switches and circuit breakers.
  - 1. Include plans, elevations, sections, details, and attachments to other work.
  - 2. Include wiring diagrams for power, signal, and control wiring.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in Section 01 7800 "Closeout Submittals" include the following:
    - a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
    - b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF format.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
  - 2. Fuse Pullers: Two for each size and type.

#### 1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

## 1.9 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
  2. Altitude: Not exceeding 6600 feet.

## 1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: One year from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

### 2.2 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.



## 2.3 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Square D.
  2. Siemens
  3. Eaton
  4. G.E.
- B. Type HD, Heavy Duty:
1. Single throw.
  2. Three pole.
  3. 600-V ac.
  4. 1200 A and smaller.
  5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
  6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
  4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
  5. Auxiliary Contact Kit: NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac
  6. Hookstick Handle: Allows use of a hookstick to operate the handle.
  7. Lugs: Compression type, suitable for number, size, and conductor material.
  8. Service-Rated Switches: Labeled for use as service equipment.

## 2.4 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Square D.
  2. Siemens
  3. Eaton
  4. G.E.
- B. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

- C. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- E. Type HD, Heavy Duty, Three Pole, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- F. Accessories:
  - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  - 3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
  - 4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
  - 5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac.
  - 6. Hookstick Handle: Allows use of a hookstick to operate the handle.
  - 7. Lugs: Compression type, suitable for number, size, and conductor material.
  - 8. Service-Rated Switches: Labeled for use as service equipment.

## 2.5 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Square D.
  - 2. Siemens
  - 3. Eaton
  - 4. G.E.
- B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.
- D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be rated as indicated on the Drawings. Circuit breaker/circuit

breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System.        Amps Available. Identical Replacement Component Required."

- E. MCCBs shall be equipped with a device for locking in the isolated position.
- F. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below.
- G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
  - 1. Instantaneous trip.
  - 2. Long- and short-time pickup levels.
  - 3. Long- and short-time time adjustments.
  - 4. Ground-fault pickup level, time delay, and I-squared t response.
- K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
- M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- O. Features and Accessories:
  - 1. Standard frame sizes, trip ratings, and number of poles.
  - 2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
  - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
  - 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.

5. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control."
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One NO and NC contact that operates only when circuit breaker has tripped.
10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, self-powered; 24-V ac

## 2.6 MOLDED-CASE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Square D.
  2. Siemens
  3. Eaton
  4. G.E.
- B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- D. Features and Accessories:
  1. Standard frame sizes and number of poles.
  2. Lugs:
    - a. Compression type, suitable for number, size, trip ratings, and conductor material.
    - b. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below rating in NFPA 70.
  3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
  4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
  5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO and NC contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered; 24-V ac

## 2.7 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).
- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
- D. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.
- E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.
- F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
  1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

### 3.2 PREPARATION

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
  - 1. Notify Architect, Construction Manager, Owner no fewer than 14 days in advance of proposed interruption of electric service.
  - 2. Indicate method of providing temporary electric service.
  - 3. Do not proceed with interruption of electric service without Architect's, Construction Manager's, Owner's written permission.
  - 4. Comply with NFPA 70E.

### 3.3 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in fusible devices.
- F. Comply with NFPA 70 and NECA 1.

### 3.4 IDENTIFICATION

- A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

### 3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Tests and Inspections for Switches:
  - 1. Visual and Mechanical Inspection:
    - a. Inspect physical and mechanical condition.

- b. Inspect anchorage, alignment, grounding, and clearances.
- c. Verify that the unit is clean.
- d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
- e. Verify that fuse sizes and types match the Specifications and Drawings.
- f. Verify that each fuse has adequate mechanical support and contact integrity.
- g. Inspect bolted electrical connections for high resistance using one of the two following methods:
  - 1) Use a low-resistance ohmmeter.
    - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
    - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
- h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
- i. Verify correct phase barrier installation.
- j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
- d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

C. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:
  - a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
  - b. Inspect physical and mechanical condition.
  - c. Inspect anchorage, alignment, grounding, and clearances.
  - d. Verify that the unit is clean.
  - e. Operate the circuit breaker to ensure smooth operation.
  - f. Inspect bolted electrical connections for high resistance using one of the two following methods:
    - 1) Use a low-resistance ohmmeter.
      - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
      - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
  - g. Inspect operating mechanism, contacts, and chutes in unsealed units.
  - h. Perform adjustments for final protective device settings in accordance with the coordination study.
2. Electrical Tests:
  - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
  - b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
  - c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
  - d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
  - e. Determine the following by primary current injection:



- 1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.
- f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
  - g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
  - h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
  - i. Verify operation of charging mechanism. Investigate units that do not function as designed.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  4. 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 enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
1. Test procedures used.
  2. Include identification of each enclosed switch and circuit breaker tested and describe test results.

3. List deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Overcurrent Protective Device Coordination Study."

END OF SECTION 26 2816

## SECTION 26 2820 - GROUND-FAULT PROTECTION

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplemental General Conditions and Division 1 Specification Sections, apply to this section.

#### 1.2 SUMMARY

- A. This section includes ground-fault sensing, relaying, tripping, and monitoring devices for installation in distribution switchboards and panelboards rated 600 V and less.

#### 1.3 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 each component specified.
- C. Wiring diagrams detailing wiring for power and control systems and differentiating between manufacturer-installed and field-installed wiring.
- D. Qualification data for firms and persons specified in "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.
- E. Field test reports indicating and interpreting test results relative to compliance with performance requirements of ground-fault protection system.
- F. Maintenance data for ground-fault relay to include in the operation and maintenance manual specified in Division 1.

#### 1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer to install ground-fault protection system components that is acceptable to manufacturer of switchboard or disconnect device in which installation is to be made.
- B. Manufacturer Qualifications: Engage a firm experienced in manufacturing ground-fault protection components similar to those indicated for this Project and with a record of successful in-service performance.

- C. Testing Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7, or a full member company of the InterNational Electrical Testing Association (NETA).
  - 1. Testing Field Supervision: Use persons currently certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- D. Comply with UL 1053.
- E. Comply with NFPA 70.
- F. Listing and Labeling: Provide products specified in this Section that are listed and labeled.
  - 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 OSHA Regulation 1910.7.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide ground-fault protection components by one of the following:
  - 1. Cutler Hammer; Advanced Products Support Center
  - 2. General Electric Company; Electrical Distribution and Control
  - 3. Hi-Z Corp.
  - 4. Siemens Energy & Automation, Inc.
  - 5. Square D Groupe Schneider

### 2.2 GROUND-FAULT SENSING DEVICES

- A. Current Sensors: Round- or split-core rectangular current transformers.
- B. Short-Circuit Rating: 200,000 symmetrical amperes.
- C. Sensor Outputs: Compatible with relay inputs.
- D. Split-Core Construction: Rectangular sensors are constructed to allow installation and removal without disturbing electrical conductors being encircled.

- E. Relay Test Provisions: Test winding in sensor is arranged to permit testing the operation of complete ground-fault protection system, including sensor, relay, monitor panel, and circuit-interrupting device.

## 2.3 RELAYS AND MONITORS

- A. Ground-Fault Relay: Solid-state type that requires no external source of electrical power for relay operation.
  - 1. Testing and Tripping Voltage: 120 VAC, from external source.
  - 2. Interlocking: Field wiring terminals and interface devices accommodate zone-selective coordination with other ground-fault relays or with ground-fault function of electronic trip units of circuit breakers indicated for coordination.
  - 3. Pick-up Current Sensitivity: Field adjustable from 100 to 1200 A, with calibrated dial designed to inhibit tampering with setting.
  - 4. Time Delay: Field adjustable from instantaneous to one second, with calibrated dial designed to inhibit tampering with setting.
  - 5. UL 1053, Class I.
  - 6. Output Circuit: Compatible with rating of tripping coils of interrupting device.
- B. Monitor Panels: Include ground-fault indicator, control-power indicator, and test and reset buttons, arranged to allow testing with and without tripping.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine equipment to receive ground-fault protection devices for compliance with installation tolerances and other conditions affecting integrity and safety of completed installation and performance of the ground-fault protection system. Do not proceed with installation until unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install ground-fault protection devices according to manufacturer's written instructions.
- B. Install sensors so they encircle power-conductor bus bars or cables symmetrically. Maintain clearances between conductors and sensor body as recommended by device manufacturer.
- C. Fasten and support sensors without mechanical stress, twisting, or misalignment being exerted by clamps, supports, bus bars, or cables.
- D. Install interconnecting wiring for zone-selective systems in raceway where it runs external to component enclosure. Comply with Division 26 Sections, Raceways and Boxes and Wires and Cables.
- E. Connections: Tighten connectors and terminals, including screws and bolts, according to

equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

### 3.3 FIELD QUALITY CONTROL

- A. Testing: Upon completion of installation of ground-fault protection system and after electrical circuits have been energized, demonstrate capability and compliance with requirements.
  - 1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.14. Certify compliance with test parameters.
- B. Correct malfunctioning units at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

### 3.4 ADJUSTING

- A. Set field-adjustable pick-up and time-sensitivity values as indicated.
- B. Perform short-circuit analysis and coordination study. Set field-adjustable pick-up and time-sensitivity values accordingly.
- C. Coordination: Use zone-selective method with 0.1-second delay of upstream devices between upstream and downstream ground-fault protection devices and circuit-breaker electronic trip units.

END OF SECTION 26 2820

## SECTION 26 3623 – AUTOMATIC TRANSFER SWITCHES

### 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. Generator and Transfer Switch System is to be included under if the Alternate gets accepted.
- B. This Section includes transfer switches rated 250 V and less, including the following:
  - 1. Automatic transfer switches
- C. Related Sections include the following:
  - 1. Division 26, Section 26 3213, Diesel Generators.

#### 1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
  - 1. Technical data on all major components of all transfer switches and other products described in this section. Data is required for the transfer switch mechanism, control system, cabinet, and protective devices specifically listed for use with each transfer switch. Include steady state and fault current ratings, weights, operating characteristics, and furnished specialties and accessories.
  - 2. Single-Line Diagram: Show connections between transfer switch, power sources, and load.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
  - 1. Dimensioned outline drawings of assembly, including elevations, sections, and details including minimal clearances, conductor entry provisions, gutter space, installed features and devices and material lists for each switch specified.
  - 2. Internal electrical wiring and control drawings.
  - 3. Interconnection wiring diagrams, showing recommended conduit runs and point-to-point terminal connections to generator set.
  - 4. Installation and mounting instructions, including information for proper installation of equipment to meet seismic requirements.

- C. **Manufacturer Seismic Qualification Certification:** Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
  - 1. Seismic certification, as required for site conditions. Seismic certifications shall be third-party certified, and based on testing. Certification based on calculations does not meet this requirement.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational both during and after the seismic event."
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. **Manufacturer and Supplier Qualification Data**
  - 1. The transfer switch manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
  - 2. The manufacturer of this equipment shall have produced similar equipment for a minimum period of 10 years. When requested, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- E. **Operation and Maintenance Data:** For each type of product to include in emergency, operation, and maintenance manuals. Include the following:
  - 1. Features and operating sequences, both automatic and manual.
  - 2. List of all factory settings of relays, timers and protective devices; provide setting and calibration instructions where applicable.
- F. Warranty documents demonstrating compliance with the project's contract requirements.

#### 1.4 QUALITY ASSURANCE

- A. Only approved bidders shall supply equipment provided under this contract.
- B. **Manufacturer Qualifications:** The equipment supplier shall maintain a service center capable of providing training, parts, maintenance and emergency repairs to equipment, including transfer switch generator sets and remote monitoring equipment (if applicable) at the site within a response period of less than eight hours from time of notification.
- C. **Source Limitations:** All transfer switches are to be obtained through one source from a single manufacturer. The generator set manufacturer shall warrant transfer switches to provide a single source of responsibility for products provided.



- 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 as suitable for use in emergency, legally required or optional standby use as appropriate for the connected load.
- E. The automatic transfer switch installation and application shall conform to the requirements of the following codes and standards:
  - 1. Transfer switches and enclosures shall be UL 1008 listed and labeled as suitable for use in emergency, legally required, and optional standby applications.
  - 2. CSA 282, Emergency Electrical Power Supply for Buildings, and CSA C22.2, No. 14-M91 Industrial Control Equipment
  - 3. NFPA 70, National Electrical Code. Equipment shall be suitable for use in systems in compliance with Articles 700, 701 and 702.
  - 4. Comply with NEMA ICS 10-1993 AC Automatic Transfer Switches
  - 5. IBC 2006 – The transfer switch(es) shall be prototype-tested and third-party certified to comply with the requirements of IBC group III or IV, Category D/F. The equipment shall be shipped with the installation instructions necessary to attain installation compliance
  - 6. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
  - 7. EN55011, Class B Radiated Emissions and Class B Conducted Emissions
  - 8. IEC 1000-4-5 (EN 61000-4-5) AC Surge Immunity
  - 9. IEC 1000-4-4 (EN 61000-4-4) Fast Transients Immunity
  - 10. IEC 1000-4-2 (EN 61000-4-2) Electrostatic Discharge Immunity
  - 11. IEC 1000-4-3 (EN 61000-4-3) Radiated Field Immunity
  - 12. IEC 1000-4-6 Conducted Field Immunity
  - 13. IEC 1000-4-11 Voltage Dip Immunity
  - 14. IEEE 62.41, AC Voltage Surge Immunity
  - 15. IEEE 62.45, AC Voltage Surge Testing
- F. Comply with NFPA 110 – Emergency and Standby Power Systems. The transfer switch shall meet all requirements for Level 1 systems, regardless of the actual circuit level.
- G. The manufacturer shall warrant the material and workmanship of the transfer switch equipment for a minimum of one (2) years from registered commissioning and start-up, or eighteen (18) months from date of shipment.
- H. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, and etc. during the minimum noted warranty period described above.

## 1.5 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:
  - 1. Notify (Architect/Construction Manager/Owner) in advance of proposed interruption of electrical service.
  - 2. Do not proceed with interruption of electrical service without (Architect/Construction Manager/Owner's) written permission.

3. Do not energize any new service or distribution equipment without notification and permission of the (Architect/Construction Manager/Owner).

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

#### A. Manufacturers: Basis of Design

##### 1. Cummins

- B. Equipment specifications for this Project are based on automatic transfer switches manufactured by Cummins Power Generation. Switches manufactured by others that meet the requirement of this specification are acceptable, if approved not less than two weeks before scheduled bid date. Proposals must include a line-by-line compliance statement based on this specification.
- C. Transfer switch shall be Linear Motor mechanisms specifically manufactured and tested to meet applicable transfer device standards. Transfer switches utilizing molded case circuit breakers with external transfer mechanisms such as walking beams and cables do not meet the requirements of this specification and will not be accepted.

### 2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Provide transfer switches in the number and ratings that are shown on the drawings. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer.
- B. Fault-Current Closing and Withstand Ratings: UL 1008 WCR ratings must be specifically listed as meeting the requirements for use with protective devices at installation locations, under specified fault conditions. Withstand and closing ratings shall be based on use of the same set of contacts for the withstand test and the closing test.
- C. Solid-State Controls: All settings should be accurate to +/- 2% or better over an operating temperature range of - 40 to + 60 degrees C (- 40 to + 140 degrees F).
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplished by a non-fused, momentarily energized solenoid or electric motor operator mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
  1. Transfer switches shall be double-throw, electrically and mechanically interlocked, and mechanically held in the Source 1 and Source 2 positions.
  2. Source 1 and Source 2 shall have dedicated contact mechanisms. Transfer switches with shared contact surfaces on a single wiper shaft mechanism are not acceptable.

3. Main switch contacts shall be high-pressure silver alloy. Contact assemblies shall have arc chutes for positive arc extinguishing. Arc chutes shall have insulating covers to prevent inter-phase flashover.
  4. Contacts shall be operated by a high-speed electrical mechanism that causes contacts to open or close within three electrical cycles from signal.
  5. The transfer switch operation shall include the ability to switch to an open position (both sources disconnected) for the purpose of load shedding from the generator set.
  6. The power transfer mechanism shall include provisions for manual operation under load with the enclosure door closed. Manual operation may be electromechanical or mechanical, but must be coordinated with control function.
  7. Transfer switch shall be provided with flame retardant transparent covers to allow viewing of switch contact operation but prevent direct contact with components that could be operating at line voltage levels.
  8. The transfer switch shall include the mechanical and control provisions necessary to allow the device to be field-configured for operating speed. Transfer switch operation with motor loads shall be as is recommended in NEMA MG1.
    - a. Phase angle monitoring/timing equipment is not an acceptable substitute for this functionality
  9. Transfer switches designated on the drawings as “4-pole” shall be provided with a switched neutral pole which is switched simultaneously with phase poles.
- G. Control: Transfer switch control shall be capable of communicating with the genset control, other switches and remote programming devices over a high-speed network interface.
- H. Factory wiring: Transfer switch internal wiring shall be composed of pre-manufactured harnesses that are permanently marked for source and destination. Harnesses shall be connected to the control system by means of locking disconnect plug(s), to allow the control system to be easily disconnected and serviced without disconnecting power from the transfer switch mechanism
- I. Terminals: Terminals shall be pressure type and appropriate for all field wiring. Terminal arrangement and cabinet space must be such that feeder conductors can enter from the top, side or bottom of the switch, at the installer’s discretion. Control wiring shall be equipped with suitable lugs, for connection to terminal strips.
- J. Enclosures: All enclosures shall be third-party certified for compliance to NEMA ICS 6 and UL 508, unless otherwise indicated:
1. The enclosure shall provide wire bend space in compliance to the latest version of NFPA70, regardless of the direction from which the conduit enters the enclosure.
  2. Exterior cabinet doors shall provide complete protection for the system’s internal components. Doors must have permanently mounted key-type latches. Bolted covers or doors are not acceptable.
  3. Transfer switches shall be provided in enclosures that are third party certified for their intended environment per NEMA requirements.
    - a. Transfer switches mounted in a controlled indoor environment shall be provided in NEMA Type 1 enclosures (IEC type IP30).

- b. Transfer switches located outdoors shall be supplied in NEMA Type 3R (IEC IP34) when dust-proof and/or rain-proof enclosures are required.

## 2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with requirements for Level 1 equipment according to NFPA 110.
- B. Indicated current ratings:
  - 1. System voltage: As indicated.
  - 2. Rated Amps: As indicated
  - 3. Switched number of poles: As indicated.
  - 4. Withstand and Closing Rating: 35,000A @ 250V
  - 5. Enclosure Type: As indicated.
  - 6. Main contacts shall be rated for 250AC minimum.
  - 7. Transfer switches shall be rated to carry 100% of rated current continuously in the enclosure supplied, in ambient temperatures of -40 to +60 degrees C (-40 to +140 degrees F), relative humidity up to 95% (non-condensing), and altitudes up to 10,000 feet (3000 meters).
- C. Manual Switch Operation: The power transfer mechanism shall include provisions for manual operation under load with the enclosure door closed. Manual operation may be electromechanical or mechanical, but must be coordinated with control function
- D. Control: Transfer switch control shall be provided with necessary equipment and software to communicate with the genset control, other transfer switches, remote annunciation equipment, and other devices over a high speed control network.
- E. Neutral Switching: Transfer switches designated on the drawings as 4-pole shall be provided with a switched neutral pole. The neutral pole shall be of the same construction and have the same ratings as the phase poles. All poles shall be switched simultaneously using a common crossbar. Substitute equipment using overlapping neutral contacts is not acceptable.
- F. Automatic Transfer Switch Control Features
  - 1. The transfer switch control system shall be configurable in the field for any operating voltage level up to 250 VAC. Voltage sensing shall be monitored based on the normal voltage at the site. Systems that utilize voltage monitoring based on standard voltage conditions that are not field configurable are not acceptable.
  - 2. All transfer switch sensing shall be configurable from an operator panel or from a Windows XP or later PC-based service tool. Designs utilizing DIP switches or other electromechanical devices are not acceptable.
  - 3. The transfer switch shall be configurable to accept a relay contact signal and a network signal from an external device to prevent transfer to the generator service.
  - 4. The transfer switch shall provide a relay contact signal prior to transfer or re-transfer. The time period before and after transfer shall be adjustable in a range of 0 to 50 seconds.
  - 5. The control system shall be designed and prototype tested for operation in ambient temperatures from - 40 degrees C to + 60 degrees C (- 40 to +140 degrees F). It shall be designed and tested to comply with the requirements of the noted voltage and RFI/EMI standards.

6. The control shall have optically isolated logic inputs, high isolation transformers for AC inputs and relays on all outputs, to provide optimum protection from line voltage surges, RFI and EMI.
  7. The transfer switch network monitoring equipment, when supplied, shall be provided with a battery-based auxiliary power supply to allow monitoring of the transfer switch when both AC power sources are non-operational. The battery power supply shall be monitored for proper condition, and the transfer switch shall include an alarm condition to indicate low battery condition.
- G. Transfer Switch Control Panel: The transfer switch shall have a microprocessor-based control with a sealed membrane panel incorporating pushbuttons for operator-controlled functions, and LED lamps for system status indicators. Panel indicating lamps shall include permanent labels.
1. The indicator panel LEDs shall display:
    - a. Which source the load is connected to (Source 1 or Source 2)
    - b. Which source or sources are available
    - c. When the switch is in test/exercise mode
  2. The indicator shall have pushbuttons that allow the operator to activate the following functions:
    - a. Activate pre-programmed test sequence
    - b. Override programmed delays, and immediately go to the next operation
    - c. Reset the control by clearing any faults
    - d. Test all of the LEDs by lighting them simultaneously
  3. The display panel shall allow the operator to view and make adjustments:
    - a. Set nominal voltage and frequency for the transfer switch
    - b. Adjust voltage and frequency sensor operation set points
    - c. Set up time clock functions
    - d. Enable or disable control functions including program transition
- H. Control Functions: Functions managed by the control shall include:
1. Solid-state under voltage sensors shall simultaneously monitor both sources. Pick-up and drop-out settings shall be adjustable.
  2. Automatic controls shall signal the engine-generator set to start upon signal from normal source sensor. Solid-state time delay start, adjustable from 0 to 10 seconds (factory set at 2 seconds) shall avoid nuisance start-ups. Battery voltage starting contacts shall be silver alloy, dry type contacts, factory wired to a field wiring terminal block.
  3. The switch shall transfer when the emergency source reaches the set point. Provide a solid-state time delay on transfer, adjustable from 2 to 120 seconds, factory set at 3 seconds.
  4. The switch shall retransfer the load to the normal source after a time delay retransfer, adjustable from 6 seconds to 30 minutes, factory set at 5 minutes. Retransfer time delay shall be immediately bypassed if the emergency power source fails. Controls shall signal the engine-generator set to stop after a time delay, adjustable from 0 to 10 minutes, and factory set at 5 minutes, beginning on return to the normal source.

5. The control system shall include field adjustable provisions to control the speed of operation of the transfer switch power contacts. In addition, the control shall include a field-configurable in-phase monitor function that causes the transfer to be initiated only when the sources are in phase. When in-phase transfer is enabled and transfer does not occur within 120 seconds, the control shall automatically transfer the load using delayed transfer.
6. Provide a field-configurable exerciser clock with provisions for operating the generator set for a test period at 7, 14, 21, or 28-day intervals in either with-load or without-load configuration. Operation time of the generator set shall be field configurable. Exerciser clock functions that require setting the test time by pressing an exercise button at the desired time of exercise (only) shall not be acceptable.
7. Power for the transfer switch operation shall be derived from the source to which the load is being transferred.

I. Control Interface

1. Provide one set Form C auxiliary contacts on both sides, operated by transfer switch position, rated 10 amps 250 VAC.
2. The transfer switch shall be provided with a network communications, and configured to allow network-based communication with the transfer switch and other network system components, including the generator set(s) provided for the Project.
3. Unassigned Auxiliary Contacts: Two normally open, 1-pole, double-throw contacts for each switch position, rated 10A at 240 VAC.

J. Engine Starting Contacts

1. One isolated and normally closed, and one isolated and normally open; rated 10A at 32 VDC minimum.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details.
- B. Identify components according to Division 26 Section "Identification for Electrical Systems."
- C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

### 3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

- B. Field control connections shall be made on a common terminal block that is clearly and permanently labeled.
- C. Transfer switch shall be provided with AL/CU mechanical lugs sized to accept the full output rating of the switch. Lugs shall be suitable for the number and size of conductors shown on the drawings.
- D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

### 3.3 SOURCE QUALITY CONTROL

- A. Prior to shipping, factory shall test and inspect components, assembled switches, and associated equipment to ensure proper operation.
- B. Factory shall check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements.
- C. Factory shall perform dielectric strength test complying with NEMA ICS 1.

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: The supplier of the transfer switch(es) and associated equipment shall inspect, test, and adjust components, assemblies, and equipment installations, including connections, and report results in writing.
- B. Manufacturer's representative shall perform tests and inspections and prepare test reports.
- C. After installing equipment and after electrical circuitry has been energized, installer shall test for compliance with requirements.
  - 1. Perform recommended installation tests as recommended in manufacturer's installation and service manuals.
  - 2. After energizing circuits, demonstrate interlocking sequence and operational function for each switch.
    - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    - b. Verify time-delay settings.
    - c. 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.

### 3.5 DEMONSTRATION

- A. After reconnection to existing generator, the generator and transfer switch supplier shall conduct a complete operation, basic maintenance, and emergency service seminar covering generator set and transfer switch equipment, for up to 10 people employed by the Owner.
  - 1. The seminar shall include instruction on operation of the transfer equipment, normal testing and exercise, adjustments to the control system, and emergency operation procedures.
  - 2. The class duration shall be at least 4 hours in length, and include practical operation with the installed equipment.

### 3.6 SERVICE AND SUPPORT

- A. The transfer switch supplier shall maintain service parts inventory for the entire power system at a central location which is accessible to the service location 24 hours per day, 365 days per year. The inventory shall have a commercial value of \$3 million or more. The manufacturer of the transfer switch shall maintain a central parts inventory to support the supplier, covering all the major components of the power system, including engines, alternators, control systems, paralleling electronics, and power transfer equipment.
- B. The transfer switch shall be serviced by a local service organization that is trained and factory certified in transfer switch service. The supplier shall maintain an inventory of critical power system replacement parts in the local service location. Service vehicles shall be stocked with critical replacement parts. The service organization shall be on call 24 hours per day, 365 days per year. The service organization shall be physically located within 100 miles of the site.
- C. The manufacturer shall maintain model and serial number records of each transfer switch provided for at least 20 years.

END OF SECTION 26 3623



## SECTION 26 4112 - LIGHTNING PROTECTION FOR STRUCTURES

### 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 lightning protection for structures and structure elements.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For air terminals and mounting accessories.
  - 1. Layout of the lightning protection system, along with details of the components and cable connections to be used in the installation.
  - 2. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.
- B. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.
- C. Field quality-control reports.
- D. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.
- E. Other Informational Submittals: Plans showing non-dimensioned locations of grounding features, including the following:
  - 1. Ground rods.
  - 2. Ground loop conductor.

## 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Certified by UL or LPI as a Master Installer/Designer, trained and approved for installation of units required for this Project.
- B. System Certificate:
  - 1. UL Master Label.
  - 2. LPI System Certificate.
  - 3. Provide ETL Master Label indicating system complies with specified requirements.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.
- D. All lightning protection equipment shall be installed per master label requirements.
- E. A UL or equivalent Master Label shall be obtained after construction is completed.

## 1.6 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. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

## PART 2 - PRODUCTS

### 2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96 and NFPA 780.
- B. Roof-Mounted Air Terminals: NFPA 780, aluminum unless otherwise indicated.
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated or comparable product by one of the following:
    - a. East Coast Lightning Equipment Inc.
    - b. ERICO International Corporation.
    - c. Harger.
    - d. Heary Bros. Lightning Protection Co. Inc.
    - e. Independent Protection Co.
    - f. Preferred Lightning Protection.
    - g. Robbins Lightning, Inc.
    - h. Thompson Lightning Protection, Inc.
    - i. A-C Lightning Security, Inc.

- j. Approved Lightning Protection Co., Inc.
  - k. West Dodd Lightning Conductor Corp.
  - l. VFC Lightning Protection
2. Air Terminals More than 24 Inches Long: With brace attached to the terminal at not less than half the height of the terminal.
  3. Air terminal bases shall be cast bronze with bolted pressure cable connectors, suitable for fastening to the supporting structure.
  4. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in roofing Sections.
- C. Provide a Franklin-rod type lightning protection system. All material and conductors shall be galvanically compatible. Material acceptable for use with copper are brass, nickel, tin, and stainless steel. Materials acceptable for use with aluminum are magnesium, zinc, galvanized steel, stainless steel, and wrought iron.
- D. Main and Bonding Conductors: Aluminum.
- E. Ground Loop Conductor: The same size and type as the main conductor except tinned.
- F. Ground Rods: Copper-clad; 3/4 inch in diameter by 10 feet long.
- G. Heavy-Duty, Stack-Mounted, Lightning Protection Components: Solid copper.
- H. Chemical Ground Rods:
1. Provide UL listed electrolytically enhanced ground rod(s) as shown on the drawings. Ground rod(s) to operate by hygroscopically extracting moisture from the air to activate the electrolytic process.
  2. Furnish ground rod(s) fabricated from Type K copper tubing approximately 10 feet long, 2 inches in diameter, and containing a hygroscopic electrolyte material. Furnish each chemical ground rod(s) with a 24-inch long #4/0 copper pigtail, a protective cover box, and bentonite clay backfill material free of polymer sealants.
  3. Minimum life expectancy: 30 Years
  4. As manufactured by Lyncole Industries, Inc., LEC, Inc., Superior Grounding Systems.
- I. Down-lead conductors shall be the same size and type as the main conductors if the structural steel of the building is not used.

## PART 3 - EXECUTION

### 3.1 INSTALLATION EXAMINATION

- A. Examine surfaces, areas, and conditions, with Installer present, for compliance with installation tolerances and other conditions affecting performance of lightning protection. Do not proceed with installation until unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Conform to the most stringent requirements when more than one standard is specified.
- B. Where indicated, run conductors in nonmetallic raceway, Schedule 80, minimum.
- C. Install lightning protection components and systems according to UL 96A and NFPA 780.
- D. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.
- E. Conceal the following conductors:
  - 1. System conductors.
  - 2. Down conductors.
  - 3. Interior conductors.
  - 4. Conductors within normal view of exterior locations at grade within 200 feet of building.
- F. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.
- G. Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.
  - 1. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.
- H. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.
- I. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.
- J. All down-lead conductors shall be fully concealed in PVC schedule 40 conduit within the building walls. Down-lead conductors shall be protected from physical damage or displacement for a distance of not less than 8 feet above grade.
- K. Above-grade cable connections, bonding devices, cable splices, and miscellaneous connectors shall be cast bronze with bolted pressure connections to cable and shall be electrolytically compatible with the conductor type. Cast or stamped, crimped-style fittings are not acceptable for above-grade use.
- L. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of area or item indicated.
  - 1. Bury ground ring not less than 24 inches from building foundation.
  - 2. Bond ground terminals to the ground loop.
  - 3. Bond grounded building systems to the ground loop conductor within 12 feet of grade level.

- M. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

### 3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

### 3.4 LIGHTNING PROTECTION GROUNDING ELECTRODE SYSTEM

- A. Made Electrodes: Install a ground rods located 5 feet outside the building perimeter and at least 2 feet from any electrical system or communications system grounding. Install ground rods in 6-inch diameter augured holes with at least 10 feet separation between rods. Backfill hole with a slurry of ground electrode backfill material.

### 3.5 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. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

### 3.6 FIELD QUALITY CONTROL

- A. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.
- B. UL Inspection: Meet requirements to obtain a UL Master Label for system.
- C. LPI System Inspection: Meet requirements to obtain an LPI System Certificate.
- D. Periodic Inspections: Provide the services of a qualified inspector to perform periodic inspections during construction and at its completion, according to LPI-177.
- E. ETL Inspection: Provide the services of ETL to inspect completed system for conformance with specified requirements.

END OF SECTION 26 4112

## SECTION 26 4313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

### 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. Type 1 surge protective devices.
2. Type 2 surge protective devices.
3. Enclosures.
4. Conductors and cables.

- B. Related Requirements:

1. Section 262413 "Switchboards" for integral SPDs installed by switchboard manufacturer.
2. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.
3. Section 262726 "Wiring Devices" for integral SPDs installed by receptacle manufacturer.

#### 1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: air of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. NRTL: Nationally recognized testing laboratory.
- F. OCPD: Overcurrent protective device.
- G. SCCR: Short-circuit current rating.
- H. SPD: Surge protective device.
- I. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

- J. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.
- K. Type 3 SPDs: Point of utilization SPDs.
- L. VPR: Voltage protection rating.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include electrical characteristics, specialties, and accessories for SPDs.
  - 2. NRTL certification of compliance with UL 1449.
    - a. Tested values for VPRs.
    - b. Inominal ratings.
    - c. MCOV, type designations.
    - d. OCPD requirements.
    - e. Manufacturer's model number.
    - f. System voltage.
    - g. Modes of protection.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

#### 1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace SPDs that fail in materials or workmanship within 10 years from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 TYPE 1 SURGE PROTECTIVE DEVICES (SPDs)

- A. Source Limitations: Obtain devices from single source from single manufacturer.
- B. Standards:

1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

C. Product Options:

1. Include integral disconnect switch.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include indicator light display for protection status.
4. Include audible alarm.
5. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V ac for remote monitoring of protection status.
6. Include surge counter.

D. Performance Criteria:

1. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
2. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 160 kA for Panelboards and 320 kA for Switchboards. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
3. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits must not exceed the following:
  - a. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
  - b. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.
4. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:
  - a. Line to Neutral: 700 V.
  - b. Line to Line: 1200 V.
5. SCCR: Not less than 200 kA.
6. Inominal Rating: 20 kA.

## 2.2 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs)

A. Source Limitations: Obtain devices from single source from single manufacturer.

B. Standards:

1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.
2. Comply with UL 1283.



C. Product Options:

1. Include LED indicator lights for power and protection status.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include NEMA ICS 5, dry Form C contacts rated at 2A and 24V ac for remote monitoring of protection status.
4. Include surge counter.

D. Performance Criteria:

1. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
2. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 100 kA for panelboards and 150 kA for Switchboards kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
3. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits must not exceed the following:
  - a. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
  - b. Line to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
  - c. Neutral to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
  - d. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.
4. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:
  - a. Line to Neutral: 700 V.
  - b. Line to Ground: 700 V.
  - c. Neutral to Ground: 700 V.
  - d. Line to Line: 1200 V.
5. SCCR: Equal or exceed 100 kA.
6. Inominal Rating: 10 kA.

2.3 TYPE 3, TYPE 4, AND TYPE 5 SURGE PROTECTIVE DEVICES (SPDs)

- A. Type 3, Type 4, and Type 5 SPDs are not approved for field installation.

2.4 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: NEMA 250, Type 3R.

## 2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's written instructions.
- C. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's written instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
  - 1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
  - 2. Do not exceed manufacturer's recommended lead length.
  - 3. Do not bond neutral and ground.
- D. Use crimped connectors and splices only. Wire nuts are unacceptable.

### 3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
  - 2. Inspect anchorage, alignment, grounding, and clearances.
  - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. SPDs that do not pass tests and inspections will be considered defective.
- C. Prepare test and inspection reports.

### 3.3 STARTUP SERVICE

- A. Complete startup checks in accordance with manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 26 4313

## SECTION 265119 - LED INTERIOR LIGHTING

### 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. Interior solid-state luminaires that use LED technology.
  - 2. Lighting fixture supports.

- B. Related Requirements:

- 1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

#### 1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- 1. Arrange in order of luminaire designation.
  - 2. Include data on features, accessories, and finishes.
  - 3. Include physical description and dimensions of luminaires.
  - 4. Include emergency lighting units, including batteries and chargers.

5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
  6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project IES LM-79, IES LM-80 and IESNA TM-21-11.
    - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
    - b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
  7. Include lighting calculations for each space using standard reflectances and working plane height of 30" AFF for comparison to Basis of Design.
- B. Shop Drawings: For nonstandard or custom luminaires.
1. Include plans, elevations, sections, and mounting and attachment details.
  2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  3. Include diagrams for power, signal, and control wiring.
- C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing laboratory providing photometric data for luminaire.
- B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
  1. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Product Certificates: For each type of luminaire.
- E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
- F. Sample warranty.

## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
  - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

## 1.7 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

## 1.8 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

## 1.9 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- B. Seismic Performance: Luminaires and LEDs shall be labeled vibration and shock resistant.
  - 1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

## 2.2 LUMINAIRE REQUIREMENTS

- 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. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. Recessed Fixtures: Comply with NEMA LE 4.
- E. CRI of minimum 80. CCT of 3500K.
- F. Rated lamp life of 50,000 hours.
- G. LEDs dimmable from 100 percent to 0 percent of maximum light output.

## 2.3 INTERNAL LINEAR DRIVER

### A. Physical Characteristics

1. Driver shall be available in an all metal-can construction for optimal thermal performance.
2. Driver shall have a slim profile with height  $\leq 1$  in and width  $\leq 1.2$  in.
3. Driver shall be provided with integral color-coded connectors.

### B. Performance Requirements

1. Driver shall operate from 50/60 Hz input source of 120V through 277V with sustained variations of  $\pm 10\%$  (voltage) with no damage to the Driver.
2. Driver output shall be regulated to  $\pm 5\%$  across published load range.
3. Driver shall have an easy way to lower the output current, without using the dimming leads.
4. Driver shall have a Power Factor greater than 0.90 for primary application to 50% of full load rating.
5. Driver input current shall have Total Harmonic Distortion (THD) of less than 20% to 50% of full load rating.
6. Driver shall have a Class A sound rating.
7. Driver shall have a minimum operating temperature of  $-20^{\circ}\text{C}$  ( $-4^{\circ}\text{F}$ ).
8. Driver shall tolerate sustained open circuit and short circuit output conditions without fail and auto-resetting without need for external fuses or trip devices.
9. Driver output ripple current shall be less than 15% measured peak-to-average, with ripple frequency  $>100\text{Hz}$ .
10. Driver performance requirements shall be met when operated to 50% of full load rating.
11. Driver shall be rated for UL Damp and Dry locations.
12. Driver shall have integral common mode and differential mode surge protection of 2.5kV(100kHz 30ohm ring wave).
13. Driver shall have integral thermal foldback to reduce driver power above rated case temperature to protect the driver if temperatures reach unacceptable levels.

14. Driver shall comply with NEMA 410 for in-rush current limits.
15. Driver shall incorporate an integral means of limiting surges to the LEDs.

C. Regulatory

1. Driver shall not contain any Polychlorinated Biphenyl (PCB).
2. Driver shall be Underwriters Laboratories (UL) recognized Class 2 per UL1310 or Canadian Standards Association (CSA) recognized Class 2 per CSA-C22.2.
3. Driver shall comply with applicable requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, for Non-Consumer equipment.
4. Driver shall be RoHS compliant.

D. Other

1. Driver shall be manufactured in a factory certified to ISO 9001 Quality System Standards.
2. Driver shall carry a five-year limited warranty from date of manufacture against defects in material or workmanship, including replacement, for operation at a maximum case temperature of 75C
3. Dimmable drivers shall be controlled by a Class 2 low voltage 0-10VDC controller with dimming range controlled between 1 and 8VDC with source current 150µA.
4. Manufacturer shall have a 10-year history of producing electronic drivers for the North American market.

E. Nominal Operating Voltage: Multi tap drivers will provide **120Vac and/or 277Vac**.

## 2.4 INTERNAL DOWNLIGHT DRIVER

A. Physical Characteristics

1. Driver shall be available in an all metal-can construction for optimal thermal performance.
2. Driver shall be in a compact enclosure with integrated studs so that it can be mounted on the outside or a junction box, without the need of an additional enclosure.
3. Driver shall be provided with integral color-coded connectors.

B. Performance Requirements

1. Driver shall operate from 50/60 Hz input source of 120V through 277V with sustained variations of +/- 10% (voltage) with no damage to the Driver.
2. Driver output shall be regulated to +/- 5% across published load range.
3. Driver shall have an easy way to lower the output current, without using the dimming leads.
4. Driver shall have a Power Factor greater than 0.90 for primary application to 50% of full load rating.
5. Driver input current shall have Total Harmonic Distortion (THD) of less than 20% to 50% of full load rating.
6. Driver shall have a Class A sound rating.
7. Driver shall have a minimum operating temperature of -20C (-4F).



8. Driver shall tolerate sustained open circuit and short circuit output conditions without fail and auto-resetting without need for external fuses or trip devices.
9. Driver output ripple current shall be less than 15% measured peak-to-average, with ripple frequency >100Hz.
10. Driver performance requirements shall be met when operated to 50% of full load rating.
11. Driver shall be rated for UL Damp and Dry locations.
12. Driver shall have integral common mode and differential mode surge protection of 2.5kV(100kHz 30ohm ring wave).
13. Driver shall have integral thermal foldback to reduce driver power above rated case temperature to protect the driver if temperatures reach unacceptable levels.
14. Driver shall comply with NEMA 410 for in-rush current limits.
15. Driver shall incorporate an integral means of limiting surges to the LEDs.

C. Regulatory

1. Driver shall not contain any Polychlorinated Biphenyl (PCB).
2. Driver shall be Underwriters Laboratories (UL) recognized Class 2 per UL1310 or Canadian Standards Association (CSA) recognized Class 2 per CSA-C22.2.
3. Driver shall comply with applicable requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, for Non-Consumer equipment.
4. Driver shall be RoHS compliant.

D. Other

1. Driver shall be manufactured in a factory certified to ISO 9001 Quality System Standards.
2. Driver shall carry a five-year limited warranty from date of manufacture against defects in material or workmanship, including replacement, for operation at a maximum case temperature of 75C.
3. Dimmable drivers shall be controlled by a Class 2 low voltage 0-10VDC controller with dimming range controlled between 1 and 8VDC with source current 150µA.
4. Manufacturer shall have a 10-year history of producing electronic drivers for the North American market.
5. Nominal Operating Voltage: Multi tap drivers will provide **120Vac and/or 277Vac**

2.5 DOWNLIGHT

- A. **Luminaires on this project have been prior approved and only those indicated on Luminaire Schedule are allowed to bid this project.**
- B. Minimum **1,000** lumens. Minimum allowable efficacy of **80** lumens per watt. Unless noted otherwise on luminaires schedule.
- C. Universal mounting bracket.
- D. Integral junction box with conduit fittings.

## 2.6 STRIP LIGHT

- A. **Luminaires on this project have been prior approved and only those indicated on Luminaire Schedule are allowed to bid this project.**
- B. Minimum **750** lumens. Minimum allowable efficacy of **80** lumens per watt.
- C. Integral junction box with conduit fittings.

## 2.7 MATERIALS

- A. Metal Parts:
  - 1. Free of burrs and sharp corners and edges.
  - 2. Sheet metal components shall be steel unless otherwise indicated.
  - 3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit new LEDs without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during replacement and when secured in operating position.
- C. Housings:
  - 1. Will be as called for in the Luminaire Schedule for this project. This will include housing and heat sink.
  - 2. Powder-coat and painted finish. Unless otherwise noted in the luminaire schedule for this project.
- D. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
  - 1. Label shall include the following lamp characteristics:
    - a. "USE ONLY" and include specific lamp type.
    - b. Lamp diameter, shape, size, wattage, and coating.
    - c. CCT and CRI for all luminaires.

## 2.8 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

## 2.9 LUMINAIRE FIXTURE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, **12 gage**.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

### 3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
  - 1. Sized and rated for luminaire weight.
  - 2. Able to maintain luminaire position after cleaning and replacement of LEDs.
  - 3. Provide support for luminaire without causing deflection of ceiling or wall.
  - 4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

- E. Flush-Mounted Luminaire Support:
  - 1. Secured to outlet box.
  - 2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
  - 3. Trim ring flush with finished surface.
- F. Wall-Mounted Luminaire Support:
  - 1. **Attached using through bolts and backing plates on either side of wall as means of attachment.**
  - 2. Do not attach luminaires directly to gypsum board.
- G. Ceiling-Recessed-Mounted Luminaires:
  - 1. Secure to any required outlet box.
  - 2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
  - 3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.
- H. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

### 3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
  - 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.
- D. Adjusting
- E. Occupancy Adjustments: When requested within **12** months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to **two** visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace drivers or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 26 5119

## SECTION 26 5219 - EMERGENCY AND EXIT LIGHTING

### 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. Emergency lighting units.
  - 2. Exit signs.
  - 3. Luminaire supports.

#### 1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
- D. Fixture: See "Luminaire" Paragraph.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
  - 1. Include data on features, accessories, and finishes.
  - 2. Include physical description of the unit and dimensions.
  - 3. Battery and charger for light units.
  - 4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
  - 5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.
    - a. Testing Agency Certified Data: For indicated luminaires and signs, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires and signs shall be certified by manufacturer.

- b. **Manufacturers' Certified Data:** Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. **Shop Drawings:** For nonstandard or custom luminaires.
  - 1. Include plans, elevations, sections, and mounting and attachment details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
- C. **Samples:** For each product and for each color and texture specified.
- D. **Samples for Initial Selection:** For each type of luminaire with factory-applied finishes.
- E. **Samples for Verification:** For each type of luminaire.
  - 1. Include Samples of luminaires and accessories to verify finish selection.
- F. **Product Schedule:**
  - 1. For emergency lighting units. Use same designations indicated on Drawings.
  - 2. For exit signs. Use same designations indicated on Drawings.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. **Coordination Drawings:** Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Luminaires.
  - 2. Suspended ceiling components.
  - 3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
  - 4. Structural members to which equipment will be attached.
  - 5. Size and location of initial access modules for acoustical tile.
  - 6. Items penetrating finished ceiling including the following:
    - a. Other luminaires.
    - b. Air outlets and inlets.
    - c. Speakers.
    - d. Ceiling-mounted projectors.
    - e. Sprinklers.
    - f. Access panels.
- B. **Qualification Data:** For testing laboratory providing photometric data for luminaires.
- C. **Product Certificates:** For each type of luminaire.
- D. **Seismic Qualification Data:** For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
  4. Provide seismic qualification certificate for each piece of equipment.
- E. Product Test Reports: For each luminaire for tests performed by a qualified testing agency.
- F. Sample Warranty: For manufacturer's special warranty.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.
1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. LED boards: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
  2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
  3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.

#### 1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.



1. Obtain Architect's approval of luminaires and signs in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

#### 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

#### 1.10 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: Two year(s) from date of Substantial Completion.
- B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
  1. Warranty Period for Emergency Power Unit Batteries: Five years from date of Substantial Completion. Full warranty shall apply for first year and prorated warranty for the remaining four years.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Luminaires and LEDs shall be labeled vibration and shock resistant.
  1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

#### 2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

- 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. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.
- C. Comply with NFPA 70 and NFPA 101.
- D. Comply with NEMA LE 4 for recessed luminaires.
- E. Comply with UL 1598 for fluorescent luminaires.
- F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.
- G. Bulb Shape: Complying with ANSI C79.1.
- H. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with LED Driver.
  - 1. Emergency Connection: Operate one LED board continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
  - 2. Operation: Relay automatically turns lamp on when power-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 from battery, and battery is automatically recharged and floated on charger.
  - 3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
    - a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
    - b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
    - c. Humidity: More than 95 percent (condensing).
    - d. Altitude: Exceeding this project site in feet.
  - 4. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
    - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
  - 5. Battery: Sealed, maintenance-free, nickel-cadmium type.
  - 6. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
  - 7. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

8. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

## 2.3 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
  1. Manufacturers: **Luminaires on this project have been prior approved and only those indicated on Luminaire Schedule are allowed to bid this project.**
  2. Operating at nominal voltage of 120 V ac, 277 V ac.
  3. Lamps for AC Operation: Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
  4. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
  5. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
  6. Master/Remote Sign Configurations:
    - a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
    - b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

## 2.4 MATERIALS

- A. Metal Parts:
  1. Free of burrs and sharp corners and edges.
  2. Sheet metal components shall be steel unless otherwise indicated.
  3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access:
  1. Smooth operating, free of light leakage under operating conditions.
  2. Designed to permit relamping without use of tools.
  3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- C. Diffusers and Globes:
  1. Diffuse glass.
  2. Glass: Annealed crystal glass unless otherwise indicated.

3. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.
2. Clear anodized finish.

E. Conduit: Electrical metallic tubing, minimum 3/4 inch in diameter.

## 2.5 METAL FINISHES

- A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

## 2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to a minimum 20-gage backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

### 3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

### 3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

- B. Luminaire will be considered defective if it does not pass operation tests and inspections.

- C. Prepare test and inspection reports.

D. Spare Exit signs:

1. Provide 10% spare exit of the total installed in this facility.
2. These spare units will be utilized and installed per AHJ final inspection of egress paths. Should AHJ request additional exit signs these spare will be installed as directed.
3. Owner will bear no cost for these spare and any installation due to AHJ requirement to add additional exit signs.
4. Any exit signs not used will be given to owner.

3.5 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.
  - a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 26 5219

## SECTION 26 5619 – LED EXTERIOR LIGHTING

### 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. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

- B. Related Requirements:

Division 26, Section 26 5119, LED Interior Lighting, for interior Luminaires, and accessories.

#### 1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color rendering index.
- C. Luminaire: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including LEDs, Drivers, Reflector, and Housing.

#### 1.4 ACTION 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 each type of luminaire.
  1. Arrange in order of luminaire schedule designation.
  2. Include data on features, accessories, and finishes.
  3. Include physical description and dimensions of luminaire.
  4. LEDs, include life, output (lumens, CCT, and CRI), and energy-efficiency data.

5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for LEDs and accessories identical to those indicated for the luminaire as applied in this Project; IES LM-79 and IES LM-80
    - a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
    - b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
  6. Wiring diagrams for power, control, and signal wiring. Wiring diagrams for control system showing both factory-installed and field-installed wiring for specific system of this Project, and differentiating between factory-installed and field-installed wiring.
  7. Photoelectric relays.
  8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
  9. Luminaire, LEDs, Drivers, Poles, and accessories. Include data on features, Poles, accessories, finishes, and the following:
    - a. Outline drawings indicating dimensions and principal features of Luminaire and Poles.
    - b. Electrical Ratings and Photometric Data: Certified results of independent laboratory tests for Luminaires and LEDs.
  10. Wind Resistance Calculations: Certified by a registered professional engineer
  11. Anchor-Bolt Templates: Keyed to specific poles and certified by manufacturer.
  12. Field test reports indicating and interpreting test results specified in Part 3 of this section.
  13. Maintenance data for products to include in the operation and maintenance manual specified in Division 1.
  14. Product certificates signed by manufacturers of lighting units certifying that their products comply with specified requirements.
- C. Include lighting calculations for each space using the following reflectance's, 75,45,20, and working plane height of 30" AFF for comparison to Basis of Design
- D. Shop Drawings: For nonstandard or custom luminaires.
1. Include plans, elevations, sections, and mounting and attachment details.
  2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
  3. Include diagrams for power, signal, and control wiring.
- E. Samples: For each luminaire and for each color and texture indicated with factory-applied finish.
- F. Delegated-Design Submittal: For luminaire supports.
1. Include design calculations for luminaire supports and seismic restraints.



## 1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Luminaires.
  - 2. Structural members to which luminaires will be attached.
  - 3. Underground utilities and structures.
  - 4. Existing underground utilities and structures.
  - 5. Above-grade utilities and structures.
  - 6. Existing above-grade utilities and structures.
  - 7. Building features.
  - 8. Vertical and horizontal information.
- B. Qualification Data: For testing laboratory providing photometric data for luminaires.
- C. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Product Certificates: For each type of the following:
  - 1. Luminaire.
  - 2. Photoelectric relay.
- E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
- F. Source quality-control reports.
- G. Sample warranty.

## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.
  - 1. Provide a list of all LED types used on Project. Use ANSI and manufacturers' codes.

## 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. LEDs: One for every 50 of each type and rating installed. Furnish at least one of each type.
2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 50 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 50 of each type and rating installed. Furnish at least one of each type.

## 1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.
- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Listing and Labeling: Provide Luminaires and accessories specified in this Section that are listed and labeled for their indicated use and installation conditions on Project.
  1. Special Listing and Labeling: Provide Luminaires for use underwater that are specifically listed and labeled for such use. Provide Luminaires for use in hazardous (classified) locations that are listed and labeled for the specific hazard.
  2. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
  3. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL where available.
- E. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- F. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- G. Mockups: For exterior luminaires, complete with power and control connections.
  1. Obtain Architect's approval of luminaires in mockups before starting installations.
  2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.
  3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
  4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

## 1.9 DELIVERY, STORAGE, AND HANDLING

- A. General: Store poles on decay-resistant treated skids at least 12 inches above grade and vegetation. Support pole to prevent distortion and arrange to provide free air circulation
- B. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.
- C. Metal Poles: Retain factory-applied pole wrappings until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps

## 1.10 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

## 1.11 WARRANTY

- A. General Warranty: The 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. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Structural failures, including luminaire support components.
    - b. Faulty operation of luminaires and accessories.
    - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering. Warranty against perforation or erosion of finish due to weathering.
    - d. Color Retention: Warranty against fading, staining, and chalking due to effects of weather and solar radiation
  - 2. Warranty Period: 5 year(s) from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Products: Luminaires on this project have been prior approved and only those indicated on Luminaire Schedule are allowed to bid this project.

## 2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to SCE/SEI 7.
- B. Seismic Performance: Luminaires and LEDs shall be labeled vibration and shock resistant.
  - 1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

## 2.3 LUMINAIRE REQUIREMENTS

- 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. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. UL Compliance: Comply with UL 1598 and listed for wet location where indicated in Luminaire schedule.
- E. Bulb shape complying with ANSI C79.1.
- F. CRI of minimum 80.
- G. CCT of 4100 K or as indicated in the luminaire schedule.
- H. L70 LED life of 50,000 minimum hours.
- I. Internal driver.
- J. Nominal Operating Voltage: Multi-Tap Drivers - 120 V or 277 V.
- K. In-line Fusing: Separate in-line fuse for each luminaire.
- L. LED Rating: LED marked for outdoor use.
- M. Source Limitations: Obtain luminaires from single source from a single manufacturer.
- N. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.
- O. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed Luminaires.
- P. Exposed Hardware Material: Stainless steel.

- Q. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- R. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor mounting in Luminaire doors.

## 2.4 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Stainless steel. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. Diffusers and Globes:
  - 1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
  - 2. Glass: Annealed crystal glass unless otherwise indicated.
  - 3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
  - 1. White Surfaces: 85 percent.
  - 2. Specular Surfaces: 83 percent.
  - 3. Diffusing Specular Surfaces: 75 percent.
- G. Housings:
  - 1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
  - 2. Provide filter/breather for enclosed luminaires.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
  - 1. Label shall include the following lamp characteristics:
    - a. "USE ONLY" and include specific lamp type.
    - b. Lamp diameter, shape, size, wattage and coating.
    - c. CCT and CRI for all luminaires.

## 2.5 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are not acceptable. Arm, Bracket, and Tenon Mount will match poles' finish.
- B. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
  - 2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
    - a. Color: As selected by Architect from manufacturer's full range.
- C. Mountings, Fastenings, and Appurtenances: Corrosion-resistant items compatible with support components. Use materials that will not cause galvanic action at contact points. Use mountings that correctly position luminaire to provide indicated light distribution.

## 2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Pole-Mounted Luminaires: Conform to AASHTO LTS-3.
- C. Wind-load strength of total support assembly, including pole, arms, appurtenances, base, and anchorage, is adequate to carry itself plus Luminaires indicated at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 Mi./Hr. with a gust factor of 1.3.
- D. Poles: Provide factory installed vibration dampers.
- E. Pole Shafts: Round, straight.
- F. Pole Bases: Anchor type with galvanized steel hold-down or anchor bolts, leveling nuts, and bolt covers.
- G. Poles: Steel tubing conforming to ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psi. Poles are 1-piece construction up to 40 feet in length and have access handhole in wall.
- H. Metal Pole Grounding Provisions: Welded 1/2-inch threaded lug, accessible through handhole.
- I. Steel Mast Arms: Fabricated from 2-inch NPS (DN50) black steel pipe, continuously welded to pole attachment plate with span and rise as indicated.

- J. Metal Pole Brackets: Designed to match pole metal. Provide cantilever brackets without underbrace, in sizes and styles indicated, with straight tubular end section to accommodate Luminaire.
- K. Pole-Top Tenons: Fabricated to support Luminaire or Luminaires and brackets indicated and securely fastened to pole top.
- L. Concrete for Pole Foundations: Comply with structural details for the base required for Poles on this project. Details in this division drawings indicate electrical information and do not call out any structural information.
  - 1. Construct according to Division 3, Section 03 3000, Cast-in-Place Concrete.
  - 2. Comply with details and manufacturer's recommendations for reinforcing, anchor bolts, nuts, and washers. Verify anchor-bolt templates by comparing with actual pole bases furnished.
  - 3. Finish: Trowel and rub smooth parts exposed to view
- M. Embedded Poles: Set poles to indicated depth, but not less than 1/6 of pole length below finish grade. Dig holes large enough to permit use of tampers the full depth of hole. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
- N. Pole Installation: Use web fabric slings (not chain or cable) to raise and set poles.
- O. Luminaire Attachment: Fasten to indicated structural supports.
- P. Luminaire Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution.
- Q. Provide LED Luminaires with indicated LEDs according to manufacturer's written instructions. Replace malfunctioning LEDs.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.
- C. Examine walls, roofs, and overhang ceilings for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

### 3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Install lamps in each luminaire.
- D. Fasten luminaire to structural support.
  - 1. Sized and rated for luminaire weight.
  - 2. Able to maintain luminaire position after cleaning and relamping.
  - 3. Support luminaires without causing deflection of finished surface.
  - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- E. Wall-Mounted Luminaire Support:
  - 1. Attached using through bolts and backing plates on either side of wall.
- F. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- G. Set Luminaires securely according to manufacturer's written instructions and approved Shop Drawings. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.
- H. Coordinate layout and installation of luminaires with other construction.
- I. Luminaire Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution. Adjust luminaires that require field adjustment or aiming once luminaire is in place .
- J. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" and Section 26 0533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.
- K. Provide LED Luminaires with indicated LEDs according to manufacturer's written instructions. Replace malfunctioning LEDs

### 3.4 GROUNDING

- A. Ground fixtures and metal poles according to Division 26, Section 26 0526, Grounding and Bonding for Electrical Systems.



1. Poles: Install 10-foot driven ground rod at each pole.
2. Nonmetallic Poles: Ground metallic components of lighting unit and foundations. Connect fixtures to grounding system with No. 6 AWG conductor, minimum

### 3.5 CORROSION PREVENTION

- A. Steel Conduits: Comply with Section 26 0533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

### 3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

### 3.7 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Give advance notice of dates and times for field tests.
- C. Provide instruments to make and record test results. Use photometers with calibration referenced to National Institute of Standards and Technology (NIST) standards.
- D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  1. Operational Test: After installing luminaires, control system, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
  2. Verify operation of photoelectric controls.
  3. Check for intensity of illumination.
  4. Check for uniformity of illumination.
  5. Check for excessively noisy Driver.
- E. Illumination Tests:
  1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
    - a. IES LM-5.
    - b. IES LM-50.
    - c. IES LM-52.
    - d. IES LM-64.
    - e. IES LM-72.

- F. Luminaire will be considered defective if it does not pass tests and inspections. Replace or repair damaged and malfunctioning units, make necessary adjustments, and retest. Repeat procedure until all units operate properly
- G. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

### 3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaires.

### 3.9 ADJUSTING

- A. Clean units after installation. Use methods and materials recommended by manufacturer. Adjust aimable fixtures to provide required light intensities.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
  - 1. During adjustment visits, inspect all luminaires. Replace LEDs or luminaires that are defective.
  - 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
  - 3. Adjust the aim of luminaires in the presence of the Architect.

### 3.10 EXTERIOR LIGHTING FIXTURE SCHEDULE

- A. The luminaire schedule located in the construction drawings describes each type of luminaire for the project. Manufacturer's catalog numbers are given for convenience. Where discrepancies occur between catalog numbers and the descriptive information, the descriptive information shall take precedence. Some required features, options, accessory equipment or special order requirements may not be included in the catalog number.

### 3.11 SPARE MATERIAL

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. All extra material will be delivered to the location as directed by the district. Provide TWO spare luminaires of each type.
- B. LED: Five for every 100 of each type and rating installed for each type of luminaire. Furnish at least one of each type in every instance.
- C. Diffusers and Lenses: Five for every 100 of each type and rating installed for each type of luminaire. Furnish at least one of each type in every instance.

- D. LED Drivers: Five for every 100 of each type and rating installed. Furnish at least one of each type.

END OF SECTION 26 5619

## SECTION 270526 - 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 01 Specification Sections, apply to this Section.

## 1.2 SUMMARY

- A. Section Includes:
  - 1. Grounding conductors.
  - 2. Grounding connectors.
  - 3. Grounding busbars.
  - 4. Grounding rods.
  - 5. Grounding labeling.

## 1.3 DEFINITIONS

- A. BCT: Bonding conductor for telecommunications.
- B. TGB: Telecommunications grounding busbar.
- C. TMGB: Telecommunications main grounding busbar.
- D. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.

## 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

## 1.5 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
  - 1. Ground rods.
  - 2. Ground and roof rings.
  - 3. BCT, TMGB, TGBs, and routing of their bonding conductors.

- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

## 1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
  - 1. Installation Supervision: Installation shall be under the direct supervision of New Mexico ES3J, who shall be present at all times when Work of this Section is performed at Project site.
  - 2. Field Inspector: Currently registered by BICSI as a designer RCDD to perform the on-site inspection.

## PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

- 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. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with TIA-607-B.

### 2.2 CONDUCTORS

- A. Comply with UL 486A-486B.
- B. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
  - 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
  - 2. Cable Tray Equipment Grounding Wire: No. 8 AWG.
- C. Cable Tray Grounding Jumper:
  - 1. Not smaller than No. 10 AWG and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with one hole and standard barrel for one crimp. If jumper is a flexible braid, it shall have a one- or two-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

## D. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.
4. Bonding Cable: **28 kmils (14.2 sq. mm)**, 14 strands of No. 17 AWG conductor, and **1/4 inch (6.3 mm)** in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; **1-5/8 inches (41 mm)** wide and **1/16 inch (1.6 mm)** thick.

## 2.3 CONNECTORS

- A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- B. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
  1. Electroplated tinned copper, C and H shaped.
- C. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on **5/8- or 1-inch (15.8- or 25.4-mm)** centers for a two-bolt connection to the busbar.

## 2.4 GROUNDING BUSBARS

- A. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, **1/4 by 4 inches (6.3 by 100 mm)** in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with TIA-607-B.
  1. Predrilling shall be with holes for use with lugs specified in this Section.
  2. Mounting Hardware: Stand-off brackets that provide a **4-inch (100-mm)** clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
  3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- B. TGB: Predrilled rectangular bars of hard-drawn solid copper, **1/4 by 2 inches (6.3 by 50 mm)** in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-B.
  1. Predrilling shall be with holes for use with lugs specified in this Section.
  2. Mounting Hardware: Stand-off brackets that provide at least a **2-inch (50-mm)** clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
  3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

- C. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-607-B. Predrilling shall be with holes for use with lugs specified in this Section.
  - 1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
  - 2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.

## 2.5 IDENTIFICATION

- A. Comply with requirements for identification products in Section 270553 "Identification for Communications Systems."

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of BCT connection.
- C. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with TIA-607-B.

### 3.3 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
  - 1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
  - 2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.

B. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than **36 inches (900 mm)**.

D. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than **36-inch (900-mm)** intervals.
4. Install grounding and bonding conductors in **3/4-inch (21-mm)** PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
  - a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

### 3.4 GROUNDING ELECTRODE SYSTEM

- A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 1/0 AWG.

### 3.5 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers **2 inches (50 mm)** minimum from wall, **12 inches (300 mm)** above finished floor unless otherwise indicated.

### 3.6 CONNECTIONS

- A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.



- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
  - 1. Use crimping tool and the die specific to the connector.
  - 2. Pretwist the conductor.
  - 3. Apply an antioxidant compound to all bolted and compression connections.
- D. Primary Protector: Bond to the TMGB with insulated bonding conductor.
- E. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.
- F. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard.
- G. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded balanced twisted-pair cables.
- H. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

### 3.7 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Duct-Bank Grounding Conductor: Bury **12 inches (300 mm)** above duct bank when indicated as part of duct-bank installation.
- B. Comply with IEEE C2 grounding requirements.
- C. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so **4 inches (100 mm)** extends above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from **2 inches (50 mm)** above to **6 inches (150 mm)** below concrete. Seal floor opening with waterproof, nonshrink grout.
- D. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect grounding conductors to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

### 3.8 IDENTIFICATION

- A. Labels shall be preprinted or computer-printed type.
  - 1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
  - 2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
  - 3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

### 3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
  - 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
  - 2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
    - a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
  - 3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
    - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB. Maximum acceptable ac current level is 1 A.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 270526

## SECTION 270528 - PATHWAYS 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 01 Specification Sections, apply to this Section.

## 1.2 SUMMARY

## A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Optical-fiber-cable pathways and fittings.
4. Metal wireways and auxiliary gutters.
5. Nonmetallic wireways and auxiliary gutters.
6. Metallic surface pathways.
7. Nonmetallic surface pathways.
8. Tele-power poles.
9. Hooks.
10. Boxes, enclosures, and cabinets.
11. Polymer-concrete handholes and boxes for exterior underground cabling.
12. Fiberglass handholes and boxes for exterior underground cabling.

## 1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid conduit.
- C. IMC: Intermediate metal conduit.
- D. RTRC: Reinforced thermosetting resin conduit.

## 1.4 ACTION SUBMITTALS

## A. Product data for the following:

1. Surface pathways
2. Wireways and fittings.
3. Tele-power poles.
4. Boxes, enclosures, and cabinets.
5. Underground handholes and boxes.

## PART 2 - PRODUCTS

## 2.1 METAL CONDUITS AND FITTINGS

- A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.
- B. General Requirements for Metal Conduits and Fittings:
  - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
  - 2. Comply with TIA-569-D.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. PVC-Coated Steel Conduit: PVC-coated [**GRC**] [**IMC**].
  - 1. Comply with NEMA RN 1.
  - 2. Coating Thickness: **0.040 inch (1 mm)**, minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
  - 1. Fittings for EMT:
    - a. Material: Steel
    - b. Type: Set screw or compression.
  - 2. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
  - 3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of **0.040 inch (1 mm)**, with overlapping sleeves protecting threaded joints.

## 2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. Description: Nonmetallic raceway of circular section with manufacturer-fabricated fittings.
- B. General Requirements for Nonmetallic Conduits and Fittings:
  - 1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
  - 2. Comply with TIA-569-D.
- C. RNC: Type EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

- D. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.
- E. Solvents and Adhesives: As recommended by conduit manufacturer.

### 2.3 HOOKS

- A. Description: Prefabricated sheet metal cable supports for telecommunications cable.
- B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- C. Comply with TIA-569-D.
- D. Galvanized.
- E. J shape.

### 2.4 BOXES, ENCLOSURES, AND CABINETS

- A. Description: Enclosures for communications.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
  - 1. Comply with TIA-569-D.
  - 2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
  - 3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
  - 4. Device Box Dimensions: **4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep)**.
  - 5. Gangable boxes are prohibited.
- C. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 3R, with continuous-hinge cover with flush latch unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Nonmetallic Enclosures:
    - a. Material: Plastic.
  - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

## PART 3 - EXECUTION

### 3.1 PATHWAY APPLICATION

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC
2. Concealed Conduit, Aboveground: EMT.
3. Underground Conduit: RNC, Type EPC-80-PVC.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:
  - a. Loading dock.
  - b. Mechanical rooms.
  - c. Gymnasiums
3. Concealed in Ceilings and Interior Walls and Partitions: EMT
4. Damp or Wet Locations: IMC.
5. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: J-hook
6. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: EMT>.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and damp or wet locations.

C. Minimum Pathway Size: **3/4-inch (21-mm)** trade size for copper and aluminum cables, and **1 inch (25 mm)** for optical-fiber cables.

D. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use set-screw or compression fittings. Comply with NEMA FB 2.10.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

### 3.2 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.

B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

- C. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- D. Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems" for hangers and supports.
- E. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling" for sleeves and sleeve seals for communications.
- F. Keep pathways at least **6 inches (150 mm)** away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- G. Complete pathway installation before starting conductor installation.
- H. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- I. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- J. Support conduit within **12 inches (300 mm)** of enclosures to which attached.
- K. Stub-ups to Above Recessed Ceilings:
  - 1. Use EMT for pathways.
  - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- M. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.
- N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.
- O. Cut conduit perpendicular to the length. For conduits of **2-inch (50-mm)** trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- P. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than **200-lb (90-kg)** tensile strength. Leave at least **12 inches (300 mm)** of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.
- Q. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
  - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  - 2. Where an underground service pathway enters a building or structure.
  - 3. Where otherwise required by NFPA 70.

- R. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- S. J-Hooks:
  - 1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
  - 2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
  - 3. Hook spacing shall allow no more than **6 inches (150 mm)** of slack. The lowest point of the cables shall be no less than **6 inches (150 mm)** adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
  - 4. Space hooks no more than **5 feet (1.5 m)** o.c.
  - 5. Provide a hook at each change in direction.
- T. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- U. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- V. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- W. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- X. Set metal floor boxes level and flush with finished floor surface.
- Y. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

### 3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
  - 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe of less than **6 inches (150 mm)** in nominal diameter.
  - 2. Install backfill as specified in Section 312000 "Earth Moving."
  - 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within **12 inches (300 mm)** of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
  - 4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.



- a. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of **60 inches (1500 mm)** from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
5. Underground Warning Tape: Comply with requirements in Section 270553 "Identification for Communications Systems."

### 3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

### 3.5 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

### 3.6 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
  1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

## SECTION 270553 - IDENTIFICATION 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 01 Specification Sections, apply to this Section.

## 1.2 SUMMARY

## A. Section Includes:

1. Color and legend requirements for labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes.
5. Signs.
6. Cable ties.
7. Fasteners for labels and signs.

## 1.3 ACTION SUBMITTALS

## A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for communications identification products.

## B. Identification Schedule:

1. Outlets: Scaled drawings indicating location and proposed designation.
2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.
3. Racks: Scaled drawings indicating location and proposed designation.
4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

## PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 70 and TIA 606-B.
- B. Comply with ANSI Z535.4 for safety signs and labels.

- C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

## 2.2 COLOR AND LEGEND REQUIREMENTS

- A. Equipment Identification Labels:

- 1. Black letters on a white field.

## 2.3 LABELS

- A. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

- 1. Minimum Nominal Size:
  - a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
  - b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
  - c. As required by authorities having jurisdiction.

## 2.4 BANDS AND TUBES

- A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

## 2.5 UNDERGROUND-LINE WARNING TAPE

- A. Tape:

- 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground communications utility lines.
- 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
- 3. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

- B. Color and Printing:

- 1. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, and ANSI Z535.4.
- 2. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL-FIBER CABLE" .

## 2.6 CABLE TIES

- A. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

- 1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

## 2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

### 3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.
- G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- H. Self-Adhesive Labels:
  1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.

2. Unless otherwise indicated, provide a single line of text with **1/2-inch- (13-mm-)** high letters on **1-1/2-inch- (38-mm-)** high label; where two lines of text are required, use labels **2 inches (50 mm)** high.

I. Underground-Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway 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.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

J. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

### 3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.
- C. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.
  1. System legends shall be as follows:
    - a. Telecommunications.
- D. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation[, **numbered clockwise when entering room from primary egress**], composed of the following, in the order listed:
  1. Wiring closet designation.
  2. Colon.
  3. Faceplate number.
- E. Backbone Cables: Label each cable with a self-adhesive label indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.
- F. Horizontal Cables: Label each cable with a self-adhesive label indicating the following, in the order listed:
  1. Room number.
  2. Colon.

3. Faceplate number.
  
- G. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.
  
- H. Equipment Identification Labels:
  1. Indoor Equipment: Self-adhesive label.
  2. Equipment to Be Labeled:
    - a. Communications cabinets.
    - b. Uninterruptible power supplies.
    - c. Computer room air conditioners.
    - d. Fire-alarm and suppression equipment.
    - e. Egress points.
    - f. Power distribution components.

END OF SECTION 270553

## SECTION 271116 - COMMUNICATIONS RACKS, FRAMES, AND ENCLOSURES

## 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. 19-inch equipment racks.
2. 19-inch freestanding and wall-mounted equipment cabinets.
3. Open Rack equipment racks.
4. Power strips.
5. Grounding.
6. Labeling.

## B. Related Requirements:

1. Section 271110 "Communications Equipment Room Fittings" for backboards and accessories.
2. Section 270526 "Grounding and Bonding for Telecommunications Equipment" for TMGBs and TGBs.
3. Section 270536 "Cable Trays for Communications Systems" for cable trays and cable tray accessories.
4. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
5. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
6. Section 271333 "Communications Coaxial Backbone Cabling" for coaxial data cabling associated with system panels and devices.
7. Section 271513 "Communications Copper Horizontal Cabling" for copper data cabling associated with system panels and devices.
8. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical-fiber data cabling associated with system panels and devices.
9. Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial data cabling associated with system panels and devices.
10. Section 271611 "Communications Hybrid Cabling" for combined copper and optical fiber data cables associated with system panels and devices.

### 1.3 DEFINITIONS

- A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.
- B. BICSI: Building Industry Consulting Service International.
- C. LAN: Local area network.
- D. RCDD: Registered communications distribution designer.
- E. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.
- F. TGB: Telecommunications grounding bus bar.
- G. TMGB: Telecommunications main grounding bus bar.

### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, certifications, standards compliance, and furnished specialties and accessories.
- B. Shop Drawings: For communications racks, frames, and enclosures. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
  - 3. Grounding: Indicate location of TGB and its mounting detail showing standoff insulators and wall-mounting brackets.

### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

### 1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff, not on retainer.



1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of RCDD.
2. Installation Supervision: Installation shall be under direct supervision of New Mexico ES7J who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as RCDD to perform on-site inspection.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. UL listed.
- B. RoHS compliant.

### 2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, **3/4 by 48 by 96 inches (19 by 1220 by 2440 mm)**. Comply with requirements for plywood backing panels specified in Section 061000 "Rough Carpentry."

### 2.3 19-INCH EQUIPMENT RACKS

- A. Description: four-post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, **19-inch (482.6-mm)** equipment mounting with an opening of **17.72-inches (450-mm)** between rails.
- B. General Requirements:
  1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
  2. Material: welded steel.
  3. Finish: Manufacturer's standard, baked-polyester powder coat.
  4. Color: Black
  5. Adjustable depth from 36.42in to 42.32in
  6. Mounting Hole: #12-24 Threaded
- C. Floor-Mounted Racks:
  1. Overall Height: **84 inches (2133.6 mm)]**.
  2. Overall Depth: Adjustable 29 **inches (750 mm)** to 35.4 **inches (900 mm)]**
  3. Number of Rack Units per Rack: 45.
  4. Threads: 12-24.
  5. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
  6. Base shall have a minimum of four mounting holes for permanent attachment to floor.
  7. Top shall have provisions for attaching to cable tray or ceiling.

## D. Wall-Mounted Racks:

1. Height: 43.1 **inches**.
2. Depth: **25.2 inches**.
3. Load Rating: **100 lb**.
4. Number of Rack Units per Rack: 20
5. Threads: 12-24.
6. Wall Attachment: Minimum Four mounting holes.
7. Equipment Access: Integral swing.

## E. Cable Management:

1. Vertical:
  - a. Single Sided
  - b. Steel and aluminum with plastic T-shaped cable guides
  - c. Color: Black
  - d. Dual-hinged door opening left or right
2. Horizontal:
  - a. Contoured, snap-on front door opening up or down
  - b. Solid chassis
  - c. 1 rack unit

## 2.4 POWER STRIPS

## A. Power Strips: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Horizontal Rack mounting.
3. Eight 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
4. LED indicator lights for power and protection status.
5. LED indicator lights for reverse polarity and open outlet ground.
6. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
7. Cord connected with **8-foot (4.5-m)** line cord.
8. Rocker-type on-off switch, illuminated when in on position.

## 2.5 LABELING

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout of communications equipment spaces.

- C. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

### 3.2 GROUNDING

- A. Comply with NECA/BICSI 607.
- B. Install grounding according to BICSI ITSIMM, "Bonding, Grounding (Earthing) and Electrical Protection" Ch.
- C. Locate TGB to minimize length of bonding conductors. Fasten to wall, allowing at least **2 inches (50 mm)** of clearance behind TGB. Connect TGB with a minimum No. 4 AWG grounding electrode conductor from TGB to suitable electrical building ground. Connect rack TGB to near TGB or the TMGB.

### 3.3 IDENTIFICATION

- A. Coordinate system components, wiring, and cabling complying with TIA-606-B. Comply with requirements in Section 270553 "Identification for Electrical Systems."
- B. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- C. Labels shall be machine printed. Type shall be **1/8 inch (3 mm)** in height.

END OF SECTION 271116

## SECTION 271513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

## 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. Category 6 twisted pair cable.
  - 2. Twisted pair cable hardware, including plugs and jacks.
  - 3. Cable management system.
  - 4. Cabling identification products.
  - 5. Grounding provisions for twisted pair cable.
  - 6. Source quality control requirements for twisted pair cable.
- B. Related Requirements:
  - 1. Section 270513 "Conductors and Cables for Communications Systems" for data cabling associated with system panels and devices.

## 1.3 DEFINITIONS

- A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- B. EMI: Electromagnetic interference.
- C. FTP: Shielded twisted pair.
- D. F/FTP: Overall foil screened cable with foil screened twisted pair.
- E. F/UTP: Overall foil screened cable with unscreened twisted pair.
- F. IDC: Insulation displacement connector.
- G. LAN: Local area network.
- H. Jack: Also commonly called an "outlet," it is the fixed, female connector.
- I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
- J. RCDD: Registered Communications Distribution Designer.

- K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- L. S/FTP: Overall braid screened cable with foil screened twisted pair.
- M. S/UTP: Overall braid screened cable with unscreened twisted pairs.

#### 1.4 COPPER HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
  - 1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
  - 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
  - 3. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. A work area is approximately **100 sq. ft. (9.3 sq. m)**, and includes the components that extend from the equipment outlets to the station equipment.
- C. The maximum allowable horizontal cable length is **295 feet (90 m)**. This maximum allowable length does not include an allowance for the length of **16 feet (4.9 m)** to the workstation equipment or in the horizontal cross-connect.

#### 1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD on staff, not on retainer.
  - 1. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
  - 2. Cabling administration Drawings and printouts.
  - 3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
    - a. Telecommunications rooms plans and elevations.
    - b. Telecommunications pathways.
    - c. Telecommunications system access points.
    - d. Telecommunications grounding system.
    - e. Telecommunications conductor drop locations.
    - f. Typical telecommunications details.
    - g. Mechanical, electrical, and plumbing systems.
- C. Twisted pair cable testing plan.

#### 1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For RCDD, installation supervisor, and field inspector.
- B. Product Certificates: For each type of product.
- C. Source quality-control reports.
- D. Field quality-control reports.

#### 1.7 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For splices and connectors to include in maintenance manuals.

#### 1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Connecting Blocks: One of each type.
  - 2. Jacks: Ten of each type.
  - 3. Patch-Panel Units: One of each type.

#### 1.9 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
  - 1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings by an RCDD on staff not on retainer.
  - 2. Installation Supervision: Installation shall be under the direct supervision of a New Mexico ES3J who shall be present at all times when Work of this Section is performed at Project site.
  - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

#### 1.10 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

## PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.

## 2.2 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
  - 1. Communications, Plenum Rated: Type CMP complying with UL 1685
- B. RoHS compliant.

## 2.3 CATEGORY 6 TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.
- B. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.
- C. Conductors: 100-ohm, 23 AWG solid copper.
- D. Cable Rating: Plenum.
- E. Jacket: Blue thermoplastic.

## 2.4 TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. General Requirements for Twisted Pair Cable Hardware:
  - 1. Comply with the performance requirements of Category 6.
  - 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
  - 3. Cables shall be terminated with connecting hardware of same category or higher.
- C. Connecting Blocks:
  - 1. 110-style IDC for Category 6.

- D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
- E. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.
  - 1. Features:
    - a. Universal T568A and T568B wiring labels.
    - b. Labeling areas adjacent to conductors.
    - c. 48 ports.
  - 2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
  - 3. Number of Jacks per Field: One for each four-pair cable indicated
- F. Patch Cords: Factory-made, four-pair cables in 36-inch (900-mm) lengths; terminated with an eight-position modular plug at each end.
  - 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
- G. Plugs and Plug Assemblies:
  - 1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
  - 2. Standard: Comply with TIA-568-C.2.
- H. Jacks and Jack Assemblies:
  - 1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
  - 2. Designed to snap-in to a patch panel or faceplate.
  - 3. Standard: Comply with TIA-568-C.2.
- I. Faceplate:
  - 1. Two port, vertical single gang faceplates designed to mount to single gang wall boxes.
  - 2. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
  - 3. Metal Faceplate: Stainless steel located in kitchen area
  - 4. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
- J. Legend:
  - 1. Machine printed, in the field, using adhesive-tape label.

## 2.5 CABLE MANAGEMENT SYSTEM

- A. Description: Computer-based cable management system, with integrated database capabilities.



## 2.6 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

## 2.7 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-B.

## 2.8 SOURCE QUALITY CONTROL

- A. Factory test cables on reels according to TIA-568-C.1.
- B. Cable will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

## PART 3 - EXECUTION

### 3.1 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.
  - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
  - 2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

### 3.2 INSTALLATION OF PATHWAYS

- A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."
- B. Comply with Section 270528 "Pathways for Communications Systems."

- C. Comply with Section 270536 "Cable Trays for Communications Systems."
- D. Drawings indicate general arrangement of pathways and fittings.

### 3.3 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. General Requirements for Cabling:
  1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
  2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
  3. Install 110-style IDC termination hardware unless otherwise indicated.
  4. Do not untwist twisted pair cables more than **1/2 inch (12 mm)** from the point of termination to maintain cable geometry.
  5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
  6. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
  7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
  8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual , Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
  9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
  10. In the communications equipment room, install a **10-foot- (3-m-)** long service loop on each end of cable.
  11. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.
- C. Open-Cable Installation:
  1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
  2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of **8 inches (200 mm)** above ceilings by cable supports not more than **60 inches (1524 mm)** apart.
- D. Group connecting hardware for cables into separate logical fields.
- E. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

### 3.4 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

### 3.5 GROUNDING

- A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."
- B. Comply with TIA-607-B and NECA/BICSI-607.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a **2-inch (50-mm)** clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

### 3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
  - 1. Administration Class: Class 2.
  - 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- D. Cable and Wire Identification:
  - 1. Label each cable within **4 inches (100 mm)** of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
  - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
  - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 feet (4.5 m)**.
  - 4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
    - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
    - b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- E. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
1. Cables use flexible vinyl or polyester that flexes as cables are bent.

### 3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
  2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
- C. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 271513

## SECTION 271523 - COMMUNICATIONS OPTICAL FIBER HORIZONTAL CABLING

## 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. 62.5/125-micrometer, multimode, optical fiber cable (OM1).
2. 50/125 micrometer, multimode, optical fiber cable (OM2).
3. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM3).
4. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM4).
5. 9/125 micrometer, single mode, optical fiber cable (OS1).
6. 9/125 micrometer, single-mode, indoor-outdoor optical fiber cable (OS2).
7. Optical fiber cable connecting hardware, patch panels, and cross-connects.
8. Grounding.
9. Cabling identification products.

## 1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- C. RCDD: Registered Communications Distribution Designer.

## 1.4 OPTICAL FIBER HORIZONTAL CABLING DESCRIPTION

- A. Optical fiber horizontal cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C and the equipment outlet, otherwise known as "Cabling Subsystem 1" in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
  1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
  2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the equipment outlet.
  3. Bridged taps and splices shall not be installed in the horizontal cabling.

- B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the equipment outlets to the equipment.
- C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

#### 1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.
  - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
  - 2. Cabling administration Drawings and printouts.
  - 3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
    - a. Telecommunications rooms plans and elevations.
    - b. Telecommunications pathways.
    - c. Telecommunications system access points.
    - d. Telecommunications grounding system.
    - e. Telecommunications conductor drop locations.
    - f. Typical telecommunications details.
    - g. Mechanical, electrical, and plumbing systems.
- C. Fiber optic cable testing plan.
- D. Qualification Data: For RCDD, installation supervisor, and field inspector.
- E. Product Certificates: For each type of product.
- F. Source quality-control reports.
- G. Field quality-control reports.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Software and Firmware Operational Documentation:
  - 1. Software operating and upgrade manuals.
  - 2. Program Software Backup: On USB media or compact disk, complete with data files.
  - 3. Device address list.
  - 4. Printout of software application and graphic screens.
- B. Maintenance Data: For optical fiber cable, splices, and connectors to include in maintenance manuals.

## 1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff, not on retainer.
  - 1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
  - 2. Installation Supervision: Installation shall be under the direct supervision of a New Mexico ES7J who shall be present at all times when Work of this Section is performed at Project site.
  - 3. Testing Supervisor: Currently certified by BICSI as an RCDD.

## 1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

## 1.9 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications equipment and service suppliers.

## 1.10 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.

### 2.2 9/125 MICROMETER, SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS2)

- A. Description: Single mode, 9/125-micrometer, 2 fibers, tight buffered, nonconductive optical fiber cable.



- B. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.
- C. Jacket:
  - 1. Jacket Color: Yellow.
  - 2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
  - 3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).
- D. Standards:
  - 1. Comply with TIA-492CAAB for detailed specifications.
  - 2. Comply with TIA-568-C.3 for performance specifications.
  - 3. Comply with ICEA S-104-696 for mechanical properties.
- E. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
  - 1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.

## 2.3 OPTICAL FIBER CABLE HARDWARE

- A. Standards:
  - 1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
  - 2. Comply with TIA-568-C.3.
- B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
- C. Patch Cords: Factory-made, single-fiber cables in 36-inch (900-mm) lengths.
- D. Connector Type: Type SC complying with TIA-604-3-B, Type LC complying with TIA-604-10-B connectors.
- E. Plugs and Plug Assemblies:
  - 1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.

## 2.4 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-B.

## 2.5 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

## 2.6 SOURCE QUALITY CONTROL

- A. Factory test preterminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.
- B. Cable will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

## PART 3 - EXECUTION

### 3.1 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
  - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
  - 2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
  - 3. Cabling installed above accessible ceiling space to be installed in J-hook management
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

### 3.2 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

- A. Comply with NECA 1, NECA 301 and NECA/BICSI 568.
- B. General Requirements for Optical Fiber Cabling Installation:
  - 1. Comply with TIA-568-C.1 and TIA-568-C.3.
  - 2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
  - 3. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
  - 4. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, provide a ~~10-foot-~~ (3-m-) long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Group connecting hardware for cables into separate logical fields.

### 3.3 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

### 3.4 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
  1. Administration Class: Class 2.
  2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

- C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, horizontal pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- D. Cable and Wire Identification:
  - 1. Label each cable within **4 inches (100 mm)** of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
  - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
  - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 feet (4.5 m)**.
  - 4. Label each unit and field within distribution racks and frames.
  - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- E. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:
  - 1. Flexible vinyl or polyester that flexes as cables are bent.

### 3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
  - 1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
  - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
  - 3. Optical Fiber Cable Tests:
    - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    - b. Link End-to-End Attenuation Tests:
      - 1) Horizontal and Multimode Horizontal Link Measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.

- 2) Attenuation test results for horizontal links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.
- C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
  - D. Remove and replace cabling where test results indicate that it does not comply with specified requirements.
  - E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
  - F. Prepare test and inspection reports.

END OF SECTION 271523

## SECTION 281500 - ACCESS CONTROL HARDWARE DEVICES

## 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. Card readers, credential cards, and keypads
- 2. Cables

## B. Related Requirements:

- 1. Section 281300 "Access Control System Software and Database Management" for control and monitoring applications, workstations, and interfaces.

## 1.3 DEFINITIONS

- A. Credential: Data assigned to an entity and used to identify that entity.
- B. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
- C. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
- D. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.
- E. PC: Personal computer. Applies to the central station, workstations, and file servers.
- F. RAS: Remote access services.
- G. RF: Radio frequency.
- H. ROM: Read-only memory. ROM data are maintained through losses of power.
- I. TCP/IP: Transport control protocol/Internet protocol.

- J. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.
- K. WMP: Windows media player.
- L. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- M. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Diagrams for cable management system.
  - 2. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
    - a. Workstation outlets, jacks, and jack assemblies.
    - b. Patch cords.
    - c. Patch panels.
  - 3. Cable Administration Drawings: As specified in "Identification" Article.
  - 4. Battery and charger calculations for central station, workstations, and controllers.
- C. Product Schedules.
- D. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "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 USB media of the hard-copy submittal.
2. System installation and setup guides with data forms to plan and record options and setup decisions.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra 25 percent for future use.
  2. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

#### 1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
  1. Cable installer must have on staff, Not on retainer, an RCDD certified by Building Industry Consulting Service International.
- B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

#### 1.9 DELIVERY, STORAGE, AND HANDLING

- A. 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.
- B. 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.
- C. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" Article.
- D. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

#### 1.10 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:



1. Control Station: Rated for continuous operation in ambient conditions of **60 to 85 deg F (16 to 30 deg C)** and a relative humidity of 20 to 80 percent, noncondensing.
2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in **air-conditioned** indoor environments shall be rated for continuous operation in ambient conditions of **36 to 122 deg F (2 to 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Indoor, Uncontrolled Environment: NEMA 250, Type 3R enclosures. System components installed in non-air-conditioned indoor environments shall be rated for continuous operation in ambient conditions of **0 to 122 deg F (minus 18 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.

## PART 2 - PRODUCTS

2.1 Provide a Vanderbilt SMS deployment. Provide and install equipment necessary for complete operation of systems

### 2.2 OPERATION

- A. Security access system hardware shall use a single database for access-control and credential-creation functions.

### 2.3 PERFORMANCE REQUIREMENTS

- 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. Comply with NFPA 70, "National Electrical Code."

### 2.4 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

- A. Provide Xceedid MT15 for wall mount, and MT11 for mullion mount card readers
- B. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
- C. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:
1. Indoors, controlled environment.
  2. Indoors, uncontrolled environment.
  3. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.
- D. Display: Digital visual indicator shall provide visible status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.

- E. Touch-Plate and Proximity Readers:
  - 1. The card reader shall read proximity cards in a range from direct contact to at least **6 inches (150 mm)** from the reader.
- F. Communication Protocol: Compatible with local processor.
- G. Touch-Plate and Contactless Card Reader: The reader shall have "flash" download capability to accommodate card format changes. The card reader shall have capability of transmitting data to security control panel and shall comply with ISO/IEC 7816.
- H. Credential Card Modification: Entry-control cards shall be able to be modified by lamination direct print process during the enrollment process without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the badge holder used at the site.
- I. Card Size and Dimensional Stability: Credential cards shall be **2-1/8 by 3-3/8 inches (54 by 86 mm)**. The credential card material shall be dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.
- J. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.
- K. Card Construction:
  - 1. Core and laminate or monolithic construction.
  - 2. Furnish equipment for on-site assembly and lamination of credential cards.

## 2.5 PUSH-BUTTON SWITCHES

- A. Push-Button Switches: Momentary-contact push buttons with stainless steel switch enclosures.
- B. Electrical Ratings:
  - 1. Minimum continuous current rating of 10 A at 120-V ac.
- C. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.
- D. Enclosures shall additionally be suitable for installation in the following locations:
  - 1. Indoors, controlled environment.

## 2.6 CABLES

- A. General Cable Requirements: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and as recommended by system manufacturer for integration requirement.

## 2.7 TRANSFORMERS

- A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

## 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 TIA 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.
- D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

### 3.3 CABLING

- A. Comply with NECA 1, "Good Workmanship in Electrical Construction."
- B. Install cables and wiring according to requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

- D. Install LAN cables using techniques, practices, and methods that are consistent with Category 5e rating of components and optical fiber rating of components, and that ensure Category 6 and optical fiber performance of completed and linked signal paths, end to end.
- E. 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 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.

### 3.4 CABLE APPLICATION

- A. Comply with TIA 569-D, "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. TIA 232-F Cabling: Install at a maximum distance of **50 ft. (15 m)** between terminations.
- D. TIA 485-A Cabling: Install at a maximum distance of **4000 ft. (1220 m)** between terminations.
- E. Card Readers and Keypads:
  - 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 ft. (75 m)**, and install No. 20 AWG wire if maximum distance is **500 ft. (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 **100 ft.** between terminations.
- G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of **25 ft. (8 m)** between terminations.

### 3.5 GROUNDING

- A. Comply with Section 270526 "Grounding and Bonding for Communications Systems."
- B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding 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, keypads, push buttons.

### 3.7 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 270553 "Identification for Communications Systems" and with TIA 606-B.
- B. Using software specified in "Cable and Asset Management Software" Article, 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 the 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 AND HARDWARE

- A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

### 3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
  - 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. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use tester approved for type and kind of installed cable. Test for faulty connectors, splices, and terminations. Test according to TIA 568-C.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for balanced twisted-pair cables must comply with minimum criteria in TIA 568-C.1.
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.

C. Devices and circuits will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

## 3.10 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service.

1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

## 3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain security access system. See Section 017900 "Demonstration and Training."

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. Corporate management.

END OF SECTION 281500

## SECTION 282000 - VIDEO SURVEILLANCE

## 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 a video surveillance system consisting of cameras, Network video recorder, data transmission wiring, and a control station with its associated equipment.

## 1.3 DEFINITIONS

- A. AGC: Automatic gain control.
- B. BNC: Bayonet Neill-Concelman - type of connector.
- C. B/W: Black and white.
- D. CCD: Charge-coupled device.
- E. FTP: File transfer protocol.
- F. IP: Internet protocol.
- G. LAN: Local area network.
- H. MPEG: Moving picture experts group.
- I. NTSC: National Television System Committee.
- J. PC: Personal computer.
- K. PTZ: Pan-tilt-zoom.
- L. RAID: Redundant array of independent disks.
- M. TCP: Transmission control protocol - connects hosts on the Internet.
- N. UPS: Uninterruptible power supply.
- O. WAN: Wide area network.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
  - 3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
- C. Design Data: Include an equipment list consisting of every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Product Warranty: Sample of special warranty.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
  - 1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

#### 1.7 PROJECT CONDITIONS

- A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
  - 1. Control Station: Rated for continuous operation in ambient temperatures of **60 to 85 deg F (16 to 29 deg C)** and a relative humidity of 20 to 80 percent, noncondensing.
  - 2. Interior, Controlled Environment: System components, except central-station control unit, installed in **air-conditioned interior environments** shall be rated for continuous operation in ambient temperatures of **36 to 122 deg F (2 to 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.



3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of **minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to **85 mph (137 km/h)**. Use NEMA 250, Type 3R enclosures.
4. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

## 1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: Two years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 SYSTEM REQUIREMENTS

- A. Video-signal format shall comply with NTSC standard, composite interlaced video. Composite video-signal termination shall be 75 ohms.
- B. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.
  1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
  2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
- C. 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.

### 2.2 PERFORMANCE REQUIREMENTS

- 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. Comply with NECA 1.
- C. Comply with NFPA 70.

## 2.3 STANDARD CAMERAS

- A. Coordinate with drawings to provide the following camera types:
  1. Type 1 – Axis P3227-LVE
  2. Type 2 – Axis P3717 (4-in-1)
  3. Type 3 – Axis P3715 (corridor)
  4. Type 4 – Axis P3227-LV
  5. Type 5 – Axis Q6010-E
  6. Type 6 – Axis Q6074-E

## 2.4 NETWORK VIDEO RECORDERS

- A. Provide Exacq Vision Z series
  1. Provide with quad NIC
  2. 160TB storage
  3. Provide licensing for each camera + 5 spare licenses

## 2.5 IP VIDEO SYSTEMS

- A. Description:
  1. System shall provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
  2. System shall have seamless integration of all video surveillance and control functions.
  3. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management. IP system shall also be capable of integrating into larger system environments.
  4. System design shall include all necessary compression software for high-performance, dual-stream, MPEG-2/MPEG-4 video. Unit shall provide connections for all video cameras, camera PTZ control data, bidirectional audio, discreet sensor inputs, and control system outputs.
  5. All camera signals shall be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
  6. Camera system units shall be ruggedly built and designed for extreme adverse environments, complying with NEMA Type environmental standards.
  7. Encoder/decoder combinations shall place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN.
  8. All system interconnect cables, workstation PCs, PTZ joysticks, and network intermediate devices shall be provided for full performance of specified system.

## PART 3 - EXECUTION

## 3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN, WAN, and IP network before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 WIRING

- A. Comply with requirements in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method: Install cables in raceways unless otherwise indicated.
  - 1. Except raceways are not required in accessible indoor ceiling spaces and attics.
  - 2. Except raceways are not required in hollow gypsum board partitions.
  - 3. Conceal raceways and wiring except in unfinished spaces.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- E. For communication wiring, comply with the following:
  - 1. Section 271513 "Communications Copper Horizontal Cabling."

## 3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

- A. Install cameras level and plumb.
- B. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.
- C. Identify system components, wiring, cabling, and terminals according to Section 270553 "Identification for Communications Systems."

## 3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

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. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
  - a. Prepare equipment list described in "Informational Submittals" Article.
  - b. Verify operation of auto-iris lenses.
  - c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
  - d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object **50 to 75 feet (17 to 23 m)** away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
  - e. Set and name all preset positions; consult Owner's personnel.
  - f. Set sensitivity of motion detection.
  - g. Connect and verify responses to alarms.
  - h. Verify operation of control-station equipment.
3. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

C. Video surveillance system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

### 3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 6 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to one visit to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
1. Check cable connections.
  2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
  3. Adjust all preset positions; consult Owner's personnel.
  4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.

3.6 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION 282000

## SECTION 28 3111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

### 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.
- B. Comply with NFPA 5000, 2000ED for a Class A system.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Fire-alarm control unit.
  - 2. Manual fire-alarm boxes.
  - 3. System smoke detectors.
  - 4. Heat detectors.
  - 5. Notification appliances.
  - 6. Device guards.
  - 7. Magnetic door holders.
  - 8. Remote annunciator.
  - 9. Addressable interface device.
  - 10. Digital alarm communicator transmitter.
  - 11. Radio alarm transmitter.
  - 12. Network communications.
  - 13. System printer.

#### 1.3 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.
  - 1. Include construction details, material descriptions, dimensions, profiles, and finishes.
  - 2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.1
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
  - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
  - b. Show field wiring required for HVAC unit shutdown on alarm.
  - c. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
  - d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
  - e. Locate detectors according to manufacturer's written recommendations.
12. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
13. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.
14. General Submittal Requirements: Submit three (3) copies of the Fiore Alarm shop drawings, battery calculations, voltage drop calculations, equipment data sheets, sequence of operation, fire alarm riser, and all related documents through the project manager to the Division of safety and Risk Management (AHJ) for review and approval prior to installation. [25 IAM Safety and Health Handbook Topic 26, 26.6.A4]

C. General Submittal Requirements

1. Submittals shall be approved by authorities having jurisdiction, State or local fire Marshall, prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
  - a. Trained and certified by manufacturer in fire-alarm system design.
  - b. NICET-certified, fire-alarm technician; Level III minimum.
  - c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and

design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Seismic Qualification Data: Certificates, for fire-alarm control unit, accessories, and components, from manufacturer.
  1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.
  1. In addition to items specified in Section 01 7800 "Closeout Submittals" include the following and deliver copies to authorities having jurisdiction:
    - a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
    - b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    - c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
    - d. Riser diagram.
    - e. Device addresses.
    - f. Record copy of site-specific software.



- g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
  - 1) Equipment tested.
  - 2) Frequency of testing of installed components.
  - 3) Frequency of inspection of installed components.
  - 4) Requirements and recommendations related to results of maintenance.
  - 5) Manufacturer's user training manuals.
- h. Manufacturer's required maintenance related to system warranty requirements.
- i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

**B. Software and Firmware Operational Documentation:**

- 1. Software operating and upgrade manuals.
- 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
- 3. Device address list.
- 4. Printout of software application and graphic screens.

**C. Acceptance:**

The following documents shall be provided to DSRM, through the project manager, PRIOR to final Inspection:

- 1. "Record of Completion"(NFPA72, 7.5.5.2).Written Statement that the system has been installed in accordance with approved plan, tested in accordance with Manufacturer's specifications and NFPA requirements (NFPA 72,, 7.5.2).

The following shall be available for examination at final inspection:

- 1. Operations & Maintenance Manual, Including manufacturer's published instructions and installation instructions, covering all system equipment (NFPA 72, 7.2.1(6)).
- 2. As-built installation drawings (NFPA 72, 7.2.1(14))

**1.7 MAINTENANCE MATERIAL SUBMITTALS**

**A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.**

- 1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no less than one unit.
- 2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no less than one unit.
- 3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no less than one unit of each type.
- 4. Detector Bases: Quantity equal to 10 percent of amount of each type installed, but no less than one unit of each type.
- 5. Keys and Tools: One extra set for access to locked and/or tamper proofed components.
- 6. Audible and Visual Notification Appliances: Two of each type installed.
- 7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

## 1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.
- C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).
- D. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

## 1.9 PROJECT CONDITIONS

- A. Perform a full test of the system. Document any equipment or components not functioning as designed.
- B. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

## 1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
  - 2. Warranty Period: Five years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

- A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.
- B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and voice and or horn]/strobe evacuation.
- C. Automatic sensitivity control of certain smoke detectors.
- D. All components provided shall be listed for use with the selected system.
- E. 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.

## 2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Carbon monoxide detectors.
6. Combustible gas detectors.
7. Automatic sprinkler system water flow.
8. Fire-extinguishing system operation.
9. Fire standpipe system.
10. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Activate smoke-control system (smoke management) at firefighters' smoke-control system panel.
9. Activate stairwell and elevator-shaft pressurization systems.
10. Close smoke dampers in air ducts of designated air-conditioning duct systems.
11. Activate preaction system.
12. Recall elevators to primary or alternate recall floors.
13. Activate elevator power shunt trip.
14. Activate emergency lighting control.
15. Activate emergency shutoffs for gas and fuel supplies.
16. Record events in the system memory.
17. Record events by the system printer.
18. Indicate device in alarm on the graphic annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.
3. Alert and Action signals of air-sampling detector system.
4. Elevator shunt-trip supervision.
5. Independent fire-detection and -suppression systems.
6. User disabling of zones or individual devices.
7. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.

2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.
11. Hose cabinet door open.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
3. Record the event on system printer.
4. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
5. Transmit system status to building management system.
6. Display system status on graphic annunciator.

## 2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

## 2.4 FIRE-ALARM CONTROL UNIT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gamewell - FCI by Honeywell.
2. Firelite.

B. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
  - a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.

- b. Include a real-time clock for time annotation of events on the event recorder and printer.
  - c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
  - d. The FACP shall be listed for connection to a central-station signaling system service.
  - e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
- 2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
  - 3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
- C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
- 1. Annunciator and Display: Liquid-crystal type, 80 characters, minimum.
  - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- D. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
- 1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.
  - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands for control of smoke-detector sensitivity and other parameters.
- E. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
- 1. Pathway Class Designations: NFPA 72, Class A.
  - 2. Pathway Survivability: Level 1.
  - 3. Install no more than 100 addressable devices on each signaling-line circuit.
  - 4. Serial Interfaces:
    - a. One dedicated RS 485 port for central-station operation using point ID DACT.
    - b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
    - c. One USB and RS 232 port for PC configuration.
    - d. One RS 232 port for voice evacuation interface.
  - 5. Fire Alarm System shall be provided with Class A Wiring, 14 gauge minimum. [BIA School Design Handbook 11100-1]

- F. Smoke-Alarm Verification:
1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
  2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
  3. Record events by the system printer.
  4. Sound general alarm if the alarm is verified.
  5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
- G. Notification-Appliance Circuit:
1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
  2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
  3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.
- H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.
- I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.
- J. The kitchen hood fire protection system will be monitored by the FACP.
- K. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
- L. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in a separate cabinet located in the fire command center.
1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.
    - a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
    - b. Programmable tone and message sequence selection.
    - c. Standard digitally recorded messages for "Evacuation" and "All Clear."
    - d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
  3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
- M. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
- N. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters, and digital alarm radio transmitters shall be powered by 24-V dc source.
1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
- O. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
1. Batteries: Vented, wet-cell pocket, plate nickel cadmium.
- P. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

## 2.5 MANUAL FIRE-ALARM BOXES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Gamewell - FCI by Honeywell.
  2. Firelite.
- B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
1. Single-action mechanism, breaking-glass or plastic-rod pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
  2. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
  3. Station Reset: Key- or wrench-operated switch.

4. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
5. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

## 2.6 SYSTEM SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gamewell - FCI by Honeywell.
2. Firelite.

B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
  - a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
  - b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
  - c. Multiple levels of detection sensitivity for each sensor.
  - d. Sensitivity levels based on time of day.
8. Locate detectors at least 5'-0" from supply air grilles.
9. Locate detectors at least 12" from luminaires.
10. Consider stratification effects when selecting detector locations.
11. Heat detectors will be provided for any kitchens, boiler rooms, electrical rooms, kiln rooms, or other locations where dirt or debris are likely to cause false alarms.
12. Heat detectors will be intermediate fixed temperature rated.

C. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.



2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).

D. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).

E. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).
3. Provide duct detectors in supply and return ducts for air handling units (AHU's) with air velocity of 2,000 cubic feet per minute or greater.
4. Ensure that duct detectors are located prior to any duct splits, or provide a duct detector on each branch of duct work where required for complete coverage.
5. Remote indicator lights and test switches shall be provided for each duct detector.
  - a. Locate the detector in the nearest corridor or other common space, wall mounted at 7'-0" above finished floor. Provide permanent label indicating which duct detector is at that location.
  - b. When a duct detector is concealed above a ceiling provide a permanent label on the access door or the ceiling tile used for service access to the duct detector, indicating which duct detector is at that location.
6. Provide duct detector with-in 5'-0" of each fire/smoke damper.
7. Activation of a duct detector will shut down the associated unit.

8. Manual override shall be provided for testing of AHU shutdown upon duct detector activation.
9. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
10. Each sensor shall have multiple levels of detection sensitivity.
11. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
12. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

## 2.7 CARBON MONOXIDE DETECTORS

### A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.
8. Test button simulates an alarm condition.

## 2.8 HEAT DETECTORS

### A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gamewell - FCI by Honeywell.
2. Firelite.

### B. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

### C. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

### D. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

## 2.9 NOTIFICATION APPLIANCES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Gamewell - FCI by Honeywell.
  - 2. Firelite.
- B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
- C. Provide a sufficient number of horns/speakers spaced as required to achieve 15 decibels above ambient sound levels and 4 decibels above the maximum sound level in each space.
- D. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
  - 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
  - 2. Provide horns/speakers as required by code and in each corridor, cafeteria, classroom, vocal room, instrumental room, mechanical room, break room, sound proof room, and sleeping rooms.
  - 3. Provide gymnasiums, and auditoriums with either live or pre-recorded voice announcements or visible devices.
  - 4. Where gymnasiums, auditoriums, cafeterias, and the like have a local sound system, provide the means to disengage the sound system upon activation of the fire alarm system and initiate a pre-recorded voice announcement. Provide a local override to allow for live announcements. The override shall time out and resume the pre-recorded message with-in 10 seconds after the end of the live message.
- E. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.
- F. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
- G. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.
- H. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
  - 1. Rated Light Output:
    - a. Will vary depending on location and volume of space, any of the following could be used: 15, 30, 75, 110, 177, cd.
    - b. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
  3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
  4. Flashing shall be in a temporal pattern, synchronized with other units.
  5. Strobe Leads: Factory connected to screw terminals.
  6. Mounting Faceplate: Factory finished, white.
  7. The candela level provided by the strobes shall be coordinated with the application and location as required to meet code requirements.
  8. Provide strobes as required by code and in each corridor, cafeteria, classroom, vocal room, instrumental room, mechanical room, break room, sound proof room, and sleeping rooms
- I. Provide separate circuits to the horns and strobes to enable separate horn/speaker silence features.
- J. Provide audible/visual notification with-in 15'-0" of all exits.
- K. Provide an exterior weatherproof horn/strobe at the fire department Siamese connection or at the point of entry of the fire department where a Siamese connection is not located.
- L. Provide two-way communication between areas of refuge and the FACP.
- M. Voice/Tone Notification Appliances:
1. Comply with UL 1480.
  2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
  3. High-Range Units: Rated 2 to 15 W.
  4. Low-Range Units: Rated 1 to 2 W.
  5. Mounting: Flush or surface mounted and bidirectional.
  6. Matching Transformers: Tap range matched to acoustical environment of speaker location.
- N. Exit Marking Audible Notification Appliance:
1. Exit marking audible notification appliances shall meet the audibility requirements in NFPA 72.
  2. Provide exit marking audible notification appliances at the entrance to all building exits.
  3. Provide exit marking audible notification appliances at the entrance to areas of refuge with audible signals distinct from those used for building exit marking.

## 2.10 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
1. Electromagnets: Require no more than 3 W to develop 25-lbf holding force.
  2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
  3. Rating: 24-V ac or dc.

- 4. Rating: 120-V ac.
- B. Material and Finish: Match door hardware.
- C. Configure door hold-opens to close upon any alarm.
- D. Coordinate voltage requirements for magnetic door hold-opens.
- E. Coordinate door hold-opens with security requirements.

#### 2.11 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
  - 1. Mounting: Flush cabinet, NEMA 250, Type 1.
- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

#### 2.12 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.
- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
  - 1. Verification that both telephone lines are available.
  - 2. Programming device.
  - 3. LED display.
  - 4. Manual test report function and manual transmission clear indication.
  - 5. Communications failure with the central station or fire-alarm control unit.
- D. Digital data transmission shall include the following:
  - 1. Address of the alarm-initiating device.
  - 2. Address of the supervisory signal.

3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

## 2.13 NETWORK COMMUNICATIONS

A. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

## 2.14 SYSTEM PRINTER

A. Printer shall be listed and labeled as an integral part of fire-alarm system.

## 2.15 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by device manufacturer.
2. Finish: Paint of color to match the protected device.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72, NFPA 101, ADAA/BAAG, 2004ED, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
  - 1. Devices placed in service before all other trades have completed cleanup shall be replaced.
  - 2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
  - 1. Connect new equipment to existing control panel in existing part of the building.
  - 2. Connect new equipment to existing monitoring equipment at the supervising station.
  - 3. Expand, modify, and supplement existing control/monitoring equipment as necessary to extend existing control/monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
- C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.
  - 1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."
- D. Manual Fire-Alarm Boxes:
  - 1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
  - 2. Mount manual fire-alarm box on a background of a contrasting color.
  - 3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.
- E. Smoke- or Heat-Detector Spacing:
  - 1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
  - 2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
  - 3. Smooth ceiling spacing shall not exceed 30 feet.
  - 4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
  - 5. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
  - 6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

- F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
  - 1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
- H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.
- I. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.
- J. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.
- K. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.
- L. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.
- M. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- N. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists 100-mph wind load with a gust factor of 1.3 without damage.

### 3.3 PATHWAYS

- A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.
  - 1. Exposed pathways located less than 96 inches above the floor shall be installed in EMT.
- B. Pathways shall be installed in 3/4" EMT minimum.
- C. Exposed EMT shall be painted red enamel.

### 3.4 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.



1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
  2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
  3. Smoke dampers in air ducts of designated HVAC duct systems.
  4. Magnetically held-open doors.
  5. Electronically locked doors and access gates.
  6. Alarm-initiating connection to elevator recall system and components.
  7. Alarm-initiating connection to activate emergency lighting control.
  8. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
  9. Supervisory connections at valve supervisory switches.
  10. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
  11. Supervisory connections at elevator shunt-trip breaker.
  12. Data communication circuits for connection to building management system.
  13. Data communication circuits for connection to mass notification system.
  14. Supervisory connections at fire-extinguisher locations.

### 3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 27 0553 "Identification for Communications Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

### 3.6 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

### 3.7 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by Architect, authorities having jurisdiction, and Owner.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.

- D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Visual Inspection: Conduct visual inspection prior to testing.
    - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
  2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
  3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
  4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
  5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
  6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- F. Provide a 48 hour battery test and a 90 minute alarm test.
- G. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports.
- I. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
- J. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

### 3.8 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

### 3.9 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
  1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

### 3.10 DEMONSTRATION

- A. After final inspection engage a factory-authorized service representative to must train Owner's maintenance personnel onsite to adjust, operate, and maintain fire-alarm system indicated in the approved operating and maintenance instructions.

END OF SECTION 28 3111

**SECTION 31 0000**  
**EARTHWORK**

**PART 1 GENERAL**

**1.01 DESCRIPTION OF WORK**

- A. Extent of earthwork shall be as indicated on drawings and shall include excavation, filling, backfilling, compaction, and grading under and around structures, and remainder of site as shown on plans.
  - 1. Preparation of subgrade for building foundations, slabs and exterior walkways is included as part of this work.
  - 2. Backfilling of trenches beyond building lines is included as part of this work.
  - 3. Site Grading is included as part of this work.

**1.02 DEFINITIONS**

- A. "Excavation" consists of removal of material encountered to subgrade elevations indicated and subsequent disposal of materials removed.
- B. "Unauthorized Excavation" consists of removal of materials beyond indicated subgrade elevations or dimensions without specific instructions from the Engineer to do so.

**1.03 REFERENCES**

- A. General: The documents referenced in this section are declared to be a part of these specifications, the same as if fully set forth, except modified herein. Except as specifically stated otherwise, the edition or revision of each document which is in effect at the beginning of work on this project shall be used.
- B. Geotechnical Investigation:
  - 1. Geotechnical Evaluation Report; Western Technologies Job No. 3120JS042, dated May 18, 2020.
- C. American Society for Testing and Materials (ASTM):
  - 1. ASTM D422 Standard Test Method for Particle Size Analysis of Soils
  - 2. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
  - 3. ASTM D1557 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2700KN-m/m<sup>3</sup>))
  - 4. ASTM D2922 Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
  - 5. ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils
- D. NFPA 5000, "Building Construction and Safety Codes": Soils
- E. New Mexico Standard Specifications for Public Works Construction, Latest Edition, including all updates, and applicable laws, codes, and regulations.
- F. 29 CFR 1926 Construction Industry Regulations (OSHA)

## **1.04 QUALITY ASSURANCE**

- A. Codes and Standards: Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.
- B. Testing and Inspection Service: The Owner shall employ a Testing Laboratory acceptable to Engineer to perform testing and inspection services for quality control testing during earthwork operations.

## **1.05 SUBMITTALS**

- A. Fill and Backfill Materials: Gradation and moisture-density relationship for each material proposed for use as fill or backfill.

## **1.06 JOB CONDITIONS**

- A. Bench Marks: Protect benchmarks on or adjacent to site from damage. If benchmarks are damaged, restore as required by authorities having jurisdiction.
- B. Unexpected Conditions: Notify Engineer and Owner's representative of unexpected subsurface conditions. Discontinue affected work in area until notified to resume work.
- C. Existing Utilities:
  - 1. Identify existing underground utilities in areas of work located by Owner. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.
  - 2. If uncharted, or incorrectly charted, piping or other utilities are 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:
  - 1. Barricade open excavations occurring as part of this work and post with warning lights.
  - 2. Operate warning lights as recommended by authorities having jurisdiction.
  - 3. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

## **PART 2 - PRODUCTS**

### **2.01 SOIL MATERIALS**

- A. Structural Backfill and Fill Materials: Clean material free of debris, waste, frozen materials, vegetation, clay lumps and other deleterious materials and having the physical characteristics as specified in the Geotechnical Report. The plasticity index should be 10 (max) when tested in accordance with ASTM D-4318.
- B. Pipe bedding material shall be processed natural material meeting the gradation requirements as specified in the geotechnical report. The plasticity index of the material used for pipe bedding shall not exceed 10 as determined by ASTM D4318.
- C. Base Course: New Mexico Department of Transportation Standard Specifications for Highway and Bridge Construction, Latest Edition, Section 304.

## **PART 3 - EXECUTION**

### **3.01 CLEARING AND GRUBBING:**

- A. General: Clearing and grubbing will be required for areas indicated on the Drawings to be excavated, improved or on which fill is to be constructed. Cleared and grubbed materials, including trash, shall be deposited to an approved disposal site.
- B. Clearing: Clearing shall consist of removal and disposal of existing paving materials, concrete and vegetation as well as matted roots, brush and rubbish within the areas to be improved and constructed upon.
- C. Grubbing: Stumps, matted roots and roots larger than two (2) inches in diameter shall be removed from within eight (8) inches of the surface of areas on which improvements and fills are to be constructed except in roadways. Materials as described above and which are within eighteen (18) inches of finished subgrade of roadways in either cut or fill sections shall be removed. Areas disturbed by grubbing shall be filled as specified in the Geotechnical Report for engineered fill and backfill.
- D. Inspection: Cleared and excavated areas shall be inspected by Geotechnical Engineer prior to scarifying and placing fills.
  - 1. Identify required lines, levels, contours and datum.
  - 2. Identify known underground utilities located by Owner. Protect stakes and flags installed by Owner.
  - 3. Identify and flag surface and aerial utilities.
  - 4. Notify utility companies to remove or relocate utilities as necessary.
  - 5. Maintain and protect existing utilities which pass through site.

### **3.02 EXCAVATION AND TRENCHING**

- A. General: The Contractor shall perform all excavation and trenching of every description and of whatever substances encountered to the depths indicated on the contract drawings or as otherwise specified. During excavation and trenching, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the banks of the trench to avoid overloading and to prevent slides or cave-ins. All excavated material not required or suitable for backfilling shall be removed and wasted. Berming and grading shall be done as may be necessary to prevent surface water from flowing into excavated areas or trenches. Any water accumulating therein shall be removed by pumping or by other methods.
- B. Excavation For Footings: Over excavation, moisture conditioning and backfill shall be as indicated in the General Foundation Notes. Excavation shall be adequate with allowances made for clearance to install services, forms, waterproofing and dampproofing. The bottom of the excavation shall be accurately graded, level, clean and clear of loose materials. Overdepth shall be backfilled with specified backfill material at the Contractor's expense. Undercutting will not be permitted.
- C. Trenching For Utilities: Trenches shall be adequate width for the proper laying of the pipe and the banks shall be as nearly vertical as practicable and safe for workmen. The bottom of the trenches shall be accurately graded and bedded to provide uniform bearing and support for each section of the pipe at every point along its entire length. Bell holes and depressions for joints shall be dug after the trench bottom has been graded and bedded in order that the pipe rests upon the prepared bottom for its full length. Care shall be taken not to excavate below the depths indicated to a minimum overdepth of 4 inches below the trench depths. Overdepths in

the rock and common excavation shall be backfilled with backfill material. Whenever wet or otherwise unstable soil that is incapable of properly supporting the pipe is encountered in the bottom of the trench, such soil shall be removed to the depth required and the trench backfilled to the proper grade with materials as specified.

- D. Inspection: Cleared and excavated areas shall be inspected by Geotechnical Engineer prior to scarifying and placing fills.
1. Identify required lines, levels, contours and datum.
  2. Identify known underground utilities located by Owner. Protect stakes and flags installed by Owner.
  3. Identify and flag surface and aerial utilities.
  4. Notify utility companies to remove or relocate utilities as necessary.
  5. Maintain and protect existing utilities which pass through site.

### 3.03 EXCAVATION

- A. General:
1. Excavate to subgrade elevations indicated.
  2. Unauthorized excavation, as well as remedial work directed by Engineer, shall be at Contractor's expense.
- B. Additional Excavation:
1. When excavation has reached required subgrade elevations, notify Engineer who will make an inspection of conditions.
  2. If unsuitable bearing materials are encountered at required subgrade elevations, notify Engineer. Do not continue excavating without specific instructions to do so from the Engineer and replace excavated material as directed by Engineer.
  3. Removal of unsuitable material and its replacement as directed will be paid on basis of contract conditions relative to changes in work.
- C. Stability of Excavations:
1. Slope sides of excavations to comply with local codes and ordinances having jurisdiction, OSHA requirements, and as required for slope stability based on site conditions. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated.
  2. Maintain sides and slopes of excavations in safe condition until completion of backfilling.
- D. Dewatering:
1. Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding project site and surrounding area.
  2. 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, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations. Use methods, materials and equipment as necessary to prevent damage to existing construction.

3. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rainwater and water removed from excavations to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

E. Material Storage:

1. Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.
2. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.
3. Dispose of excess soil material and waste materials off site in accordance with local codes and ordinances.
4. Excavation for Structures:
5. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.

F. Cold Weather Protection:

1. Protect excavation bottoms against freezing.

### 3.04 FILL AND BACKFILL

A. Begin fill and backfill operations as promptly as work permits, but not until completion of the following:

1. Acceptance of construction below finish grade including, where applicable, damp proofing, waterproofing, and perimeter insulation.
2. Inspection, testing, approval, and recording locations of underground utilities.
3. Removal of concrete formwork.
4. Removal of trash and debris.
5. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

B. Site Preparation:

1. This site shall be prepared by removing and clearing any existing foundations, paved areas, grass, trees, tree roots, and organic topsoils where indicated on the construction drawings.
2. The Subgrade shall be proof rolled to detect local weak areas which should be excavated, processed, and recompacted in loose lifts of approximately 10-inch (Maximum) thickness and compacted to a minimum of 95% of maximum dry density (per Geotechnical Report).

C. Subgrade Preparation:

1. The top 8 inches of in-place soil shall be plowed or scarified, processed to near optimum moisture and compacted per the Geotechnical Report.
2. The site shall be proof rolled to detect soft areas which should be removed and properly replaced.
3. Subgrade shall be tested by a qualified Laboratory Technician under the supervision of a Registered Professional Engineer specializing in geotechnical studies.

D. Placement:

1. All select fill material shall have properties specified in, and be placed per, the Geotechnical Report. All soil for fill shall be free of large rock (larger than 2") or other deleterious material. The plasticity index and liquid limit of material used as select, non-expansive fill shall be



routinely verified during fill placement using laboratory tests. Visual observation and classification shall not be relied upon to confirm the material to be used as select, non-expansive fill satisfies the above Atterberg-limit criteria.

2. The site shall be proof rolled to detect soft areas which should be removed and properly replaced.
3. Each lift shall be tested by a qualified Laboratory Technician under the supervision of a Registered Professional Engineer specializing in geotechnical studies.

### **3.05 GRADING**

- A. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are indicated, or between such points and existing grades.
- B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding.
- C. Finish surfaces free from irregular surface changes, and as follows:
  1. Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 0.10' above or below required subgrade elevations.
  2. Walks: Shape surface of areas under walks to line, grade and cross-section, with finish surface not more than 0.10' above or below required subgrade elevation.
- D. Compaction: After grading, compact subgrade surfaces to the depth and indicated percentage of maximum density for each area classification.

### **3.06 MAINTENANCE**

- A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.
- B. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.
- C. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.
- D. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work and eliminate evidence of restoration to greatest extent possible.
- E. Any previously tested and approved areas requiring maintenance re-work shall be re-tested prior to acceptance.

### **3.07 DISPOSAL OF EXCESS AND WASTE MATERIALS**

- A. Remove waste materials, including trash and debris, and properly dispose of it off Owner's property.
- B. Coordinate with owner and engineer for placement of excess excavated material for stockpile location on Owner's property.

### **3.08 FIELD QUALITY CONTROL**

- A. An independent testing laboratory, selected and paid for by the Owner and approved by the Engineer, shall be retained to perform construction testing of in-place materials.  
Testing and inspection shall include, but is not limited to, the following tests. Testing and inspection shall be performed by a licensed Geotechnical Engineering firm or its representative.
  - 1. Determine maximum densities and optimum moisture contents in accordance with ASTM D-1557.
  - 2. Determine in-place density by either the sand-cone method (ASTM D1556) or the nuclear method (ASTM D2922).
- B. Test subgrade; fill materials and embankments at the following rates:
  - 1. One field density test for each 500 square yards of subgrade.
  - 2. One field density test for each 500 cubic yards of fill or for each fill layer, whichever results in the greater number of tests.
  - 3. One moisture-density for each type of subgrade material encountered and each type of fill material used, as indicated by sieve analysis and plasticity index.
- C. If testing results indicate that density of in-place material is less than that required, recompact and retest until requirements of this specification are met. Costs of retesting are the Contractor's expense.
- D. Provide Engineer written notification 48 hours in advance of when testing will be conducted. Conduct tests in presence of Engineer or Engineer's representative.

**END OF SECTION**

## SECTION 312000 -EARTHWORK

### PART 1 GENERAL

#### 1.01 WORK INCLUDED

- A. The work covered by this Section consists of furnishing all plant, labor, equipment, appurtenances and material in performing all operations, hauling, placing, spreading, watering, processing, compacting and shaping earth sections complete in place in accordance with the Project Manual and Drawings.

#### 1.02 RELATED WORK ELSEWHERE

- A. Section 31 10 00 - Clearing
- B. General foundation notes on Drawings. In case of conflict or omission, the general foundation notes shall govern.

#### 1.03 SUBSURFACE SOIL DATA

- A. Subsurface soil investigations have been made and the results are available for examination by the Contractor. This is not a warranty of conditions, the Contractor is expected to examine the site and determine for himself the character of materials to be encountered.
- B. No additional allowance will be made for rock removal, site clearing and grading, filling, compaction, disposal, or removal of any unclassified materials.

#### 1.04 REFERENCES

- A. American Society for Testing and Materials (ASTM).
  - 1. ASTM D 1556-90 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
  - 2. ASTM D 1557-91 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>).
  - 3. ASTM D 2922-96 Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
  - 4. ASTM D 3017-96 Standard Test Method for Water content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
  - 5. ASTM D 4318-95a Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

## 1.05 SUBMITTALS

- A. Submit copies of materials certificates and test results for materials in accordance with type of tests, frequencies and remarks as outlined in the sampling and testing schedule.

## 1.06 TESTING AND INSPECTION

- A. General: The Contractor shall employ the services of a registered, licensed Geotechnical Engineer to observe all controlled earthwork soil testing. The testing laboratory shall provide continuous on-site observation by experienced personnel during construction of fill material. The Contractor shall notify the testing laboratory at least two working days in advance of any field operations of controlled earthwork, or of any resumption of operations after stoppages.
- B. Report of Field Density Tests
  - 1. The Geotechnical Engineer shall submit, daily, the results of field density tests required by these specifications.
- C. Costs of Tests and Inspection
  - 1. The cost of testing, inspecting and engineering, as specified in this section of the specifications, shall be borne by the Contractor.
- D. Lines and Grades: Alignment and grade of all elements shall be made on true tangents and curves. Grades shall conform to the elevations indicated on Drawings, with minor adjustments, to provide a smooth approach at building lines, at connections to existing paving and to provide proper drainage. Correct irregularities at no cost to the Owner.

## 1.07 WEATHER LIMITATIONS

- A. Controlled fill shall not be constructed when the atmospheric temperature is below 35 degrees F. When the temperature falls below 35 degrees, it shall be the responsibility of the Contractor to protect all areas of completed work against any detrimental effects of ground freezing by methods approved by the testing laboratory. Any areas that are damaged by freezing shall be reconditioned, reshaped, and compacted by the Contractor in conformance with the requirements of this specification without additional cost to the Owner.

## PART 2 PRODUCTS

### 2.01 NON - STRUCTURAL FILL MATERIAL

- A. The material shall be clean, free of roots, organic matter, trash, debris, lumps or stones larger than 6 inches.

### 2.02 STRUCTURAL FILL MATERIAL

- A. Material shall consist of soils that conform to the following physical characteristics:

Sieve Size Sq. Openings	Percent Passing By Weight
6 inch	100
4 inch	85 – 100
¾ inch	70 - 100
No. 4	50 - 100
No. 200	40 (max)

- B. Maximum expansive potential (%).....1.5
- C. Maximum soluble sulfates (%).....0.10

PART 3 EXECUTION

3.01 PREPARATION

- A. Clearing and Grubbing: Prior to placing structural fill all borrow areas and areas to receive structural fill shall be stripped of vegetation and deleterious materials. Strippings shall be hauled offsite or stockpiled for subsequent use in landscaped areas or non-structural fill areas as designated by the Owner or his representative and approved by the Geotechnical Engineer.

3.02 CONSTRUCTION AREA TREATMENT

- A. Site Preparation - Fill Areas: Prior to placing structural fill the areas to be filled shall be scarified to a depth of eight inches and moisture conditioned as described below. The area to be filled shall then be compacted to a minimum of 95 percent of maximum density as determined in accordance with ASTM D 1557. Any soft or "spongy" areas shall be removed as directed by the Geotechnical Engineer and replaced with structural fill as described herein.
- B. Site Preparation - Cut Areas: Following excavation to rough grade all building and pavement areas shall be scarified to a depth of eight inches and moisture conditioned as described below. All building and paved areas shall be compacted to a minimum of 95 percent of maximum density as determined by ASTM D 1557.

3.03 EQUIPMENT AND METHODS

- A. In areas not accessible to heavy equipment, distribute by and compact with hand operated vibratory compactors.

3.04 BORROW

- A. The Contractor shall provide sufficient material for fill to the lines, elevations and cross sections as shown on the contract drawings from borrow areas.
- B. The Contractor shall obtain from the Owners of said borrow areas the right to excavate material, shall pay all royalties and other charges involved, and shall pay all expenses in developing the source including the cost of right-of-way required for hauling the material.

3.05 COMPACTION

- A. Fill shall be spread in layers not exceeding 8 inches, watered as necessary, and compacted. Moisture content at time of compaction shall be 3 percent below optimum moisture or higher. A density of not less than 95 percent of maximum dry density within the building pads and paved areas shall be obtained. Fill areas outside the building pads and paved areas shall be compacted to 95 percent of maximum dry density.
- B. Optimum moisture content and maximum dry density for each soil type used shall be determined in accordance with ASTM D 1557.
- C. Compaction of the fill shall be by mechanical means only. Where vibratory compaction equipment is used, it shall be the Contractor's responsibility to ensure that the vibrations do not damage nearby buildings or other adjacent property. Where vibratory compaction is not possible, pneumatic rolling equipment shall be used.

MATERIAL	MINIMUM PERCENT COMPACTION
Structural & granular fill in construction area	95
Subgrade below structural fill	95
Structural fill under exterior walls	95
Subgrade under asphalt & sidewalks	95
Miscellaneous backfill	90

3.06 MOISTURE CONTROL

- A. The material, while being compacted, shall be within the moisture range of 3% below to 3% above optimum, well distributed throughout the layer.

3.07 DENSITY REQUIREMENTS

- A. Density of undisturbed soils, in-place fill and backfill shall be determined in accordance with the procedures of ASTM D 1556 or ASTM D 2922 and D 3017. If tests indicate that the density of in-place soil is less than required, the material shall be scarified, moistened or dried as necessary to obtain proper moisture content and recompacted as necessary to achieve the proper densities. Sufficient density tests shall be made and reports submitted by the Testing Laboratory indicating all cut and fill areas were compacted and graded in accordance with the requirements.

### 3.08 SLOPE PROTECTION & DRAINAGE

- A. Berming and grading shall be done as may be necessary to prevent surface water from flowing into and out of the construction area. Any water accumulating therein shall be removed by pumping or by other methods.

### 3.09 SOIL EROSION PROTECTION

- A. The Contractor shall ensure that no soil erodes or blows from the site into public right-of-way or onto private property.
- B. The Contractor shall promptly clean up any material which erodes or blows into the public right-of-way or onto private property.

### 3.10 PRESERVATION OF PROPERTY

- A. Provide temporary fences, barricades, coverings, or other protections to preserve existing items indicated to remain and to prevent injury or damage to persons or property. Apply protections to adjacent properties as required.
- B. Restore damaged work to condition existing prior to start of work, unless otherwise directed.

### 3.11 EXISTING UTILITIES

- A. The Contractor shall verify the location of any utility lines, pipelines, or underground utility lines in or near the area of the work in advance of and during Earthwork. The Contractor is fully responsible for any and all damage caused by failure to locate, identify and preserve any and all existing utilities, pipelines and underground utility lines. Repair damaged utilities to the satisfaction of the utility owner at no expense to the Owner.
- B. Should uncharted or incorrectly charted piping or other utilities be encountered during grading, consult the Architect immediately for directions as to procedures.
- C. Cooperate with the Owner and public or private utility companies in keeping service and facilities in operation.

### 3.12 WASTE

- A. Dispose of all waste off Owner's property.
- B. Burning of waste will not be permitted.

### 3.13 AIR POLLUTION

- A. Use water sprinkling, temporary enclosures, and other suitable methods to limit dust and dirt air pollution. Comply with governing regulations pertaining to environmental protection.

SAMPLING AND TESTING SCHEDULE  
FOR EARTHWORK

FIELD QUALITY CONTROL

MATERIAL	TEST FOR	FREQUENCY	REMARKS
NATURAL GROUND	Compaction in accordance with ASTM D 1556 or ASTM D 2922 and D 3017	1 per 500 square yards of surface	Conduct a minimum of 2 tests on each section.
EMBANKMENT AND/OR SUBGRADE	Soil Conditions Moisture-Density in Accordance with ASTM D 1557	Test 1 per soil Classification	
	Compaction control in accordance with ASTM D 1556 or ASTM D 3017	1 per each lift every 300 square yards of surface	1) Immediately after placing 2) Conduct a minimum of 2 tests per section
		1 per each lift for each 100 cubic yards of fill	



END OF SECTION 312000

**SECTION 32 1200  
FLEXIBLE PAVING**

**PART 1 GENERAL**

**1.01 RELATED DOCUMENTS**

- A. All materials shall be as indicated on Drawings and shall comply with applicable NMDOT Standard Specifications, Latest Edition, regarding source, quality, gradation, mix design proportioning, measurement and payment.

**1.02 SUBMITTALS**

- A. Design Mix: Before any asphalt concrete paving is constructed, submit actual design mix to the Engineer for review and/or approval. Design mix submittal shall follow the format as indicated in the NMDOT Standard Specifications, Latest Edition.
- B. Material Certificates: Submit materials certificate to onsite independent testing laboratory, which is signed by material producer and Contractor, certifying that materials comply with, or exceed, the requirements herein.

**1.03 JOB CONDITIONS**

- A. Weather Limitations
  - 1. Apply prime and tack coats when ambient temperature is above 40°, and when temperature has been above 35° for 12 hours immediately prior to application. Do not apply when subgrade is wet or contains excess moisture.
  - 2. Construct asphalt concrete paving when atmospheric temperature is above 40°.

**PART 2 PRODUCTS**

**2.01 MATERIALS**

- A. Provide asphalt-aggregate mixture as recommended by local or state paving authorities to suit project conditions. Use locally available materials and gradations which meet NMDOT Standard Specifications, Latest Edition and exhibit satisfactory record on previous installations.
- B. Mineral Filler: Rock or slag dust, hydraulic cement, or other inert material complying with AASHTO M-17/ASTM D 242, if recommended by applicable New Mexico standards.
- C. Asphalt Cement: Comply with AASHTO M-226/ASTM D 3381; AC-20, AR-80, viscosity grade.
- D. Tack Coat: Emulsified asphalt; AASHTO M-140/ASTM D 997 or M 208/ASTM D 2397, SS-1h, CSS-1, or Cms-1h, diluted with one-part water to one-part emulsified asphalt.
- E. Asphalt-Aggregate Mixture: Per NMDOT Standard Specifications, Latest Edition.

**2.02 EQUIPMENT**

Maintain equipment in satisfactory operating condition and correct breakdowns in a manner that will not delay or be detrimental to progress of paving operations.

**PART 3 EXECUTION**

**3.01 PREPARATION**

- A. Remove loose material from compacted base material surface immediately before applying prime coat.
- B. Proof roll prepared base material surface to check for unstable areas and areas requiring additional compaction.
- C. Do not begin paving work until deficient base material areas have been corrected and are ready to receive paving.

**3.02 APPLICATIONS**

- A. Prime Coat

1. Apply bituminous prime coat to all base material surfaces where asphalt concrete paving will be constructed.
  2. Apply bituminous prime coat in accordance with NMDOT Standard Specifications, Latest Edition.
  3. Apply at minimum rate of 0.1 to 0.3 gallons per square yard over compacted base material. Apply to penetrate and seal, but not flood surface.
  4. Make necessary precautions to protect adjacent areas from over-spray.
  5. Cure and dry as long as necessary to attain penetration and evaporation of volatile components.
- B. Tack Coat
1. Apply tack coat to contact surfaces of previously constructed asphalt concrete base courses or Portland cement concrete and surfaces abutting or projecting into asphalt concrete and surfaces abutting or projecting into asphalt concrete pavement.
  2. Apply tack coat to asphalt concrete base course or sand asphalt base course. Apply emulsified asphalt tack coat between each lift or layer of full depth asphalt concrete and sand asphalt bases and on surface of all such bases where asphalt concrete paving will be constructed.
  3. Apply emulsified asphalt tack coat in accordance with NMDOT Standard Specifications, Latest Edition.
  4. Apply at minimum rate of 0.03 to 0.12 gallon per square yard of surface.
  5. Allow to dry until at proper condition to receive paving.

### 3.03 ASPHALTIC CONCRETE PLACEMENT

- A. Place asphaltic concrete as per NMDOT Standard Specifications, Latest Edition.
- B. Place asphalt concrete mixture on completed compacted subgrade surface, spread, and strike off. Spread mixture at following minimum temperatures:
  1. When ambient temperature is between 40° F and 50° F: 285° F.
  2. When ambient temperature is between 50° F and 60° F: 280° F.
  3. When ambient temperature is higher than 60° F: 275° F.
- C. Place inaccessible and small areas by hand. Place each course to required grade, cross-section, and compacted thickness.
- D. Paving Machine Placement: Apply successive lifts of asphalt concrete in transverse directions with the surface course placed in the direction of surface-water flow. Place in typical strips not less than 10' - 0" wide.
- E. Joints: Make joints between old and new pavements, or between successive days' work, to ensure continuous bond between adjoining work. Construct joints to have same texture, density, and smoothness as other sections of asphalt concrete course. Clean contact surfaces and apply tack coat.
- F. Asphalt Concrete Curbs: Construct asphalt curbs over compacted pavement surfaces only when indicated on Drawings. Apply light tack coat unless pavement surface is still tacky and free from dust. Place curb materials to cross-section indicated by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms as soon as material has cooled.

### 3.04 ROLLING AND COMPACTION

- A. Rolling and Compaction shall be accomplished per NMDOT Standard Specifications, Latest Edition.
- B. The mixture, after being spread, shall be thoroughly compacted by rolling as soon as it will bear the weight of the rollers without undue displacement. The number, weight, and types of rollers



**SECTION 32 1300**  
**CONCRETE PAVEMENT, CURB AND SIDEWALK**

**PART 1 - GENERAL**

**1.01 SUMMARY**

- A. This Section includes all portland concrete pavement outside the building limits, including but not limited to:
  - 1. Driveways and roadways
  - 2. Parking lots
  - 3. Curbs and gutters
  - 4. Sidewalks
- B. For concrete located within the building limits: refer to Section 03 0100 thru 03 2000 – Cast-In-Place Concrete

**1.02 REFERENCE STANDARDS**

- A. American Society of Testing Materials (ASTM)
  - 1. A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
  - 2. A185 - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
  - 3. A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
  - 4. C33 - Standard Specification for Concrete Aggregates
  - 5. C94 - Standard Specification for Ready-Mixed Concrete
  - 6. C150 - Standard Specification for Portland Cement
  - 7. C171 - Standard Specification for Sheet Materials for Curing Concrete
  - 8. C260 - Standard Specification for Air-Entraining Admixtures for Concrete
  - 9. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
  - 10. C494/C494M - Standard Specification for Chemical Admixtures for Concrete
  - 11. C979 - Standard Specification for Pigments for Integrally Colored Concrete
  - 12. C1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete
  - 13. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
  - 14. D1752 - Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
  - 15. D3405 - Standard Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements
  - 16. D5249 - Standard Specification for Backer Material for Use with Cold- and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
  - 17. D5893 - Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

- B. American Concrete Institute (ACI)
  - 1. 301R-99 – Specifications for Structural Concrete
  - 2. 304R – Placing and Handling Concrete, etc.
  - 3. 309R-96 – Guide for Consolidating of Concrete
  - 4. 330.1 – Standard Specifications for Plain Concrete Parking Lots
  - 5. 330R-92 – Guide for Design & Construction of Concrete Parking Lots
  - 6. 211.1R-91 – Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
- C. American Association of State Highway and Transportation Officials (AASHTO)
  - 1. M182 – Standard Specifications for Burlap Cloth made from Jute for Kenaf
  - 2. M153 – Standard Specifications for Preformed Sponge Rubber and Cork Expansion Joint Filler
- D. ADAABAAG Americans with Disabilities Act
  - 1. Architectural Barriers Act Accessibility Guidelines 36 CFT Part 1191

**1.03 SUBMITTALS**

- A. Mix Design: For each concrete mix to be utilized.
- B. Material certificates and test reports.
- C. The General Contractor and the Subcontractor shall execute the Conformance Submittal(s) at the end of this section.

**PART 2 - PRODUCTS**

**2.01 STEEL REINFORCEMENT**

- A. The type of steel reinforcement shall be as shown on the drawings.
  - 1. Plain-Steel Welded Wire Fabric: ASTM A 185, 6inches x 6inches #10 mesh fabricated from steel wire into flat sheets;
  - 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 40, deformed;
  - 3. Plain Steel Wire: ASTM A 82, as drawn; and,
  - 4. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening steel reinforcement. Manufacture bar supports according to CRSI's Manual of Standard Practice.
  - 5. Diamond Dowels: ¼” x 4 ½” Diamond Dowels by PNA

**2.02 CONCRETE MATERIALS**

- A. Portland Cement: ASTM C 150, Type I, II or III.
- B. Aggregate: ASTM C 33. Combined aggregate gradation for concrete pavement and other designated concrete shall be 8% - 18% for large top size aggregates (1½”) or 8% - 22% for smaller top size aggregates (1” or ¾”) retained on each sieve below the top size and above the No. 100 sieve. Concrete pavements shall have a maximum aggregate size of 1½”.
- C. Water/Ready Mix Concrete: ASTM C 94.
- D. Admixtures: Certified by manufacturer to contain not more than 0.1 % water-soluble chloride ions by mass of cement and to be compatible with other admixtures, as follows:
  - 1. Air-Entraining Admixture: ASTM C 260;
  - 2. Water-Reducing Admixture: ASTM C 494, Type A;

3. Water-Reducing and High-Range Admixture: ASTM C 494, Type F;
  4. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E; and,
  5. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.
- E. Fly Ash: The use of fly ash, slag and bottom ash is prohibited.
- F. Calcium Chloride: The use of calcium chloride or admixtures containing more than 0.05% chloride ions is prohibited.
- G. Curing Materials:
1. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry;
  2. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet;
  3. Water: Potable;
  4. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete;
  5. Clear Solvent-Borne Liquid-Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B;
  6. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B;
  7. White Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B.

## **2.03 CONCRETE MIXES AND MIXING**

- A. Concrete Mixes: Prepare design mixes, proportioned according to ACI 211.1R-91 and ACI 304, with the following properties:
1. Compressive Strength (28 Days): 4,000 psi;
  2. Slump Limit: maximum of 5 inches at time of placement for pavement, 2 inch maximum for curb and sidewalk;
  3. Air Content: 5% to 8% for pavement, curb and sidewalk.
- B. Coloring Agent: When required, add coloring agent to mix according to manufacturer's written instructions.
1. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork; and,
  2. Coloring Agent: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.
- C. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94 and ASTM C 1116.
- D. Project-Site Mixing: On-site mixing must be approved by the Owner. Comply with requirements and measure, batch, and mix concrete materials and concrete according to ASTM C 94. Mix concrete materials in appropriate drum-type batch machine mixer.

## **2.04 JOINTS, FILLERS, AND SEALANTS**

- A. See Architectural Site Plan, Site Plan Details, and Specifications for details.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

- A. Surface Preparation: Proof roll prepared subbase, per Section 31.00.00 and the geotechnical report- Earthwork and remove loose material from surface.

- B. Forms: Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations, per Section 02010, Project Survey and Layout.
  - 1. Maintain sufficient quantity of forms to allow continuance of work so that forms remain in place a minimum of 24 hours after concrete placement;
  - 2. Forms shall be cleaned and casted with form release agent thoroughly after each use and before concrete is placed; and,
  - 3. Flexible or curved forms shall be used on curves. Forms shall be of full depth of the concrete and of a strength when staked, sufficient to resist the presence of the concrete and the loads resulting from the finish operations without springing, setting or losing their shape.
- C. Reinforcement: Accurately position and support reinforcement, and secure against displacement. Set wire ties with ends directly into concrete.
  - 1. Install welded wire fabric in lengths as long as practicable; lap at least one full mesh, and lace splices with wire; and,
  - 2. Support reinforcing steel on wire chairs to ensure that wire stays mid-depth of sidewalk section during concrete pour.
- D. Joints: Construct pre-molded expansion and contraction joints, tied construction joints, control joints, thickened edge expansion joints, isolation joints, and construction joints, straight with face perpendicular to concrete surface. Construct transverse joints perpendicular to centerline unless otherwise detailed.
  - 1. Expansion joints and Contraction joints: Pre-molded as indicated on the drawings;
    - a. Provide joint filler for the entire depth of the slab section and not less than 1 inch below finished surface so as to allow for joint sealer.
    - b. Provide thickened edge expansion joint as indicated on the drawings.
    - c. Provide 1/2 inch contraction joints for curb and gutter at 10 feet on center.
    - d. Provide 1/2 inch expansion joints for curb and gutter and sidewalk at 100 feet on center.
  - 2. Tied construction joints: As indicated on drawings;
  - 3. Control joints: Depth shall be equal to 1/4 of the concrete thickness or 1 inch, whichever is deeper. For sidewalks, control joint spacing shall be equal to the sidewalk width. For concrete pavement, control joint spacing shall be placed as shown on the drawings, no greater than 30 times the slab thickness on center either way;
    - a. Form tooled joints in fresh concrete by grooving top portion with recommended tool and finishing edges with jointer.
    - b. Form sawed joints using powered saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut joints into hardened concrete within 24 hours of the concrete placement and as soon as surface will not be torn, abraded, or otherwise damaged by cutting action.
  - 4. Construction Joints: Place construction joints at end of placements and at locations where placement operations are stopped for period of more than 1/2 hour, except where such placements terminate at expansion joints. Provide 1/4" x 4 1/2" Diamond Dowels by PNA at 24" on center or as shown on the drawings;
  - 5. Isolation Joints: Locate isolation joints as indicated on the drawings. Provide premolded joint filler for catch basins, manholes, inlets, structures, walks, light pole bases and other fixed objects;
  - 6. Joint Fillers: Extend joint fillers full-width and depth of joint, and not less than 1/2 inch or more than 1 inch below finished surface where joint sealer is indicated. Furnish joint fillers 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; and,
7. Joint Sealants: All joints shall be sealed with approved exterior pavement joint sealants and shall be installed per manufacturer's recommendations.
- E. Concrete Placement: Comply with recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete. Place concrete in a continuous operation within planned joints or sections.
1. Moisten subbase to provide a uniform dampened condition at time concrete is placed;
  2. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping according to recommendations in ACI 309R;
  3. Screed and initial-float concrete surfaces with darby or bull float before excess moisture or bleed water appears on the surface;
  4. Protect concrete from cold or hot weather during mixing, placing, and curing; and,
  5. All concrete walks and aprons shall be a minimum of 4 inches thick as shown on the drawings, with a turned down edge as detailed.
- F. Evaporation Retarder: Apply to concrete surfaces if hot, dry, or windy conditions exist. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- G. Pavement Tolerances: Comply with tolerances in ACI 330.1, Specification for Plain Concrete Parking Lots.

### **3.02 FINISHES AND CURING**

- A. All exterior concrete shall receive a medium broom finish.
- B. Curing: Begin curing after finishing concrete, but not before free water has disappeared from concrete surface. Cure concrete by one or a combination of the following methods:
1. Moisture cure concrete by water, continuous fog spray, continuously wet absorptive cover, or by moisture-retaining-cover curing. Keep surfaces continuously moist for not less than 7 days; and,
  2. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.
- C. All exterior concrete surfaces shall receive one coat of exterior sealer.

### **3.03 REPAIRS AND PROTECTION**

- A. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.
- B. Protect concrete from damage. Provide adequate traffic control to prevent traffic from pavement for at least 14 days after placement.
- C. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than 2 days before date scheduled for substantial completion inspections.

### **3.04 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

- B. ACI Publications: Comply with ACI 301R-99 and ACI330R-92, unless modified by the requirements of the Contract Documents.
- C. The owner shall provide and pay for testing services. A slump test and air test shall be performed for each load delivered. Four standard test cylinders shall be taken for each 55 cubic yards of concrete or each days pour, whichever is more frequent. Two cylinders shall be broken at 7 days and two cylinders shall be broken at 28 days.

**END OF SECTION**

## SECTION 323113 - CHAIN LINK FENCES AND GATES

### 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. This Section includes the following:
  - 1. Chain-Link Fences: Industrial
- B. Related Sections include the following:
  - 1. Division 03 Section Cast-in-Place Concrete for concrete post concrete fill.

#### 1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide chain-link fences and gates capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
  - 1. Minimum Post Size and Maximum Spacing for Wind Velocity Pressure: Determine based on mesh size and pattern specified, and on the following minimum design wind pressures and according to CLFMI WLG 2445:
    - a. Wind Speed: 90 mph
    - b. Fence Height: 6 feet
    - c. Line Post Group: IA, ASTM F 1043, Schedule 40 steel pipe
    - d. Wind Exposure Category: C
- B. Lightning Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

#### 1.4 SUBMITTALS

- A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates.
  - 1. Fence and gate posts, rails, and fittings.
  - 2. Chain-link fabric, reinforcements, and attachments.
- B. Shop Drawings: Show locations of fences, gates, posts, rails, tension wires, details of extended posts, extension arms, gate swing, or other operation, hardware, and accessories. Indicate

materials, dimensions, sizes, weights, and finishes of components. Include plans, sections, details of post anchorage, attachment, bracing, and other required installation and operational clearances.

- C. Qualification Data: For Installer.

## 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed chain-link fences and gates similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. Pre-installation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

## 1.6 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

### 2.2 CHAIN-LINK FENCE FABRIC

- A. General: Height four (4) feet. Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist. Comply with ASTM A 392, CLFMI CLF 2445, and requirements indicated below:
  - 1. Steel Wire Fabric: Metallic coated wire with a diameter of 0.148 inch
    - a. Mesh Size: 2 inches
    - b. Weight of Metallic (Zinc) Coating: ASTM A 392, Type II, Class 1, 1.2 oz./sq. ft. with zinc coating applied before weaving.
    - c. Weight of Zn-5-Al-MM Aluminum-Mischmetal Alloy Coating: ASTM F 1345, Type III, Class 1, 0.60 oz./sq. ft. 2, 1.0 oz./sq. ft.
    - d. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.

### 2.3 INDUSTRIAL FENCE FRAMING

- A. Posts and Rails: Comply with ASTM F 1043 for framing, ASTM F 1083 for Group IC round pipe, and the following:

1. Group: IA, round steel pipe, Schedule 40
2. Fence Height: 4 feet
3. Strength Requirement: Heavy industrial according to ASTM F 1043.
4. Post Diameter and Thickness: According to ASTM F 1043 ASTM F 1083.
  - a. Top Rail: 1.66 inches
  - b. Line Post: 1.875 by 1.63 inches
  - c. End, Corner and Pull Post: 3.5 by 1.5 inches
  - d. Swing Gate Post: According to ASTM F 900 2.375-inch diameter, 3.11-lb/ft. weight 4-inch diameter, 8.65-lb/ft.
  - e. Horizontal-Slide Gate Post: According to ASTM F 1184.
    - 1) Openings up to 12 Feet: Steel post, 2.875-inch diameter, and 4.64-lb/ft. weight.
    - 2) Openings Wider Than 12 Feet : Steel post, 4-inch diameter, and 8.65-lb/ft. weight.
    - 3) Guide posts for Class 1 horizontal-slide gates equal the gate post height, 1 size smaller, but weight is not less than 3.11 lb/ft.; installed adjacent to gate post to permit gate to slide in space between.
5. Coating for Steel Framing:
  - a. Metallic Coating:
    - 1) Type A, consisting of not less than minimum 2.0-oz./sq. ft. average zinc coating per ASTM A 123/A 123M or 4.0-oz./sq. ft. zinc coating per ASTM A 653/A 653M.

## 2.4 TENSION WIRE

- A. General: Provide horizontal tension wire at the following locations:
  1. Location: Extended along bottom of fence fabric.
  2. Location: Extended along top of barbed wire arms and top of fence fabric for supporting barbed tape.
- B. Metallic-Coated Steel Wire: 0.177-inch- diameter, marcelled tension wire complying with ASTM A 817, ASTM A 824, and the following:
  1. Metallic Coating: Type II, zinc coated (galvanized) by hot-dip process, with the following minimum coating weight:
    - a. Class 1: Not less than 0.8 oz./sq. ft. of uncoated wire surface.
    - b. Matching chain-link fabric coating weight.

## 2.5 INDUSTRIAL SWING GATES

- A. General: Comply with ASTM F 900 for single and double swing gate types.

1. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F 1043 and ASTM F 1083 for materials and protective coatings.
- B. Frames and Bracing: Fabricate members from galvanized steel tubing with outside dimension and weight according to ASTM F 900 and the following:
  1. Gate Fabric Height: 2 inches less than adjacent fence height
  2. Leaf Width:
  3. Frame Members:
    - a. Tubular: 1.90 inches round
- C. Frame Corner Construction:
  1. Welded and 5/16-inch- diameter, adjustable truss rods for panels 5 feet wide or wider.
- D. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame 12 inches as required to attach barbed wire assemblies.

## 2.6 FITTINGS

- A. General: Comply with ASTM F 626.

## 2.7 BARBED WIRE

- A. Zinc-Coated Steel Barbed Wire: Comply with ASTM A 121, Standard Chain-Link Fence grade for the following two-strand barbed wire:
  1. Standard Size and Construction: 0.099-inch- diameter line wire with 0.080-inch diameter, 2-point round barbs spaced not more than 4 inches o.c.

## 2.8 GROUT AND ANCHORING CEMENT

- A. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.

## 2.9 FENCE GROUNDING

- A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
  1. Material above Finished Grade: Copper
  2. Material on or below Finished Grade: Copper.
  3. Bonding Jumpers: Braided copper tape, 1 inch wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

- B. Connectors and Grounding Rods: Comply with UL 467.
  - 1. Connectors for Below-Grade Use: Exothermic welded type.
  - 2. Grounding Rods: Copper-clad steel.
    - a. Size: 5/8 by 96 inches.

2.10 All fencing, gates and backstops for baseball field, softball field, batting gates, soccer field and tennis courts shall be in compliance with details shown on the plans.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance.
  - 1. Do not begin installation before final grading is completed, unless otherwise permitted by Architect.
  - 2. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

#### 3.3 INSTALLATION, GENERAL

- A. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements specified.
  - 1. Install fencing on established boundary lines inside property line.

#### 3.4 CHAIN-LINK FENCE INSTALLATION

- A. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.
  - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
  - 2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

- a. Exposed Concrete: Extend 2 inches above grade; shape and smooth to shed water.
- C. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 30 degrees or more.
- D. Line Posts: Space line posts uniformly at 8 feet o.c.
- E. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Install braces at end and gate posts and at both sides of corner and pull posts.
  - 1. Locate horizontal braces at midheight of fabric 6 feet or higher, on fences with top rail and at 2/3 fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
- F. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c. Install tension wire in locations indicated before stretching fabric.
  - 1. Bottom Tension Wire: Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.
- G. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
- H. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 1 inch between finish grade or surface and bottom selvage, unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
- I. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches o.c.
- J. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at 1 end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
  - 1. Maximum Spacing: Tie fabric to line posts and top rail at 12 inches o.c. and to braces at 24 inches o.c.
- K. 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.
- L. Barbed Wire: Install barbed wire uniformly spaced angled toward security side of fence. Pull wire taut and install securely to extension arms and secure to end post or terminal arms.



- M. Barbed Tape: Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.
- N. Tennis Court Fencing: Construct tennis court fence according to ASTM F 969.

### 3.5 GROUNDING AND BONDING

- A. Fence Grounding: Install at maximum intervals of 1500 feet except as follows:
  - 1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet
    - a. Gates and Other Fence Openings: Ground fence on each side of opening.
      - 1) Bond metal gates to gate posts.
      - 2) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.
- B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.
- C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2, unless otherwise indicated.
- D. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location, including the following:
  - 1. Each Barbed Wire Strand. Make grounding connections to barbed wire with wire-to-wire connectors designed for this purpose.
  - 2. Each Barbed Tape Coil: Make grounding connections to barbed tape with connectors designed for this purpose.
- E. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
- F. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
  - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
  - 2. Make connections with clean, bare metal at points of contact.
  - 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
  - 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
  - 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

- G. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

### 3.6 ADJUSTING

- A. Gate: Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

END OF SECTION 323113

## SECTION 329300 - PLANTS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Work under this section consists of the planting of trees, shrubs, and ground covers, including the furnishing of all labor, equipment, and materials and performing all work in connection therewith in accordance with the Drawings and Specifications.

#### 1.2 PLANT NAMES

- A. The botanic and common names used for the plants called for on the Drawings are generally in conformity with the approved names given in Standardized Plant Names, 1980 Edition, published by The American Joint Committee on Horticultural Nomenclature. The names of varieties not included therein are generally in conformity with the names accepted in the nursery trade.

#### 1.3 PLANT MATERIAL SUBSTITUTIONS

- A. Plant material substitutions shall not be made without the written permission of the Owner's Representative. The use of materials differing in kind, quality or size from that specified shall be allowed only after the Owner's Representative is convinced that all means of obtaining the specified materials have been exhausted. At the time bids are submitted, the Contractor is assumed to have located the materials necessary to complete the job as specified. All requests for substitutions shall be submitted no later than five (5) working days prior to the opening of bids.

#### 1.4 SUBMITTALS

- A. Furnish samples of the following prior to construction:
  - 1. Mulch
  
- B. Furnish supplier literature and chemical analysis of the following prior to construction:
  - 1. Backfill amendment
  - 2. Soil conditioner
  - 3. Filter fabric
  
- C. Furnish delivery tickets the same day materials are delivered to the project site for the following:
  - 1. Backfill amendment
  - 2. Soil conditioner

## PART 2 - MATERIALS

### 2.1 PLANT MATERIALS

- A. A complete plant list, including quantities, sizes and other requirements is shown on the Drawings. In the event that a discrepancy occurs between quantities of plants indicated in the plant schedule and on the planting plan, the plant quantities indicated on the planting plan shall govern.

### 2.2 PLANT MATERIAL QUALITY

- A. Plant material quality, size and condition shall be in accordance with American Standard for Nursery Stock, 1986, as published by the Committee on Horticultural Standards of the American Association of Nurserymen, Inc., the Drawings, and the following requirements:
1. All plants shall be typical of their species or variety. All plants shall have normal, well developed branches and vigorous root systems. They shall be sound, healthy, vigorous, and free from defects, disfiguring knots, abrasions of the bark, sunscale injuries, plant diseases, insect eggs, borers, and all other forms of infections.
  2. Unless otherwise stated on the Drawings or approved by the Owner's Representative, all plants shall be nursery grown and shall be tagged with nursery labels indicating species and variety.
  3. Container grown plant material shall have been grown in its delivery container for not less than six (6) months, but for not more than two (2) years. Any rootbound material will not be accepted.
  4. Multi-stem: All countable stems, in aggregate, shall average the size specified. To be considered a stem, the division of the trunk shall be no more than six inches from ground level.
  5. Balled and burlapped plant material shall have a solid ball of earth of minimum specified size held in place securely by burlap and stout twine or rope. Light poultry binding is acceptable. Stout wire or wire baskets are acceptable only as a temporary means for securing burlap until tree is in place. Broken or loose balls will be rejected.
  6. Unless specifically noted on the Drawings, all trees shall have a single trunk that is straight and free of "dog legs", "crooks", "Y-crotches", or other disfiguring shapes. The central leader of all trees shall not have been pruned. Trees with double leaders are not acceptable.
  7. All plant material shall have a uniform shape around its complete circumference. Plant material with irregular branching patterns or with branching patterns more highly developed on one side than on other sides will not be accepted.
  8. All plant material shall be reviewed by the Owner's Representative at the Contractor's yard or at a wholesale nursery of the Contractor's choice prior to

delivery to the job site. All material shall then be reviewed after planting.

10. The Contractor shall mark each plant intended for use on the project with an identifying tag prior to the Owner's Representative's review of the plants.
11. The Owner's Representative shall be the judge of the quality and acceptability of all plant material. All rejected material shall be immediately removed from the site and replaced with acceptable material at no additional cost to the Owner.

### 2.3 PLANTING SOIL MIXTURE

- A. Planting Soil Mixture shall be a mixture of one part backfill amendment to two parts existing soil.

The backfill amendment shall consist of:

1. 70% by volume, organic compost. Compost shall be a well decomposed, stable, weed free organic matter source. It shall be derived from agricultural, food, or industrial residuals, biosolids, yard trimmings, source separated or mixed solid waste. The product shall contain no substances toxic to plants and shall be reasonably free (<1% by dry weight) of man-made foreign matter. The compost will possess no objectionable odors and shall not resemble the raw material from which it was derived. The product shall meet the standards established through the US Composting Council's Seal of Testing Assurance Program." Compost to be screened to 1/2" minus, pH within a range of 6.0-8.5. Electrical conductivity (EC) of compost not to exceed 10 mmhos/cm. Percentage of organic matter shall be in the range of 30-65%, tested by simple combustion. Compost provider shall be permitted with the NMED.
2. 30% by volume clean, screened, white vitric tuff, graded to 3/16" x 5/16".
2. Components to be homogeneously mixed, in ten cubic yard batches to provide a uniform product, free from weed seeds, sticks, rocks, or other deleterious material.
3. Each delivery shall have a load ticket. The load ticket shall list:
  - Type of Mixture
  - Source of Mixture.
  - Approximate volume of load.
  - Date of delivery or loading.
  - Name of individual representing the source.
  - Ticket shall be collected and provided to the Owner's Representative.

### 2.4 SOIL CONDITIONER

- A. Shall be granulated 90% sulfur.

### 2.5 MULCH

- A. Mulch shall be as specified on the Drawings.

## PART 3 - EXECUTION

### 3.1 PLANTING OPERATIONS

- A. Prior to planting operations, landscape areas shall be cleared of rocks and lumps greater than 1" diameter, vegetation, and debris to a minimum depth of 12" and finish grading shall be complete and accepted by the Owner's Representative. Planting operations shall be performed only during favorable weather conditions in accordance with accepted practice.
- B. In any one day, only those plant materials intended to be planted that day shall be delivered to the project site. Unless otherwise approved by Owner's Representative, all plant materials shall be located where shown on the Drawings except when adjustments due to field conditions are required. The location of all trees and shrubs shall be staked by the Contractor and reviewed by the Owner's Representative prior to installation. Tree locations shall be represented by using 1" x 2" x 12" wood stakes or colored flags. The name of the tree shall be indicated on the stake or flag so it is readily identified. Shrub locations shall be determined by colored flags or by placement of containerized plant material.

### 3.2 PLANTING

- A. Planting and backfilling shall be performed in accordance with accepted nursery practice, the Drawings, and the following requirements:
  1. The Contractor shall take care when backfilling planters to provide adequate compaction of the fill material in order to prevent settling.
  2. Prepare all planting pits and install plants as shown on Drawings. Plants shall be set plumb and straight.
  3. Remove wire basket, wood box, plastic, twine, and/or rope prior to backfill. Remove burlap except from bottom of root ball prior to backfill.
  4. Backfill for planting pits shall consist of the specified planting soil mixture and .10 pounds soil conditioner per cubic foot of backfill. The plant shall be positioned in the hole, and backfilled. The backfilling shall be completed, and material tamped. When pit is nearly filled, water thoroughly and allow water to soak away. If settling of backfill occurs after watering, add more backfill to bring to finish grade.
  5. After completion of planting, trees shall be pruned at the direction of the Owner's Representative.

### 3.3 MULCH

- A. Mulch shall be completed as indicated on the Drawings.

- B. Avoid placing mulch against the trunk or stem of any plant material.

### 3.4 MAINTENANCE AND PROTECTION

- A. Maintenance and protection of trees, shrubs, and ground covers shall begin immediately following the installation of each plant and shall continue until the entire project is accepted. Maintenance shall include watering, weeding, cultivating, removal and replacement of dead plant material, removal of debris, resetting of trees to upright positions, restoration of earth basins, and such other operations as may be necessary for the health of the planted stock and the general appearance of the landscaped areas. Maintenance and protection shall include repair of damage to plants and replacement of severely damaged plants resulting from trespass, erosion (including erosion from application of irrigation water), weather, vandalism, disease or other condition or action.

### 3.5 WARRANTY

- A. All plant materials shall be guaranteed to be in a live, healthy, and normal growing condition from the date of final project acceptance through one twelve month period. The Contractor shall not be held responsible for replacement of plants and materials lost through vandalism and/or other destruction after final project acceptance.
- B. The Contractor shall monitor the condition of the landscape at regular intervals during the warranty period to verify that the landscape is receiving proper maintenance. Frequency of monitoring visits shall be as required to ensure proper maintenance. If at any time during the warranty period the Contractor should encounter at the site conditions unfavorable to the health of the planted stock, he shall notify the Owner and Owner's Representative of such in writing. Inadequate or improper maintenance by the Owner during the warranty period will not relieve the Contractor of his warranty obligation, unless such improper maintenance continues beyond the date the Contractor has notified the Owner and Owner's Representative.
- C. Plant materials that are dead or in an unhealthy, impaired growth condition during the warranty period shall be removed and replaced by the Contractor as directed by the Owner's Representative at no additional cost to the Owner. Replacement material shall be of equal quality, size, and species as that which is being replaced and shall be approved by the Owner's Representative prior to planting. Plants replaced during the first six months of the warranty period shall be under warranty until the end of the warranty period. Plants replaced after the first six months of the warranty period shall be under warranty for six months after the replanting date.

### 3.6 REVIEWS

- A. The following observations shall be the minimum required observations during the course of construction. Additional observations shall be made at any time at the discretion of the Owner's Representative. It shall be the responsibility of the Contractor to notify the Owner's Representative, in writing, 48 hours in advance of each required observation. The sequence of required observations shall not be changed from the sequence listed below. The Contractor shall not proceed with work of the next sequence without written

approval of the work of the previous sequence.

1. Review plant material at Contractor's yard or wholesale nursery prior to delivery to job site.
2. Review staked locations of plant material prior to planting.
3. Review of planting operations.
4. Review at final project completion.
5. Review 11 months after final project acceptance.

END OF SECTION



## SECTION 329220 – REVEGETATION SEEDING

### PART 1 - GENERAL

#### 1.1 DESCRIPTION OF WORK

- A. Work under this section consists of preparing all areas indicated on the Drawings for revegetation seeding and furnishing and installing seed as specified herein.

#### 1.2 SUBMITTALS

- A. Furnish supplier literature of the following prior to construction:
  - 1. Seed
  - 2. Wood cellulose mulch
- B. Furnish the following the same day materials are delivered to the project site:
  - 1. Delivery tickets indicating species and quantity of seed delivered

### PART 2 - PRODUCTS

#### 2.1 SEED

- A. Seed shall be as specified on the drawings.
- B. Each bag of seed shall be sealed and labeled by the seed dealer in accordance with Federal Seed Laws and New Mexico Department of Agriculture Labeling Laws. This includes: species and variety of seed, lot number, purity, germination, percent crop, percent inert, percent weed (including noxious weeds), origin, test date and net weight. Per Federal Seed Laws, analysis shall be no older than 9 months for seed shipped intra-state.

#### 2.2 WOOD CELLULOSE MULCH

- A. Wood cellulose mulch shall consist of a specially prepared virgin wood fiber processed to contain no growth-inhibiting or germination-inhibiting factors. Mulch shall be manufactured and processed so that wood cellulose fibers remain in uniform suspension in water under agitation and will blend with grass seed, tackifier, and other additives to form a homogenous slurry.

Provide processed mulch materials with the following characteristics:

- 1. Can form a blotter-like ground cover on applications
- 2. Has moisture and percolation properties; and
- 3. Can cover and hold grass seed in contact with soil

#### 2.3 TACKIFIER

- A. Tackifier shall be a safe, nontoxic, plant material or polymer based product that is specifically designed for use in hydroseeding, and with wood cellulose mulch.

## PART 3 - SEED BED PREPARATION

### 3.1 PREPARATION

- A. Prior to start of soil preparation finish grade shall be established and approved as meeting the requirements of the Drawings.
- B. Rip seed bed in two directions and plow with a 'plow disc' to a minimum of six (6) inches. Remove all stones larger than 2" diameter. Remove all trash, debris, vegetation, dirt clods or other material that would interfere with seeding operations.
- C. Tillage shall be performed across the slope when practical. No work shall be done when the moisture content of the soil is unfavorable or the ground is otherwise in non-tillable condition.
- D. The extent of seed bed preparation shall not exceed the area on which the entire seeding operation can be applied to such prepared seed bed prior to any surfaces crusting or loss of seed due to erosion. If erosion or crusting occurs, the entire area affected shall be reworked beginning with seed bed preparation.
- E. Prior to seeding, the finish grade shall be brought to a firm, even surface, free from stones, lumps, debris, vegetation and dirt clods, and shaped to provide drainage in accordance with the Drawings. The finish grade shall be inspected and approved by the Owner's Representative prior to seeding.

## PART 4 - SEEDING

- 4.1 The seed mix and rate shall be as specified on the Drawings. The prescribed mix shall be uniformly applied over the area to be seeded at the rate indicated on the Drawings.
- 4.2 Contractor's vehicles and other equipment shall not travel over the seeded areas. If, as determined by the Owner's Representative, rain or some other factor occurs over prepared surfaces prior to seeding which prevents seeding to the proper depth, the Contractor shall again prepare the seed bed at no additional cost to the Owner.

### 4.3 TIME OF SEEDING

Native grass revegetation seeding shall be accomplished from April 15 through August 30. If seeding is not accomplished during the "time of seeding" the Contractor shall accomplish the seeding at the "time of seeding" during the next calendar year. Extension of the Contract to meet the "time of seeding" shall be accomplished at no additional expense to the Owner.

### 4.4 SEEDING OPERATIONS

- A. Native seed shall be sown by hydroseeding. Seed shall not be sown during windy weather.
  - 1. Hydraulic mulching equipment shall include a pump capable of being operated at 1000 GPM and 100 PSI pressure. The equipment shall have a pressure gauge

and a nozzle adaptable to hydraulic seeding requirements. Storage tanks shall have a means of estimating the volume used to volume remaining in the tank.

2. Wood cellulose fiber for hydraulic seeding shall not contain any substance or factor which might inhibit germination or growth of seed. It shall be dyed an appropriate color to allow metering of its application. The wood cellulose fiber shall have the property of becoming evenly dispersed and suspended when agitated in water. When sprayed uniformly on the surface of the soil, the fiber shall form a blotter-like ground cover which readily absorbs water, and allows infiltration to the underlying soil. Weight specifications from suppliers, and for all applications shall refer only to air dry weight of the fiber, a standard equivalent to 10% moisture. The mulch material shall be supplied in packages having a gross weight not in excess of 100 pounds, and shall be marked by the manufacturer to show the air dry weight content. Suppliers shall certify that laboratory and field testing of their product has been accomplished and that it meets all of the foregoing requirements pertaining to wood cellulose fiber mulch.
3. Wood cellulose fiber mulch shall be added with the proportionate quantities of water and other approved materials in the slurry tank. All ingredients shall be mixed to form a homogeneous slurry. Using the color of the mulch as a metering agent, the operator shall spray-apply the slurry mixture uniformly over the designated seeded area. Unless otherwise ordered for specific areas, wood cellulose fiber mulch shall be applied at the rate of 1,400 pounds per acre.
4. Hydraulic seeding shall not be done in the presence of free surface water resulting from rains, melting snow or other causes or during windy weather.

#### 4.5 OBSERVATION

- A. The following observations shall be the minimum required observations of revegetation seeding during the course of construction. Additional observations shall be made at any time at the discretion of the Owner's Representative. It shall be the responsibility of the Contractor to notify the Owner's Representative, in writing, 48 hours in advance of each required observation. The sequence of required observations shall not be changed from the sequence listed below. The Contractor shall not proceed with work of the next sequence without written approval of the work of the previous sequence.
  1. Finish grade shall be observed.
  2. Seeding operations shall be observed.
  3. Seeded area shall be observed after completion.
  4. Seeded area shall be observed at the final walk-through.

END OF SECTION

## SECTION 328400 - LANDSCAPE IRRIGATION SYSTEM

### PART 1 - GENERAL

#### 1.1 DESCRIPTION OF WORK

- A. The work consists of installing a complete underground irrigation system as shown on the Drawings and as specified hereafter. The Contractor shall furnish all labor, equipment, materials and permits necessary for the completion of the system, unless otherwise specified to be furnished by others. Unless otherwise specified or indicated on the Drawings, the construction of the irrigation system shall include the furnishing, installing and testing of all components pertinent to the system. The Contractor shall perform all trenching, excavating, boring, backfilling, compacting, concrete work, electrical work, welding, and any other work necessary for the completion of the irrigation system.

#### 1.2 SITE INVESTIGATION

- A. The Contractor shall examine related work and surfaces before starting the work of this section. The Contractor shall report to the Owner's Representative, in writing, conditions which will prevent the proper execution of irrigation installation. Deviations from Drawings and Specifications shall be executed only with the express permission of the Owner's Representative and at no cost to the Owner. If inadequacies or inappropriate design are found on the Drawings, they shall be promptly brought to the attention of the Owner's Representative in writing before proceeding with installation of the system.

#### 1.3 CODES, RULES AND SAFETY ORDERS

- A. All work and materials shall be in full accordance with the latest local rules and regulations of safety.

#### 1.4 PROTECTION

- A. The Contractor shall furnish and maintain all warning signs, shoring, barricades, red lanterns, and other protection devices, as required by the Safety Orders of the Division of Industrial Safety and local ordinances.

#### 1.5 DEVIATIONS OF LAYOUT

- A. Reasonable changes in the location of piping, valves or other irrigation components shown on the Drawings will be considered prior to installation. Deviations from specified locations must be approved by the Owner's Representative prior to installation. Any changes in location of irrigation components shall be effected at no cost to the Owner.

#### 1.6 COORDINATION

- A. The Contractor shall coordinate and cooperate with other contractors on site to ensure rapid and efficient completion of all contracted work.

## 1.7 SUBMITTALS

- A. The Contractor shall prepare submittals providing manufacturer's specifications and product information on the following components:

Manual and automatic valves	Heads and emitters	Enclosures
Backflow preventer	Valve boxes	Drains
24 Volt wire	Wire splicing materials	Controller
Piping and tubing	PVC fittings	Filters
Joint materials	Detectable line marking tape	Grounding wire
PVC primer and cement	Threaded joint sealant or tape	Grounding rods
Quick couplers	Swing joints	

- B. Each set of submittals shall be bound or provided electronically in PDF format, and shall be clearly labeled with the project name and date.
- C. The Contractor shall not proceed with the irrigation system work until receiving approval of the irrigation submittals from the Owner's Representative.

## 1.8 AS-BUILTS

- A. The Contractor shall provide and keep up to date a complete set of "As-Builts" which shall be corrected daily to show all changes in the location of heads, controllers, backflow preventers, valves, drains, meters, points of connection, pull boxes and wire splice boxes, pipe and wire routing and other changes that may have been made from the original Drawings and Specifications. All gate valves, manual drains, wire splice and automatic and manual valve locations shall be shown with actual measurements to reference points so they may be easily located in the field.
- B. At the time of final acceptance, the Contractor shall furnish one electronic copy (on CD) and one paper copy of "As-Builts" prepared by a qualified draftsman in AutoCAD format, showing the entire completed system as actually installed. This is the responsibility of the Contractor and shall not be construed to be the responsibility of any other party. This drawing shall be accurate and to scale. The symbols for valves, heads, and piping and other components shall be the same as originally shown on the Drawings. The legend shall be modified to designate any "record" changes. This "As-Built" shall be drawn on a project base sheet provided by the Owner's Representative. The final drawings shall be dated and clearly labeled "AS-BUILT".

## 1.9 CONTROLLER CHART

- A. The Contractor shall provide two controller charts for each controller. Chart shall show the area covered by each automatic valve station on the controller with a different color used to show the area of coverage for each valve. Chart shall be a reduced drawing of the actual "As-Built" system. The size of the chart shall be the maximum size that the controller door will allow. If controller sequence is not legible when the drawing is reduced, drawing shall be enlarged to a size that is readable.

- B. When completed and approved, chart shall be laminated with minimum 20 mils thick sheets. Chart shall be completed and approved prior to final observation and acceptance of the irrigation system. Contractor shall install one chart in each controller enclosure and shall provide one chart for each controller to the Owner's Representative.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

- A. All materials shall be new and without flaws or defects of any type and shall be the best of their class and kind. All materials shall have a minimum warranty of one year against material defects or defective workmanship.
- B. All material shall be the brands and types noted on the Drawings or as specified herein, or approved equal (refer to Section 6.7 of the New Mexico Standard Specifications for Public Works Construction, 1979 Edition).
- C. The irrigation system was designed around equipment manufactured by specific companies as a standard. Approved equal equipment by other manufacturers may be used only with the approval of the Owner's Representative. Request for approval of non-specified materials shall be submitted to the Owner's Representative a minimum of seven (7) days prior to the opening of bids. Submission of irrigation sprinkler heads for approval as equal shall only be considered if submitted heads match the precipitation rate, gallons per minute and spacing of specified sprinkler heads.
- D. Irrigation components designated for use with recycled water shall be marked in accordance with the Uniform Plumbing Code.

### 2.3 PLASTIC PIPE AND FITTINGS

- A. Plastic Pipe: Piping with a diameter of two inches (2") or less shall be Schedule 40 PVC and shall conform to ASTM D 1785. Piping with a diameter of two and one-half inches (2-1/2") or greater shall be Class 200 "O" ring gasket pipe, SDR 21 and shall conform to ASTM D 2241. All PVC pipe shall be continuously marked with identification of the manufacturer, type, class, and size, and shall be free of holes, foreign material, blisters, wrinkles, dents or sunburn.
- B. PVC Fittings: Fittings on PVC lines shall be Schedule 40 PVC, Type 1, Cell Classification 12454 and shall comply with ASTM D 2466.
- C. Threaded Nipples: All threaded PVC nipples shall be Schedule 80 molded PVC pipe. All galvanized nipples shall be Schedule 40 galvanized steel pipe.

### 2.4 VALVES AND VALVE BOXES

- A. Valves: Valves for use in electrically controlled automatic control systems shall be diaphragm actuated and hydraulically operated solenoid valves as specified on the Drawings.

- B. Isolation valves shall be as specified on the Drawings.
- C. Valve Boxes: Valve boxes shall be as noted on the Drawings. Valve box colors shall be as follows:
  1. Green: Turf areas (potable water)
  2. Tan: Gravel mulch areas (potable water)
  3. Purple: Reclaimed water

## 2.5 HEADS AND EMITTERS

- A. Heads and emitters shall be as specified on the Drawings.

## 2.6 CONTROLLER

- A. Controller shall be as specified on the Drawings.

## 2.7 BACKFLOW PREVENTER AND HEATED ENCLOSURE

- A. The backflow prevention device and heated enclosure shall be as specified on the Drawings.

## 2.8 PRIMER, CEMENT AND THREADED JOINT SEALANT

- A. Primer shall conform to ASTM F 656 and meet NSF. Cement shall be low VOC, NSF approved, and meet ASTM D 2564. Cement and primer shall be IPS Weld-On depending on size and schedule of pipe and fittings as follows:

Schedule 40 PVC Pipe and Fittings up to 6" Dia.: P-68 Primer and 705 Cement

Schedule 80 PVC Pipe and Fittings up to 4" Dia.: P-70 Primer and 705 Cement

Schedule 80 PVC Pipe and Fittings larger than 4" Dia.: P-70 Primer and 711 Cement

- B. All threaded connections between metal to metal, PVC to metal, and PVC to PVC shall be made using Spears Blue 75 thread sealant or Polytetrafluoroethylene (PTFE) thread seal tape. PTFE thread seal tape shall comply with MIL-T-27730A Specifications shall have a minimum thickness of 3.5 mils and shall be 99% pure PTFE. Thread sealing compound shall not be used on threaded connections between sprinkler and nipple or bubbler and nipple. Thread sealant or PTFE tape shall be used in accordance with manufacturer's installation instructions.
- C. All "O" ring gasket and pipe spigot ends shall be lubricated using the lubricant recommended or supplied by the pipe manufacturer. If the pipe manufacturer does not provide a lubricant for the pipe, use IPS Weld-on EZ Flush pipe lubricant, NSF approved.

## 2.9 WIRE

- A. Wire for the 120 volt wiring shall be solid copper (or stranded copper in larger wire

sizes), underground feeder for direct burial and PVC insulated. Size of wire shall be #12 AWG.

- B. Wire for the 24 volt wiring shall be solid copper wire, PVC insulated, UL approved underground feeder wire for direct burial in ground. Common wires shall be #12, white, except as noted on Drawings. The control wires shall be #14 of any color other than white unless otherwise indicated on Drawings. The wire shall be supplied in either 500' or 2,500' rolls.
- C. Wire Splicing Materials: All wire splices shall be made water-tight using 3M DBR/Y direct bury splice kit or approved equal.
- D. Grounding wire, ground rods and wire clamps for controllers shall be as specified by the controller manufacturer.
- E. Control wires shall be marked with the associated valve number with E-Z Coder WDR or equal wire marking tape at each valve, at the controller and at wire splices.

## 2.10 DETECTABLE LINE MARKING TAPE

- A. Detectable line marking tape for irrigation main and lateral lines shall be manufactured by T.A. Christy Enterprises or approved equal and shall consist of a minimum 5.0 mil (0.0050") overall thickness; five-ply composition; ultra high molecular weight; 100% virgin polyethylene; acid, alkaline, and corrosion resistant.
- B. The tape width shall be a minimum of 6".
- C. Elongation properties shall be in accordance with ASTM D882-80A and shall be less than 150% at break.
- D. Tensile strength shall be in accordance with ASTM D882-80A and shall be not less than 7800 PSI.
- E. The tape shall have a minimum 20 gauge (0.0020") solid aluminum foil core, adhered to a 2.55 mil (0.00255") polyethylene backing.
- F. Tape color and legend combination shall be in accordance with APWA requirements. For irrigation lines with potable water supply, the color shall be blue and the legend shall read "CAUTION: IRRIGATION LINE BURIED BELOW". For irrigation lines with non-potable water supply, the color shall be purple and the legend shall read "CAUTION: RECYCLED/RECLAIMED WATER LINE BURIED BELOW".

## 2.11 OTHER MISCELLANEOUS FITTINGS AND MATERIALS

- A. All other miscellaneous fittings and materials shall be as specified on the Drawings.

## PART 3 - EXECUTION

### 3.1 GENERAL



- A. This section includes installation specifications for all items installed as a part of the irrigation system. Certain construction procedures or minor equipment installation procedures that are necessary for the proper installation of the system may have been omitted from these specifications. In any case, Contractor shall install all materials and equipment in a neat and workmanlike manner according to manufacturer's recommendations and specifications, local and state codes, as shown on the Drawings and as specified herein.

### 3.2 PRODUCT HANDLING

- A. The Contractor shall be responsible for correct procedures in loading, unloading, staking, transporting and handling all materials to be used in the system. The Contractor shall avoid rough handling which could affect the useful life of equipment. Pipe shall be handled in accordance with the manufacturer's recommendations on loading, unloading and storage.

### 3.3 POINT OF CONNECTION

- A. Existing water main line locations shown on the Drawings are schematic. It shall be the Contractor's responsibility to pot hole and field check to determine actual locations as an incidental requisite to the construction contract.
- B. The proposed controller location indicated on the Drawings is approximate. Actual location of the controller shall be determined by Owner's Representative in the field.
- C. Where connections to existing pipe or stub out is required, the Contractor shall make necessary adjustments should pipe or stub out not be located exactly as shown, at no additional cost to the Owner.

### 3.4 STATIC PRESSURE TEST

- A. The design pressure of the irrigation system is shown on the Drawings. Prior to start of construction of the irrigation system, the Contractor shall, in the presence of the Owner's Representative, provide a gauged test of available static pressure at the point of connection. In the event that the actual static pressure is significantly different (plus or minus 10 psi) than the design static pressure, the Contractor shall not proceed with the work until receiving written direction from the Owner's Representative.

### 3.5 EXCAVATION AND TRENCHING

- A. The Contractor shall stake the location of each run of pipe and all sprinkler heads and valves prior to trenching. Each run of the system shall be approved by the Owner's Representative prior to installation.
- B. Excavation and trenching for pipe lines shall be a true and straight line with the trench banks as nearly vertical as practical. The width of the trenches shall not be greater than necessary to permit proper joining, tamping, backfilling, bedding or any other installation procedures that may be necessary. Trench widths shall be wide enough to

provide a minimum horizontal and vertical separation of 4" between pipes in the same trench.

- C. In areas where trees are present, trench lines shall be adjusted on the site to eliminate any damage to tree roots.
- D. Trench depths shall be sufficient to provide the specified pipe cover as described elsewhere in these Specifications or as noted on the Drawings. In rocky areas the trench depth and width shall be increased as needed to provide for a minimum of 6" of pipe bedding at bottom and sides of pipe.
- E. Depth of Bury: Minimum cover over mainline and lateral piping shall be as noted on the Drawings.

### 3.6 PIPE AND FITTINGS INSTALLATION

- A. Installation of plastic pipe and fittings shall be in accordance with ASTM D 2774, the manufacturer's recommendations and the procedures described in these Specifications.
- B. Caution shall be exercised by the Contractor in handling, loading, unloading, and storing of PVC pipe and fittings. All PVC pipe shall be stored and transported in a vehicle with a bed long enough to allow the pipe to lie flat without subjecting it to undue bending or concentrated external load at any point. Pipe shall be protected from damage by exposure to sunlight. Any section of pipe that has been dented or damaged or in any other way found to be defective, either before or after laying shall be replaced with sound pipe at no cost to the Owner.
- C. Before installation, the inside of the pipe shall be cleaned of all dirt and foreign matter and shall be kept in a clean condition during and after laying of pipe. When work is not in progress, open ends of pipe and fittings shall be secured closed so that no trench water, earth or other foreign substances will enter the pipe or fittings. Where pipe ends are left for future expansion or connections, they shall be valved and capped as directed on the Drawings.
- D. All PVC pipe and fittings shall be assembled to permit the pipe or fittings to be jointed at the true parallel position of the fittings. Placement of pipe which cause excessive bending and stress on pipe and fittings will not be permitted. No excess piping or fittings shall be permitted in the installation of the system, as this may increase pressure loss or potential for blockage.
- E. Before installing the pipe, all rocks over 1 inch diameter, rubbish and debris shall be removed from the trenches. If the adjacent soil is rocky, the trenches shall be bedded and filled with clean dirt or sand to provide a minimum of 6" clearance between the pipe and the native soil. Material used for pipe bedding and trench filling shall be approved by the Owner's Representative. The full length of each section of the pipe shall rest solidly upon the pipe bed, with recesses excavated to accommodate bells, joints and couplings.
- F. Pipe shall not be laid in water or when trench or weather conditions are unsuitable for

the work. Any water which may be encountered or may accumulate in the trenches or excavation shall be pumped out or otherwise removed as necessary to keep the bottom of the trench or excavation free and clear of water during the progress of the work. Pipe shall not be laid when the temperature is 32 degrees F or below.

- G. PVC pipe will expand or contract at the rate of +/- 3/8" per 100' per 10 degrees F change of temperature. Therefore, the pipe shall be installed in a manner to provide for expansion and contraction as recommended by the manufacturer.
- H. The minimum horizontal and vertical clearance between lines in the same trench shall be 4".
- I. After all piping, risers, valves, thrust blocks, etc., have been installed and partially backfilled as specified in other parts of these Specifications, the control valve shall be opened and a full head of water used to flush out the system. Caution shall be observed to provide for release of any entrapped air in the system. After the system is thoroughly flushed, risers shall be capped and the system pressure tested in accordance with the testing section of these Specifications. At the conclusion of the pressure test, the heads shall be installed and the backfill operation completed.

### 3.7 SOLVENT WELDING PROCEDURE

- A. All solvent weld joints shall be made in accordance with the solvent manufacturer's recommendations and ASTM D 2855.
- B. PVC plastic pipe shall be squarely cut utilizing a miter box mounted hacksaw or PVC specialty saw with a blade of 18 or 24 teeth per inch.
- C. Interior and exterior burrs shall be removed and the exterior shall be beveled to produce a 10-15 degree bevel.
- D. Thoroughly clean the mating pipe end and the fitting socket with a clean, dry cloth.
- E. Using a properly sized applicator (approximately 1/2 the diameter of the pipe), apply a light coating of primer to the inside of the fitting socket, then apply a thin coat to the outside of the pipe end. Apply a second, light coat of primer to the inside of the fitting socket taking care to avoid puddling of primer in fitting.
- F. Apply a uniform coat of cement to the outside of the pipe end with a properly sized applicator (approximately 1/2 the diameter of the pipe).
- G. In like manner, apply a thin coating of cement to the inside of the fitting socket.
- H. Re-apply a light coat of cement to the outside of the pipe end and quickly insert it into the fitting to the full depth of the fitting socket, while rotating the pipe or fitting approximately 1/4 turn to ensure even distribution of cement.
- I. Hold in position for approximately 30 seconds.

- J. Wipe off any excess solvent cement that forms as a bead around the outer shoulder.
- K. Contractor shall not use an excessive amount of solvent cement that could cause burrs or obstructions to form on the inside of the pipe joint.
- L. Solvent weld joints shall be allowed to cure for minimum 24 hours before pressure is applied to the system.

### 3.8 BACKFILLING

- A. Upon completion of a particular section of the irrigation system, and after sufficient time has elapsed for the curing of solvent weld joints, partial backfilling shall begin, leaving all joints, risers and connections exposed for visual inspection during the hydrostatic testing. Only upon successful completion of the hydrostatic test shall the backfill operation be completed for any one particular section.
- B. All backfill material shall be subject to approval by the Owner's Representative. Backfill material shall be free from rock, large stones, brush, sod, frozen material or other unsuitable substances that may damage pipe or compromise compaction during the backfilling operations.
- C. In the event that the material from the excavation or trenching is found to be unsuitable for use in backfill by the Owner's Representative, it shall be removed from the site and properly disposed of by the Contractor at his own expense. The Contractor shall then, at no cost to the Owner, arrange for, purchase, and furnish suitable backfill material consisting of earth, loam, sandy clay, sand or other approved materials free of large clods of earth or sharp stones and capable of attaining the same relative density of the surrounding ground.
- D. In rocky areas, the trench depth shall be 6" below the normal trench depth to allow for 6" of suitable backfill as padding for the pipe. In like manner, there shall be minimum 6" of suitable backfill on all sides of the pipe as padding against rock in the wall of the trench.
- E. All mainline and lateral piping shall have detectable line marking tape installed in the trench six (6") inches above the pipe. After pipe is placed in trench and the first 6" layer of backfill is placed and compacted, the detectable marking tape shall be placed continuously in all trenches prior to completion of backfill operations.
- F. Backfill shall be placed in horizontal layers not exceeding 6" in depth and shall be thoroughly tamped, or water compacted to near original density or so that no settling will result. Backfill shall be placed to the original ground level. If settlement of trenches occurs within one (1) year from date of completion, it shall be the Contractor's responsibility to refill trenches and re-seed, re-sod or re-install landscape mulch in the repaired areas.

### 3.9 SADDLE TAPS

- A. No saddle taps shall be permitted unless approved by the Owner's Representative.

### 3.10 THRUST BLOCKS

- A. Concrete thrust blocks shall be provided where necessary to resist system pressure, including at all direction changes, size changes, valves and terminations or at any other points of the system that will result in an unbalanced thrust line for equipment 2-1/2" and larger and as indicated on the Drawings. Thrust blocks shall not obstruct the outlets of fittings which are intended for future connections. Thrust blocks shall be poured against undisturbed earth and in accordance with the Drawings.

### 3.11 SLEEVED CROSSING

- A. Unless otherwise noted on the Drawings, all piping installed under sidewalks, roadways, parking lots, etc., shall be sleeved in a Class 200 PVC pipe two (2) sizes larger than the pipe to be sleeved. Wire shall be placed in a separate sleeve from that of the pipe crossing and shall be Class 200 PVC minimum 2" size, or larger as required to accommodate the quantity of wire to be sleeved. Ends of sleeves shall be sealed with duct tape after installation of wire or piping.

### 3.12 HEAD INSTALLATION (ROTORS AND POP UPS)

- A. Heads shall be of the type and make specified and shall be installed as shown on the Drawings. Heads shall be installed with a 4" space between the edge of the head and curbs, walks, walls, driveways, building walls, etc. Heads shall be installed in the vertical position and backfilled and compacted to 80% modified Proctor.
- B. Head spacing shall not exceed the spacing shown on the Drawings and shall be in the location and configuration as shown on the Drawings. Contractor shall verify turf area dimension while staking head location. Heads shall be spaced to achieve uniform coverage.
- C. After all piping and risers are in place and connected and before installation of the heads, all control valves for a given section shall be fully opened and a full head of water shall be used to flush out the system. If water pressure without the heads installed is not sufficient to provide adequate water flow from end risers, the Contractor shall cap off enough heads closest to the water source to provide adequate flushing of the end riser assemblies.

### 3.13 CONTROLLER INSTALLATION

- A. The controller location is indicated on the Drawings. The Contractor shall familiarize himself with the requirements of making the power connections at the locations noted (120 volt supply to the controller) and shall include in his price for the-irrigation system, the cost to complete this portion of the work.
- B. The controller shall be mounted and wired according to the manufacturer's recommended procedures and as specified herein and on the Drawings.
- C. Unless otherwise indicated in the Drawings, the Contractor shall direct-wire the 120 volt power supply to the controller.

- D. Remote control valves shall be connected to controller in the numerical sequences as shown on the Drawings or as directed by the Owner's Representative.
- E. Controllers shall be grounded as specified by the manufacturer and as indicated on the Drawings.

### 3.14 AUTOMATIC CONTROL VALVE INSTALLATION

- A. Automatic control valves shall be of the type and size indicated on the Drawings. Installation shall be according to these Specifications, the Drawings and the manufacturer's recommendations.
- B. The valve boxes shall be of the size and type as shown on the Drawings.
- C. Valve wire splices shall be waterproofed using 3M DBR/Y direct bury splice kit or approved equal. The Contractor shall provide a 36" wire expansion coil to facilitate raising splices to ground level without cutting wires.

### 3.15 24 VOLT CONTROL VALVE WIRING

- A. Wire installation procedures shall conform to local codes.
- B. The Contractor shall install the 24 volt control valve wiring in the same trench as the irrigation mainline. All wires shall be laid below the pipe. In no case shall the wire be laid on top of the pipe. The wires shall be laid loose in the trench and taped together at 10'-0" intervals. When trenches used for piping are not appropriate for routing wire, Contractor shall install wire in a separate trench at 18" bury depth.
- C. Wire splices, other than at valve box locations, shall be kept to a minimum and if needed shall be made only at common splice points and placed in a wire splice box, Applied Engineering 9" round valve box with flush cover or equal. Wire splices shall be waterproofed using 3M DBR/Y direct bury splice kit or approved equal.
- D. At control wire splices, the Contractor shall provide a 36" wire expansion coil to facilitate raising splices to ground level without cutting wires.
- E. Continual wire shall be one color and in no case shall wires of different colors be spliced together.
- F. All 24 volt wiring shall be installed in PVC conduit when inside a building. All 24 volt wiring installed on exterior building walls shall be installed in metal conduit.

### 3.16 120 VOLT CONTROLLER POWER WIRING

- A. The Contractor shall familiarize himself with the work required to complete this portion of the installation. All 120 volt wiring shall be installed in accordance with local electrical codes. The 120 volt service shall consist of one (1) black and one (1) white wire. The neutral wire shall be bonded.

- B. The 120 volt power shall be supplied to the controller location and the backflow preventer location by a licensed electrician.

### 3.17 TESTING

- A. Upon completion of the irrigation system's mainline, the entire mainline shall be tested with the Owner's Representative present, for a one hour period at 100 psi, unless otherwise noted. Prior to testing, the mainline shall be partially backfilled, leaving all joints and connections exposed for visual inspection. All dirt shall be flushed from the system and the line filled with water to remove air. The mainline shall be brought to static pressure. A pressure gauge and temporary valve shall be installed at the end of the mainline to permit air pressure to be applied to the main. A pressure of 100 psi shall be retained for a one hour period. Any leaks occurring during the one hour pressure test shall be repaired and the system retested until the system passes the test.
- B. Upon completion of the lateral piping sections, each lateral system shall be pressure tested, with the Owner's Representative present for one hour at 100 psi. On systems using flex nipples or swing joints, the lateral system shall be tested prior to installation of the flex nipples or swing joints. Prior to testing, the lateral lines shall be partially backfilled leaving all joints and connections exposed for visual inspection. All air and dirt shall be flushed from the system and all open fittings shall be capped. The testing procedure shall be the same as used for the main line. Any leaks occurring during the hydrostatic test shall be repaired and the system retested until the system passes the test. If after one hour 100 psi pressure has been retained, the heads shall be installed, and the backfill operation completed.
- C. The Contractor shall be responsible for payment of construction observations for retesting of any lines or system components that fail initial pressure or performance test. Costs shall include the time of the observer at the observer's standard rate, travel time and travel expenses.

### 3.18 ADJUSTING OF SYSTEM

- A. After completion of testing and installation, the Contractor shall adjust all valves for the proper operating pressure and adjust all heads for uniform coverage and even flow. Contractor shall wire the controller to have station numbers correspond with valve numbers indicated on the Drawings or as directed by the Owner's Representative. The valve number shall be indicated on the controller panel for each station. Contractor shall program the controller to provide optimum system performance.

### 3.20 CLEAN UP

- A. The Contractor shall continuously keep a neat and orderly area in which he is installing the system. Disposal of rubbish and waste material resulting from the installation shall be continual. Upon completion of the system, the Contractor shall remove from the Owner's property at his own expense, all temporary structures, rubbish, waste material, tools and equipment resulting from or used in the installation of the system.

### 3.21 PROTECTION OF EXISTING UTILITIES

- A. The Contractor shall be responsible for locating all existing cables, conduits, piping, and any other utilities or structures that may be encountered either above or below ground. All necessary precautions shall be taken by the Contractor to prevent any damage to the existing utilities and improvements. In the event that such damage should occur from his operations, the Contractor shall repair or replace damaged utilities to their original condition at no expense to the Owner.

### 3.22 ROCK

- A. If the Contractor encounters rock or other unfavorable trenching conditions, no additional compensation will be paid. When material from the excavation or trenching is unsuitable for use as backfill, additional backfill material suitable for this purpose shall be brought in at the expense of the Contractor. It shall be the Contractor's responsibility to remove and dispose of all unsuitable materials removed from the trench that cannot be used in the backfill operation.

### 3.23 FINAL ACCEPTANCE

- A. When the Contractor is satisfied that the system is operating properly, that it is balanced and adjusted and that all work and clean-up is completed, he shall issue a notice of completion to the Owner's Representative requesting a final observation. The Owner's Representative will respond to the notice of completion and shall appear with the Owner for an observation of the project. At that time the Contractor shall demonstrate the operation of each system in its entirety. In reviewing the work, no allowance for deviation from the original Drawings and Specifications will be made unless prior approval has been obtained.
- B. Any inconsistency to the Specifications or the Drawings will be noted by the Owner's Representative and a written copy of required corrections shall be given to the Contractor. The Contractor shall complete all corrections in a timely manner and then shall issue a request to the Owner's Representative for an inspection of corrected work. Final acceptance will not occur until correction of all items work is complete.

### 3.24 OPERATIONAL INSTRUCTION

- A. After the system has been tested and accepted, the Contractor shall instruct the Owner's Representative on the operation and maintenance of the system.
- B. The Contractor shall provide the Owner with two (2) keys for each of the following:
  - 1. manual isolation valves
  - 2. manual drain valves
  - 3. valve boxes
  - 4. controller enclosure
  - 5. backflow preventer enclosure
  - 6. quick couplers
  - 7. any locking assembly in need of key access



- C. The Contractor shall provide the Owner with two copies of a Maintenance Manual bound in a three ring binder. The maintenance manual shall include copies of the approved submittals, operation manuals and manufacturer's warranties on all irrigation products.

### 3.25 SYSTEM MAINTENANCE AND GUARANTEE

- A. Maintenance of the irrigation system shall begin immediately following the installation of the system and shall continue until the entire project is accepted. Maintenance shall include repair of defects or damages, adjustments and fine tuning of the system, and repairs of damages resulting from vandalism, erosion, weather, and the like.
- B. For a period of one (1) year from final acceptance of the entire project, the Contractor shall promptly furnish and install, without cost to Owner, any and all parts or materials which prove defective in material or workmanship. Damage to the landscape or other property due to irrigation system line breaks shall be repaired and brought to original condition by the Contractor at no expense to the Owner.
- C. In the fall, at the Owner's request, the Contractor shall drain the system, and otherwise prepare the system for winter. In the spring, at the Owner's request, the Contractor shall reactivate the system, repair any defects or damage and adjust the system. As these services are performed, the Contractor shall instruct the Owner.
- D. For a period of one (1) year from final acceptance of the system, the Contractor shall repair any settlement of trenches by one of the following methods as directed by the Owner's Representative.
  - 1. Turf areas:
    - a. Bring to grade by top-dressing (raking topsoil into the grass).
    - b. Bring to grade with planting soil mixture and install seed mix to match existing turf.
  - 3. Sod areas or tree/shrub planting areas: Remove existing sod or mulch. Fill depression with planting soil mixture, and replace with new sod or mulch to match existing.Repair by any of the above methods shall result in a smooth, level area.

### 3.26 OBSERVATIONS

- A. The following observations shall be the minimum required observations during the course of construction. Additional observations shall be made at any time at the discretion of the Owner's Representative. It shall be the responsibility of the Contractor to notify the Owner's Representative, in writing, 48 hours in advance of each required observation. The sequence of required observations shall not be changed from the sequence listed below. The Contractor shall not proceed with work of the next sequence without written approval of the work of the previous sequence. The Contractor shall attach a copy of the written observation approvals to all applications for payment.
  - 1. Observe staked locations of mainline, valves, laterals and heads.

2. Observe installation and pressure test of mainline.
3. Observe 24 volt control wire installation and ensure that existing controller operates all valve zones properly.
4. Observe installation and pressure test of automatic valves and lateral lines prior to installation of flex nipples, swing joints, and heads.
5. Observe head placement, coverage and operating pressure prior to planting.
6. Observe at final project review.
7. Observe 11 months after final project acceptance.

END OF SECTION

**SECTION 33 1000**  
**WATER UTILITIES**

**PART 1 - GENERAL**

**1.01 DESCRIPTION OF WORK**

- A. Pipes, materials and appurtenances for potable water systems.
- B. Installation.

**1.02 REFERENCES**

- A. NMAPWA Construction Standards and Specifications.
- B. AWWA:
  - 1. C110: Gray iron and ductile iron fittings 3" through 48" for water and other liquids.
  - 2. C600: Installation of Ductile-Iron Water Mains and Their Appurtenances.
  - 3. C605: Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.
  - 4. C700: Cold water meters - displacement type.
  - 5. C900: Polyvinyl chloride (PVC) pressure pipe 4" through 12" for water.
  - 6. C905: Polyvinyl chloride (PVC) pressure pipe 14" through 36" for water.
- C. ASTM:
  - 1. A370: Mechanical Testing of steel products.
  - 2. A536: Ductile iron castings.
  - 3. D1330: Rubber sheet gaskets.
  - 4. D1598: Test for time-of-failure of plastic pipe under long-term hydrostatic pressure.
  - 5. D1599: Test for short-term rupture strength of plastic pipe, tubing and fittings.
  - 6. D1784: Polyvinyl chloride (PVC) compound and chlorinated polyvinyl chloride (PVC) compounds, rigid.
  - 7. D1785: Polyvinyl chloride (PVC) plastic pipe, Schedules 40, 80 and 120.
  - 8. D1869: Rubber rings for asbestos cement pipe.
  - 9. D2239: Polyethylene plastic pipe.
  - 10. D2241: Polyvinyl chloride (PVC) plastic pipe (SDR-DO).
  - 11. D3139: Joints for plastic pressure pipes using flexible elastomeric seals.
  - 12. E8: Tension testing for metallic materials.

**1.03 SUBMITTALS**

- A. Submittals per Section 01 33 00.
- B. Product Requirement: Section 01 60 00.
- C. Manufacturer's installation recommendations.

**1.04 GENERAL REQUIREMENTS**

- A. Pipes, fittings and materials to be new, of highest quality and shall be in first class condition when installed.
- B. Pipe, fittings and appurtenances of the same type and made by the same manufacturer.
- C. Provide labor, equipment and materials for pipe field testing.

- D. Contact and coordination with utility's owner is the full responsibility of the Contractor.

**1.05 HANDLING AND STORAGE OF PIPE AND APPURTENANCES**

- A. Pipe, valves, hydrants, and other appurtenances shall, unless otherwise directed, be unloaded, hauled and laid as follows:
  - 1. Pipe and appurtenances shall be lifted by hoists with broad well-padded contact surfaces, or rolled on skidways in such a manner to avoid shock.
  - 2. Under no circumstances shall pipe or appurtenances be dropped.
  - 3. Pipe must not be rolled or skidded against pipe already on the ground.
- B. The Contractor shall be responsible for the safe storage of material furnished by or to him and accepted by him, and intended for the work, until it has been incorporated in the completed project.
- C. Installation:
  - 1. In distributing material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench.
  - 2. Pipe shall be handled in a manner that only a minimum amount of damage to the pipe exterior will result. Damaged piping shall be repaired in a manner satisfactory to the Engineer or replaced.
  - 3. The interior of all pipe, fittings, and other appurtenances shall be kept free from dirt and foreign matter at all times.

**1.06 QUALITY ASSURANCE**

- A. Ductile Iron:
  - 1. Tests:
    - a **ASTM E8: Tension Testing of Metallic Materials.**
    - b **ASTM E23: Impact Test.**
  - 2. Marking: cast on each pipe length:
    - a **Weight, class, nominal thickness and casting period.**
    - b **Manufacturer's name, year of production and the letters "DI" or the words "Ductile Iron."**
- B. PVC Pipe and Fittings:
  - 1. Tests: ASTM D3034
  - 2. Marking: indelible, in each pipe:
    - a **Diameter and cell classification.**
    - b **Manufacturer's name, ASTM, SDR or Schedule and date of production.**
    - c **Service designation.**
    - d **NSF approved.**
  - 3. Rubber rings: marked with the manufacturer's identification, size, year of production and classes of pipe in which they are to be used.
- C. Valves:
  - 1. Valves shall be built and equipped for the type of operation shown on the Plans or as directed by the Engineer.
  - 2. All valves shall be of standard makes approved by the Engineer and shall have the name, monogram, or initials of the manufacturer cast thereon.

3. Dielectric gaskets or unions will be used when dissimilar metals are connected to each other

## PART 2 PRODUCTS

### 2.01 MATERIALS AND FABRICATION

#### A. Ductile Iron:

1. Pipe:
  - a. **ANSI A21.51 (AWWA C151).**
  - b. **ASTM A536, Grade 60-42-10.**
  - c. **Ductile iron pipe shall meet ANSI/AWWA A21.51/C151 specifications:**
2. Fittings:
  - a. **Ductile iron, ANSI A21.10 (AWWA C111).**
  - b. **ASTM A536, Grade 80-60-03 or 70-50-05.**
  - c. **Hydrostatic test: Rated at minimum 150psi.**
3. Threaded connections: ANSI B2.1 NPT.
4. Joints:
  - a. **Mechanical: 350 psi working pressure.**
  - b. **Flange: DI; ANSI A21.14 or B16.1, 125 lb.**
  - c. **Gaskets: ASTM D1330, Grade I.**
  - d. **Push-on gaskets: neoprene or other synthetic rubber, D412 and D395. Natural rubber not acceptable.**
  - e. **Lubricant: Heavy vegetable soap solution suitable for potable water use.**
5. Flanged adapters:
  - a. **Body: ASTM Class 30 cast iron.**
  - b. **Flanges: DI ANSI A21.15.**
  - c. **Bolts: Steel with heavy hex nuts, ASTM A576.**
  - d. **Gaskets: Fastite neoprene.**

#### B. Polyvinyl Chloride (PVC):

1. Pipe and fittings:
  - a. **AWWA C900:**
    - (1) All Sizes: SDR14 or as scheduled.
    - (2) Pressure Class: 200 psi or as scheduled.
2. Joints:
  - a. **Gasket bell end: ASTM D3139 for plastic pressure pipes using elastomeric seals.**
  - b. **Gaskets: ASTM F477, elastomeric.**
  - c. **Solvent-Cement: Manufacturer's standard; use only where specifically scheduled, shown on Drawings or approved by Engineer.**

#### C. Service Lines:

1. High Density Polyethylene up to 2": ASTM D2737, SDR-9, copper pipe size
  - a. **ASTM D2239, SDR-9, iron pipe size; or:**

**b. ASTM D2737, SDR-7, copper pipe size.**

2. Copper, Type K: ASTM B8
3. Minimum pressure rating: 150 psi.
4. Joints:

**a. Compression fittings.**

**b. Compatible with heavy duty copper service fittings.**

**2.02 APPURTENANCES**

**A. Fire Hydrants:**

1. Latest revision of AWWA C-502.
2. Mueller A423 Super Centurion 250 or Engineer-approved equivalent.
3. 1-1/2" Pentagon bronze operating nut equipped with elastomer weather seal between the top casting and the operating nut.
4. Sealed oil reservoir will inmate a system of ford lubrication of the thrust collar area each time the hydrant is operated.
5. Two 2.5" and one 4.5" nozzles with National Standard fire hose threads mechanically connected into the barrel, O-ring sealed with National Standard nozzle caps.
6. Steel safety stem coupling with stainless steel fasteners and two-piece breakaway safety flange.
7. Centerline of hose nozzle will be a minimum of 18" above ground line.
8. 5-1/4" diameter main valve opening.
9. Upper valve plate shall be all bronze.
10. All internal surfaces of the shoe, the lower valve plate and cap nut shall be coated with a factory-applied, two-part, thermosetting epoxy coating with a minimum thickness of 4 mils.
11. The bronze valve seat shall be threaded into a bronze drain ring or shoe bushing; the drain channel shall be all bronze.
12. The hydrant shall have two drain outlets above the lower flange of the hydrant shoe assembly.
13. Minimum 200 psi working pressure, and be certified as such by the manufacturer.
14. Lower barrel to shoe connection will have a minimum of six bolts made of stainless steel.
15. All hydrants furnished will have a standard 10-year warranty certified by the manufacturer.
16. Painted chrome yellow.
17. One Manufacturer's hydrant wrench supplied with each hydrant installed.

**B. Resilient Wedge Gate Valves:**

1. Size as shown on Drawings.
2. Mueller, Clow, Waterous, American Darling, Resilient Wedge Gate Valves or Engineer approved equivalent.
3. Valves shall conform to AWWA C-509 and comply with its latest revisions.
4. The wedge shall be cast iron, fully encapsulated in molded rubber including the guides. The bronze stem nut must be rigidly enclosed in the wedge to maintain alignment.

5. The stem shall have two O-rings above and one O-ring below the collar. Stem seats must be replaceable with the valve under pressure.
  6. The stem material shall be stainless steel (AISI420) or Engineer-approved equivalent.
  7. The waterway shall be full size to allow for tapping use; no cavities or depressions are permitted in the seat area.
  8. Valve body and bonnet shall be electrostatically applied, fusion bonded and epoxy coated, both inside and out, by the valve manufacturer. The coating shall meet the requirements of AWWA C-550. Coating to be applied only at the valve manufacturer's facilities.
  9. The bonnet bolts shall not be exposed to the environment or, alternatively, be in 316 stainless steel.
  10. O-ring style seals shall be used as gaskets on the bonnet and on the stuffing box.
  11. All valves must be tested by hydrostatic pressure equal to the requirements in the AWWA C-509 specifications prior to shipment from the manufacturer.
  12. 2-inch AWWA operating nut for valves in below-ground service; handwheel for above-ground service.
  13. Mechanical joint ends for pipe or as shown on drawings.
- C. Swing Check Valves:
1. 3" and smaller: bronze, swing disc, screwed ends.
  2. 4" and larger: iron body, bronze trim, swing disc, renewable disc and seat, outside weight and lever for exposed service, flanged ends.
- D. Air Pressure and Vacuum Relief Valves:
1. Cast iron body, cover and baffle; stainless steel trim and float.
  2. Sized for up to 800 gpm; 0 - 250 psi.
  3. Seat: Buna-N.
  4. 3" and smaller: NPT threaded outlet.
  5. 4" and larger: Plain outlet with steel protector hood.
  6. Val-Matic, Crispin or Engineer-approved equivalent.
- E. Backflow Preventer:
1. Body: Bronze ASTM B-61 and working parts.
  2. Springs: Stainless steel.
  3. Valve discs: Neoprene.
  4. Diaphragm: Neoprene-coated cotton duck.
  5. Minimum working pressure: 250 psi.
  6. Hydrostatic test pressure: 350 psi.
  7. Breco Model 6 (Hersey-Sparling) or Engineer-approved equivalent.
- F. Valve Boxes:
1. Cast iron, adjustable extension, traffic type.
  2. Minimum thickness of metal at any point: 3/16".
  3. Removable cast iron cover.

4. For valves on washwater and irrigation system only: Class 200 PVC pipe.
  5. All valve boxes for plug valves shall be designed for integral installation of the required valve position indicator.
  6. Cast iron boxes: Factory painted inside and out with manufacturer's recommended asphalt paint.
  7. Cover marked "Water".
- G. Tapping Sleeves:
1. Minimum working pressure 250 psi.
  2. Mechanical joint type.
  3. Sizes as shown on Drawings.
  4. Mueller Type H-615 with two end gasket sets that allow to fit all classes of cast iron pipe or Engineer-approved equivalent.
- H. Tapping Crosses:
1. Minimum working pressure 250 psi.
  2. Mechanical joint type.
  3. Sizes as shown on Drawings.
  4. Mueller Type H-715 with two end gaskets sets that allow to fit all classes of cast-in pipe or Engineer-approved equivalent.
- I. Tapping Valves:
1. Minimum working pressure 250 psi.
  2. Size as shown on the Drawings.
  3. Mueller Type H-667 mechanical joint on outlet side and flange end on opposite side; attach to tapping drilling machine, or Engineer-approved equivalent.
  4. AWWA C500.
- J. Inserting Valves:
1. Sizes as shown on Drawings.
  2. Minimum working pressure 250 psi.
  3. Comply with Part 2.02C.
  4. Mueller Type H-800 for cast iron pipe or Engineer-approved equivalent.
  5. Gauges:
  6. All gauges shall be 3" in diameter.
  7. Each gauge shall be installed with block and bleed valves, and with a snubber and dielectric coupling.
- K. Tracer Wire:
1. Conductor shall be solid or stranded copper per ASTM B-1, B-3, or B-8.
  2. Insulation of conductor shall be yellow, high molecular weight polyethylene (HMWPE).
  3. The temperature rating of the tracer wire shall be 75 degrees Celsius, dry and wet. The voltage rating shall be 600 Volts.
  4. Tracer wire shall be installed on all gas/propane and water lines.
- L. Sentry Posts:



1. Metal posts.
2. Water pipeline warning sign.
3. Color: blue.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

##### **A. General:**

1. Trenching, Backfilling and Compacting: Section 31.00.00
2. Pipe Cutting:
  - a. Pipe cutting measurement taken at site.
  - b. Cutting of pipe or inserting valves, fittings, or closure pieces shall be done in a neat and workman like manner without damage to the pipe.
3. Direction of Bells:
  - a. Unless otherwise directed, pipe shall be laid with bell ends facing the direction in which work is progressing.
  - b. Pipe laid on an appreciable slope shall be laid with bell ends facing uphill.
4. Pipe Plugs: At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Engineer.
5. Pipe Cleanliness:
  - a. Clean all pipe, fittings and appurtenances before use.
  - b. Foreign materials or objects shall be prevented from entering the pipe while it is placed in the trench.
6. Temporarily support, adequately protect and maintain all underground and surface utility structures, drains, sewers, and other obstructions encountered in the progress of work.

##### **B. Pipe Alignment and Grade**

1. All pipe shall be laid and maintained to the required lines and grades; with fittings, valves, and hydrants at the required locations, with joints centered and spigots home; and with all valve and hydrant stems plumb.
2. Deviations:
  - a. Wherever existing utility structures or branch connections leading to main sewers or to main drains, or other conduits, ducts, pipes or structures present obstructions to the grade and alignment of the pipe, they shall be permanently supported, removed, relocated, or reconstructed by the Contractor through cooperation with the owner of the utility, structure or obstruction involved.
  - b. No deviation shall be made from the required line or grade except with the written consent of the Engineer.
  - c. The Contractor shall make all necessary explorations to determine the location of existing pipes, valves, or other underground structures. The Owner and Engineer shall furnish all available information; however, such information cannot be guaranteed as accurate.
3. Depth of Bury:
  - a. **Depth of bury shall be as shown in the Plans.**
  - b. **Minimum depth of bury of 3'-6" as measured from the established road grade or the surface of the permanent improvement to the top of the barrels of the**

**pipe. When crossing the arroyo and/or drainage swales, depth of bury shall be 4'-0".**

- C. Pipe Laying:
  - 1. Proper implements, tools, and facilities shall be provided and used for the safe and convenient performance of the work.
  - 2. All pipe fittings, valves and hydrants shall be lowered carefully into the trench by means of a derrick, ropes, or other suitable tools or equipment, in such a manner as to prevent damage to water main materials and protective coatings and linings.
  - 3. Under no circumstances shall water main materials be dropped into trench.
  - 4. Trench shall be dewatered prior to installation of pipe.
- D. Jointing and Assembling:
  - 1. Joints shall be installed in accordance with manufacturer's written Installation and Operation Manual and approved submittals.
  - 2. Lubricants: Vegetable soap solution suitable for use on potable water systems.
  - 3. precaution must be taken to prevent entrance of soil and other contaminants.
  - 4. Use mechanical or push-on for exterior locations.
  - 5. All lumps, blisters, burrs or excess coating shall be removed from the socket and plain ends of each pipe, and the outside of the plain end and the inside of the bell shall be wiped leaned and dry and be free from dirt, sand, grit, or any other foreign materials.
- E. Clean all lines by repeated flushings after installation.
- F. Disinfection: Refer to NMAPWA Construction Standards and Specifications.
- G. Pipe Sleeves:
  - 1. For all pipes passing through concrete or masonry.
  - 2. Install where practical before concrete is placed.
  - 3. Sleeve seal: watertight, modular sealing element when sleeve is placed in slabs with one side against soil.
- H. Buried pipe anchorage:
  - 1. Anchors, joint harness or other acceptable means of preventing pipe movement whether indicated or not required for:
    - a. **Unlugged bell and spigot or all unflanged tees.**
    - b. **Y branches.**
    - c. **Bends deflecting 22 ½ degrees or more.**
    - d. **Plugs and caps.**
    - e. **Fittings in fills or unstable ground.**
    - f. **Above grade or exposed structure.**
  - 2. Restrained joints shall be installed within the vicinity of the arroyo and/or drainage swales.
- I. Valves: Installed as shown on Drawings with valve boxes and joint restraint.
- J. Fire hydrants: As indicated on Drawings with concrete blocking.

### 3.02 FIELD QUALITY CONTROL

- A. All pipes and fittings tested in the presence of and to the satisfaction of the Engineer. AWWA C600 and C605 should be followed for proper pipe installation procedures and hydrostatic testing methods.
- B. Test Conditions (PVC):
  - 1. Medium: Water.
  - 2. Perform test at 150 psi for one hour per 1,000 linear foot of pipe or 2 hours minimum
- C. Testing Equipment:
  - 1. Pressure gauge used to perform pressure test shall be a digital type gauge with the ability to display testing pressure to one hundredth (1/100) of a psi. The pressure gauge shall be rated for at least the required testing pressure.
  - 2. All equipment for use in supplying water for the testing procedure shall be for potable water use only. A suitable amount of chlorine should be added to the storage device in order to disinfect such device. Prior notice will be given to engineer of method used for supplying water for testing.
  - 3. When existing water mains are used to supply test water, they should be protected from backflow contamination by temporarily installing a double check-valve assembly between the test and supply main, or by other means approved by the Engineer.
  - 4. All testing equipment are subject to and shall be disinfected per NMAPWA Construction Standards and Specifications, prior to any test. All equipment must pass a bacteriological test prior to being placed in service.
- D. Procedure (PVC):
  - 1. Disconnect fixtures, equipment and accessories that may be damaged by test pressure.
  - 2. Plug ends as required.
  - 3. Water shall be applied by means of a pump connected to the pipe in a satisfactory manner.
  - 4. All air shall be expelled from the pipe prior to pressure testing.
  - 5. No installation will be accepted unless the leakage is less than the number of gallons per hour as determined by the formula in New Mexico Standard specifications for Public Works Construction Section 801:
  - 6. Leakage shall be defined as the quantity of water that must be supplied into the pipe section being tested to maintain a pressure within 5 psi of the specified leakage-test pressure after the pipe has been filled with water and the air in the pipeline has been expelled.
  - 7. All joints showing visible leaks shall be properly repaired. Any cracked or defective pipes, fittings, valves, or hydrants discovered in consequence of this pressure test shall be removed and replaced by the Contractor with sound material, and the test repeated.
  - 8. Retest repaired joints, pipes and fittings until system is tight and test results are satisfactory to the Engineer.
  - 9. Pipe testing and preparation for use should strictly follow AWWA C605 Section. 7: Preparation for use.
  - 10. Ductile Iron pipe hydrostatic pipe testing shall be done in accordance with section C600: Installation of Ductile-Iron Water Mains and Their Appurtenances. Previously described procedures for hydrostatic testing is for Polyvinyl Chloride (PVC) pipe only.

### **3.03 PIPE SCHEDULE**

- A. PVC Pipe:
  - 1. Pipe sizes 4" or less, ASTM 2241, PVC 1120, SDR-21 pressure class 200 psi.
  - 2. Pipe sizes 4" through 12", AWWA C900, SDR 14, pressure class 200 Or Engineer acceptable alternate:
- B. Ductile Iron Pipe: Pipe sizes 3" through 12", pressure class 350 psi.
- C. End connections to be push-on joints unless otherwise indicated on the Drawings.
- D. Repair and/or replacement of existing water lines damaged during construction: Material generally to match existing or at least quality required by this section.
- E. Provide sizes as shown on the Drawings.

### **3.04 VALVE SCHEDULE**

- A. Resilient wedge gate valves: as shown on the Drawings.
- B. Provide sizes as shown on the Drawings and as provided for in the Bid Schedule.

**END OF SECTION**

**SECTION 33 3000**  
**SANITARY SEWER UTILITIES**

**PART 1 - GENERAL**

**1.01 DESCRIPTION OF WORK**

- A. All sanitary sewer work and materials in this Section shall be performed in accordance with the Contract Drawings and the NMAPWA Construction Standards and Specifications, Latest Edition, including all updates, and all applicable laws, codes, and regulations.
- B. Generally include but not be limited to furnishing all necessary material, labor, and equipment to construct the following:
  - 1. Installation of the building sanitary sewer lateral(s)
  - 2. Installation of precast concrete septic tank and distribution box
- C. Trench excavation, backfill, and compaction shall be performed in accordance with Section 31.00.00 of these specifications.
- D. All pipe shall be installed in an uphill direction where possible beginning at the lowest elevation. In the event that the Contractor wishes to deviate from this, sufficient elevation checks shall be made of the eventual downstream terminus points and approval shall be obtained from the Engineer prior to beginning work.

**1.02 SUBMITTALS**

- A. The Contractor shall submit manufacturer specifications, catalogue cut sheets, and/or material samples to the Engineer for approval prior to construction. This shall generally include but not be limited to the following:
  - 1. Polyvinyl chloride pipe
  - 2. Precast concrete manholes, tanks and boxes
  - 3. Access Manway frames and grates

**PART 2 - PRODUCTS**

**2.01 PIPE**

- A. Sanitary sewer pipe shall be made of polyvinylchloride (PVC) and sized as shown on the Contract Drawings. The pipe shall be rated SDR 35 and conform to the requirements of ASTM D-3034. Joints shall be push-on rubber gaskets according to ASTM D-3212.

**2.02 FRAMES AND COVERS**

- A. Castings for frames and covers shall be made of grey iron conforming to the sizes and types shown on the Contract Drawings.
- B. Castings for catch basins shall meet requirements for AASHTO M105, Grade 30 and be free of cracks, casting faults, or other composition defects. Castings shall be furnished with burrs ground off at foundry.
- C. Frames and grates for sanitary manholes shall be bedded on mortar to prevent movement or "rocking".
- D. Covers shall be stamped "SEWER" on the top to indicate manhole type.

**2.03 PRECAST CONCRETE STRUCTURES**

- A. Sanitary manholes, septic tanks and boxes shall conform to the sizes and types shown on the Contract Drawings.

- B. Sanitary manholes, septic tanks and boxes shall be precast steel reinforced concrete with monolithic base fabricated in conformance with ASTM C478. The reinforced steel shall conform to the latest ASTM A185 Standards.
- C. Rubber gasket seals shall be provided between each precast concrete riser to ensure a watertight seal.
- D. Rubber boots or mechanical seals such as LINK SEAL as manufactured Thunderline Corp., Belleville, MI, or approved equal, shall be provided at all cutouts for pipe inverts to provide a positive watertight seal.

## **2.04 PIPE BEDDING AND TRENCH BACKFILL MATERIALS**

- A. Bedding Material is specified in Section 31 00 00 of these specifications.
- B. Backfill Material: Backfill material shall be placed above the pipe bedding to subgrade elevations. This material shall be on-site soil, free of organics, wood, metals, cobbles greater than 6 inches, and deleterious materials, and shall be subject to the approval of the Engineer.

## **PART 3 - EXECUTION**

### **3.01 TRENCH EXCAVATION**

- A. Trenching operations shall be performed in accordance with Section 31 00 00 of these specifications.

### **3.02 PIPE INSTALLATION**

- A. Pipe shall be installed with the bedding details given on the Contract Drawings and as specified in accordance with Section 31 00 00 of these specifications.
- B. The pipe shall be delivered, stored, handled, lifted, and laid in the prepared excavation in accordance with the manufacturer's recommendations. The elevations of the pipe shall not vary more than 1/2 inch from the elevations indicated on the Contract Drawings.
- C. Inlet structures shall be constructed as shown on the Contract Drawings. The elevations of the inverts and tops of the structures shall not vary more than 1/2 inch from the proposed grades.
- D. Pipes entering and exiting the sanitary manhole shall be neatly cut flush with the inside of the manhole. Irregularities and rough edges inside the manhole shall be pointed with non-shrink grout.
- E. Channels across the floor of the sanitary manholes shall be shaped to provide for smooth flow between pipe inverts. Concrete and mortar shall be used to obtain a channel having a smooth, fine textured surface.
- F. Frames shall be embedded in mortar and bear uniformly on the structure such that there is no movement or "rocking".

### **3.03 BEDDING AND TRENCH BACKFILL PLACEMENT AND COMPACTION**

- A. Trench, backfill and compaction shall be performed in accordance with Section 31 00 00 of these specifications.

### **3.04 SURVEYING**

- A. The Contractor shall provide adequate survey controls to construct the utility to the lines and grades shown on the Contract Drawings. Elevations of pipe inverts and structures shall not vary more than 1/2 inch from specified elevations. Deviations from the plans will be permitted only with the approval of the Engineer.
- B. An "As-Built" record shall be kept during construction showing the actual locations and grades. A copy of the as-built plan shall be submitted to the Engineer and Owner at the completion of the work.

**3.05 CLEANING INSPECTION AND TESTING**

- A. The Contractor shall cooperate with the Engineer as required to facilitate testing and inspection of the work. The Contractor shall clean and "lamp" the lines under the inspection of the Engineer before final acceptance of the work by the Owner.
- B. The Contractor shall provide necessary materials, equipment, and labor to perform the tests as described herein.
- C. The sanitary sewer lateral shall be tested for exfiltration.
- D. Exfiltration
  - 1. The Contractor shall provide a leakage test using the "Low Pressure Air Test" method. Prior to the acceptance test, the Contractor shall have cleaned the pipeline. The Contractor shall furnish test plugs, air compressor, and personnel for conducting the test. Pipe shall be plugged between two manhole locations. Air shall be slowly supplied to the plugged pipe installation until the pressure reaches 5.0 psi. A minimum time of two minutes shall be allowed for temperature stabilization.
  - 2. The air supply will then be cut off. The rate of air loss shall then be determined by measuring the time interval for the pressure to drop from 4.5 to 3.5 psi. Test gages shall be graduated to the nearest 0.10 psi.
  - 3. The pipeline shall be considered acceptable when the time interval for the pressure drop from 4.5 psi to 3.5 psi exceeds the corresponding allowable times given in the following table:

<b>MINIMUM ALLOWABLE PIPE DIAMETER (inches)</b>	<b>TIME INTERVAL (minutes: Seconds)</b>
6	2:15
8	4:00
10	4:45
12	5:40
15	7:05
18	8:30

- E. The Contractor shall maintain the pipe and structures in clean working condition until final acceptance by the Owner.

**END OF SECTION**

**SECTION 33 4000**  
**STORM DRAINAGE UTILITIES**

**PART 1 GENERAL**

**1.01 WORK INCLUDED:**

- A. Work of this Section shall consist of the construction of storm sewer systems in substantial compliance with the specifications and the lines and grades shown on the plans.

**1.02 RELATED SECTIONS:**

- A. Earthwork: SECTION 31 00 00
- B. Flexible Paving : SECTION 32 12 00

**1.03 QUALITY ASSURANCE:**

- A. All work and materials shall be in full accordance with the New Mexico Standard Specifications for Public Works Construction, Latest Edition, including all updates, and all applicable laws, codes, and regulations.

**PART 2 PRODUCTS**

**2.01 STORM DRAINAGE SYSTEM:**

- A. Reinforced Concrete Pipe: Comply with requirements of ASTM C 76, Class III, unless otherwise indicated on Drawings, and install with rubber gasketed joints complying with ASTM C 443. Install rubber gaskets in strict accordance with pipe manufacturer's recommendations.
- B. Polyvinyl Chloride (PVC) Pipe: Only permitted when pipe diameter is 12" and smaller and must meet requirements of ASTM D 1784. Pipe and fittings shall comply with ASTM D 3034, rated SDR 35. Pipe shall be continually marked with manufacturer's name, pipe size, cell classification, SDR rating, and ASTM D 3034 classification. Pipe joints shall be integrally molded bell ends in accordance with ASTM D 3034, Table 2, with factory supplied elastomeric gaskets and lubricant meeting ASTM F477.
- C. High Density Polyethylene Pipe (HDPE):
  - 1. Acceptable manufacturer: Hancor or ADS. Use of HDPE requires a pre-construction meeting with manufacturers representative to ensure proper installation practices are understood and used by contractor. Contractor shall notify engineer, in writing, the date and time of the completion of this meeting.
  - 2. Pipe must be smooth interior, with a manning's n value not greater than 0.013.
  - 3. HDPE shall use bell & spigot, with water-tight type joints.
  - 4. HDPE shall conform with the following specifications:
    - a. ASTM F 405 - Standard Specifications for Corrugated Polyethylene Pipe and Fittings
    - b. ASTM F 667, Standard Specifications for Large Diameter Corrugated Polyethylene Pipe Fittings.
    - c. ASTM D 1248.
    - d. ASTM D 2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.
    - e. ASTM D 3212, Standard Specification for Joints for Drain and Sewer Plastic Pipe Using Flexible Elastomeric Joints.
    - f. ASTM F 1417, Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-pressure Air.



- g. ASTM F 477-95, Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- h. ASTM F 667, Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings.

### **PART 3 EXECUTION**

#### **3.01 EXCAVATION AND BACKFILL:**

- A. Trenches shall be excavated in accordance with the requirements of the New Mexico Standard Specifications for Public Works Construction and to a width sufficient to allow for proper joining of the pipe and thorough compaction of the bedding and backfill material under and around the pipe. Where feasible, trench walls shall be vertical (only as permitted by OSHA). The completed trench bottom below the bedding shall be firm for its full length and width.
- B. When RCP is used backfill shall conform with the requirements of the (1) geotechnical report and (2) the New Mexico Standard Specifications for Public Works Construction.
- C. When HDPE is used backfill shall conform with the requirements of the Manufacturer's Specifications.

#### **3.02 LAYING PIPE:**

- A. Pipe laying shall begin at the downstream end of the pipe line except for extensions of existing pipes. The bottom of the pipe shall be in contact with the shaped bedding throughout its full length. The bell or grove (female) ends of rigid pipes and outside circumferential laps of flexible pipes shall be placed facing upstream. Flexible pipe shall be placed with longitudinal laps or seams at the sides.

#### **3.03 JOINING PIPE:**

- A. Pipe joints shall be bell & spigot type joints. The method of joining pipe sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.
- B. Joints shall be made using rubber gaskets as provided by the pipe manufacturer for the purpose of joining the pipe.
- C. Mortar joints shall only be used were specifically authorized by the architect or engineer, and then shall be made with an excess of mortar to form a bead around the outside of the pipe and finished smooth on the inside.

#### **3.04 TESTING:**

- A. Pipe shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged, shall be taken up and re-laid or replaced at no additional expense. Pipe testing shall be performed in accordance with New Mexico Standard Specifications for Public Works Construction.
- B. All leaks or other defects which develop under the test shall be corrected by the Contractor at his expense. The test shall be repeated until all leaks or other defects have been eliminated.

**END OF SECTION**

DZILTH-NA-O-DITH-HLE COMMUNITY SCHOOL  
SUPPLEMENTAL TECHNICAL PROVISIONS

TECHNICAL PROVISIONS

The following sections of the Albuquerque Area- Indian Health Service/Office of Environmental Health and Engineering (AAIHS/OEHE)-Sanitation Facilities Construction (SFC) Technical Provisions, February 2016.

<u>SECTION</u>	<u>TITLE/DESCRIPTION</u>
SECTION 01	TRENCH EXCAVATION & BACKFILL FOR PIPELINES AND APPURTENANT STRUCTURES
SECTION 02	CONCRETE
SECTION 03	REINFORCING STEEL
SECTION 06	GRAVITY SANITARY SEWERS
SECTION 40	SEWAGE TREATMENT LAGOON CONSTRUCTION

ADDED TECHNICAL PROVISIONS

SECTION 11375	FLOATING AERATORS
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## TECHNICAL PROVISIONS

### SECTION 01 - TRENCH EXCAVATION & BACKFILL FOR PIPELINES AND APPURTENANT STRUCTURES

#### TP-101 SCOPE:

Excavation, as used in these specifications refers to all construction activities necessary to install subsurface utilities in accordance with the plans and specifications. Such activities include, but are not limited to:

All necessary clearing, grubbing and site preparation; removal of all materials that may interfere with construction activities (except existing pipe work, conduits, utility structures or other items to be left in place) to the lines and grades indicated on the plans and otherwise described herein. The Contractor shall remove all construction trash from the site and transport to a legal disposal site.

Removal and/or storage of subsurface materials from trench and construction excavation areas to allow installation of designated utilities or structures. All suitable material removed from excavations shall be used, insofar as practicable, in the formation of embankments, fills and backfilling.

Preparation of sub-grades and backfilling of trench and construction areas upon completion of utility or structure construction.

All necessary bracing, shoring and protection (but not including tight sheeting in trenches and structure excavation ordered left in place by the Owner or Owner's Representative).

Final grading, dressing and cleanup of the construction site.

#### TP-102 SAFETY:

All trench excavation shall be coordinated in strict accordance with current OSHA requirements found in the Occupational Safety and Health Standards - Construction Standards for Excavations (29 CFR 1926, Subpart P).

Trenches shall be properly sheeted, shored, or sloped in accordance with the current OSHA standards. Trench excavation shall not proceed more than 500 feet in advance of pipeline work without the Owner or Owner's Representative's approval. All trenches shall be completely backfilled at the end of each working day, unless otherwise approved by the Owner or Owner's Representative. No excavation shall be left open without proper barricades and warning lights. Such devices shall conform to the Manual of Uniform Traffic Control Devices (ANSI D6.1) or such permits as are appended to these specifications.

The contractor shall be responsible for safety on the job site and shall designate a trained "competent person" knowledgeable in trench safety to supervise the work.

#### TP-103 SHORING AND SHEETING SYSTEMS:

Protection of employees in excavations shall conform to applicable OSHA Standards. Any trench protection and modification to trenching safety plans shall be submitted to the Owner or Owner's Representative in writing to be maintained as part of the record.

The Contractor shall install all shoring and sheeting systems required to prevent cave-ins and protect his employees and adjacent property and structures in accordance with current OSHA standards. No extra payment will be made for these items, the cost thereof being merged with and considered a part of the cost for the related excavation.

Before sheeting is withdrawn, or trench boxes moved forward, they shall be raised, in place, just above the pipe crown to safely allow the Contractor to completely fill any voids left in the pipe zone.

#### TP-104 ROAD, RAILROAD AND SPECIAL UTILITY CROSSINGS (IF REQUIRED):

The Contractor shall be responsible for compliance with all requirements of special crossing permits applicable to this project. Copies of such permits shall be included in the Appendix of these specifications. If no special crossing permits are appended, and such crossings are indicated on the plans, crossings will comply with all applicable provisions of Section 11 of the Technical Provisions in addition to those indicated under other provisions of this Section. At least two days notice shall be given to the Owner or Owner's Representative before work is done on any crossing.

#### TP-105 WORK WITHIN RIGHT-OF-WAYS & TRAFFIC CONTROL

When performing any work within the right-of-way of roads or railroads, the Contractor shall comply with the right-of-way permit for the installation including all of the requirements for traffic control and compaction. All work within the right-of-way of roads shall be performed in accordance with the "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects FP-03 U.S. Customary Units – Section 614." All work within the right-of-way of roads shall be performed in accordance with the latest edition of the Manual on Uniformed Traffic Control Devices (MUTCD)." In addition, the Contractor shall submit a traffic control plan to the project engineer for review and approval prior to any work within the right-of-way of any roads or railroads.

#### TP-106 DRAINAGE:

The Contractor shall control the grading in the vicinity of the excavation so that the ground surface is properly sloped to prevent water from running into the excavated areas. Water that has accumulated in the excavation from rainfall and/or surface runoff, or from any other cause which might have been prevented by proper care and foresight, shall be removed and the subgrade restored to its proper bearing capacity, all at the Contractor's expense.

#### TP-107 EXCAVATION:

A. General: All excavation, other than by drilling and blasting, undertaken with the excavation equipment commonly used in the industry for this type of excavated material shall be classified as common excavation.

All excavation shall be made by open cut method except as approved or specified. During excavation, materials suitable for backfill shall be neatly piled no closer than 24-inches from the edge of the excavation. All materials not required or not suitable for backfill shall be removed and wasted at locations designated by the Owner or Owner's Representative.

1. Width: The sides of all trenches for the installation of utility piping systems shall be as nearly vertical as soil conditions will permit from ground level to the pipe. Except for the trenching of 1-inch water service lines, the width of the trench shall not be less than 16-inches nor more than 24-inches wider than the outside diameter of the pipe barrel. Trench excavation shall be centered on pipe alignment such that a minimum clear space of 8-inches is provided on each side of the pipe. Trench width above the level of the top of the pipe may be as wide as necessary for shoring or sheathing and for proper installation of the work.

2. Depth: The trench shall be excavated to the depth that permits pipe to be laid at the elevations shown on the engineering drawings or with the required depth of cover specified by the Owner or Owner's Representative. Depth of cover shall be measured from the finished grade or the surface of the permanent improvement to the top of the pipe barrel.

3. Preparation: The bottom of the trenches shall be accurately shaped to line and grade and shall provide uniform bearing and support for each section of the pipe on specifically placed bedding material at every point along its entire length. Bell holes and depressions for joints shall be dug after the trench bottom has been graded and shall be only of such length, depth and width as required for properly making the particular type joint. Care shall be taken not to excavate below the depths indicated. Unauthorized over depths shall be backfilled with suitable bedding material at the Contractor's expense.

4. Previous Excavation: If the trench passes over a sewer or other previous excavation, the trench bottom shall (1) be compacted to provide support equal to that of the undisturbed native soil or (2) conform to the specific regulatory requirements that preclude damage to the existing installed facility.

5. Unstable Subgrade: Where soft, spongy or otherwise unsuitable material is encountered, which will not provide a firm foundation for pipe, the Owner will direct the extent to which removal and replacement shall be made with suitable material. Special pipe foundation material is NOT anticipated. However, if required, a price shall be negotiated between the Owner and Contractor for special pipe foundation material.

6. Underground Obstructions: The Contractor shall preserve intact any underground pipes, culverts or other utilities encountered during construction (except as hereinafter permitted) provided their location is such that they do not interfere with new pipelines or structures being installed. The Contractor shall notify all appropriate utility authorities of his construction schedule so they may be at the site to locate and protect their property. If any utilities or structures are accidentally broken or disturbed, they shall be replaced immediately to a condition at least equal to that in which they were found, all at the Contractor's expense. Couplings used to repair water service lines shall be brass compression couplings and couplings used to repair sewer service lines shall be solid sleeve couplings that provide a rigid connection between pipes. The repair work shall be done in a manner acceptable to the Owner or Owner's Representative and the utility company. Any existing water or sewer services that will intersect or interfere with the new pipelines or structures shall be rerouted by the Contractor in the manner indicated by the Owner or Owner's Representative. Existing water or sewer services from the mains to private property that interfere with trenching operations may be cut and replaced at the Contractor's option and expense, provided that users of such services are notified at least 2 hours in advance and that the use of such service shall in no case be interrupted for more than 4 hours, unless specifically permitted in writing by the user. Materials and construction for these items shall be as provided in other sections of these specifications. All new and existing water and sewer mains and water and sewer services shall be protected from freezing at all times during construction.

B. Rock: The inclusion of a bid item and estimated quantity for rock excavation in the bid schedule indicates that rock excavation is probable. However, the exclusion of this item from the bid schedule does not preclude the possibility that rock will be encountered; it merely indicates that it is not anticipated. If unanticipated rock is encountered, the Owner or Owner's Representative will negotiate a price for rock excavation with the contractor. The following paragraphs define solid rock and loose rock excavation.

Solid rock shall be defined as large masses of igneous, metamorphic, or sedimentary rock that, in the opinion of the Owner or Owner's Representative, cannot be

excavated without drilling, blasting, or the use of rippers or other specialized equipment. Any material excavated without the use of blasting or specialized ripping equipment shall not be considered rock.

Solid rock excavation shall be measured in cubic yards from the top of the rock to a point 4-inches below the invert of the installed pipe and an assumed 24-inches trench width, regardless of the actual trench width and depth excavated. For structures, the rock shall be profiled 12-inches outside the perimeter of the structure and computed based on a product of the profile of the rock and an assumed 24-inches outside the structure's perimeter and 6-inches below the structure's footing. The rock volume will be computed as the product of the profiled rock area, as measured by the Owner or Owner's Representative. The measurements shall be within the nearest 0.1-feet from the surface and no less than every 10-feet by one of the following methods:

1. Excavating and exposing the rock profile for measurement. This shall be the responsibility of the contractor and no additional payment shall be made for this excavation.
2. Rock profile determined by drilling without excavating and measurements taken prior to any blasting.
3. Rock profile measured after blasting and excavation. A 20% deduction shall be made in rock determination when this method is used to allow for expansion in ledge due to blasting.

Loose rock shall be defined as boulders and other detached stones each having a volume of 1 cubic yard or more. Loose rock shall be removed from the excavation in such a way that a clear distance of at least 4-inches exists between the rock and the bottom of the pipe and 6-inches exist between the rock and the bottom structure. Loose rock shall not be used for backfill. Loose rock excavation shall be measured in cubic yards, including the total volume of only those rocks or boulders that are individually over 1 cubic yard in volume.

Trench in which rock is encountered shall be excavated at least 4-inches deeper than the pipe invert and refilled to the required elevation with sand, gravel, or crushed rock passing a 3/4-inch mesh screen. Bedding material shall extend upward at least 12-inches above the pipe. Payment for this fill material shall be considered incidental to the rock excavation and no additional payment shall be made.

Should rock excavation be encountered, it shall be the responsibility of the Contractor to have an experienced powderman handle all blasting and be able to furnish proof of his/her credentials. The Contractor shall also inform all residents in the vicinity of proposed blasting activities and shall be responsible for any damage to persons or property as covered in the General Provisions.

C. Removal of Water: The contractor shall remove and dispose of all water entering the trenches and shall keep the trenches water free until the facilities are in

place and sealed against the entrance of water. Use of a trash pump for removal of nuisance water shall be at no extra cost and shall not be considered dewatering. In no case shall water, earth, or any foreign materials be allowed to enter the water main or sewer lines.

The removal of nuisance water is determined by pumping the water out of the trench with a heavy-duty 4" construction trash pump with a strainer for a minimum of 1 hour. The strainer shall be placed in a bed of pea gravel or a slotted PVC pipe in order to screen the debris.

All water removed from trenches shall be conveyed to natural drainage channels, storm sewers, or proper reservoirs as approved by Owner or Owner's Representative. Such removal of water shall be in a manner that prevents property damage, erosion, or sedimentation.

The inclusion of a bid item and estimated quantity for dewatering in the bid schedule indicates that dewatering is probable. However, the exclusion of this item from the bid schedule does not preclude the possibility that water will not be encountered, it merely indicates that it is not anticipated.

If continuous pumping with well points is required to maintain a satisfactory trench, and the contractor is so directed by the Owner or Owner's Representative, this work shall be considered as dewatering. Well points shall be set separately for each trench being dewatered. Dewatering shall be based on the actual number of lineal feet of trench dewatered and paid for at the negotiated price between the contractor and Owner or Owner's Representative.

D. Structural Excavation: Excavation for structures shall extend a sufficient distance from walls and footings to provide for forming, except where concrete for walls or footings is authorized to be deposited directly against excavated surfaces. Care shall be taken to avoid excavating below the depths indicated in the plans. Over-excavation shall be restored to proper elevation by filling with suitable granular bedding material at the Contractor's expense.

#### TP-108 BACKFILLING:

A. General: Trenches shall not be backfilled until the Owner or Owner's Representative has inspected and approved the pipe installation and jointing as being in compliance with the requirements of plans and specifications.

Bedding and backfill materials to a depth of 12-inches above the pipe shall be carefully deposited in layers not more than 6-inches thick, loose measurements, wetted to optimum moisture content and hand or mechanically compacted to at least 95% of the reference density for this material as described in the specification titled "Compaction Requirements, Methods and Testing. From 12 inches above the pipe to



ground surface, the excavation material shall be placed in layers not to exceed 12-inches, mounded and left in a uniform, neat condition.

Wherever trenches have not been properly filled, or if settlement occurs, they shall be reopened to the depth required for proper compaction and refilled and re-compacted as specified above and approved by the Owner or Owner's Representative.

Compaction methods and equipment may utilize hand and mechanical tampers and rollers. The equipment and procedures proposed by the Contractor shall be subject to the approval of the Owner or Owner's Representative.

B. Materials: All backfill material shall be approved in advance of installation by the Owner or Owner's Representative. Materials shall be obtained from areas approved by the Owner or Owner's Representative.

Backfill material will not be paid for separately, but shall be considered as subsidiary to and a part of the cost for the applicable contract bid item.

1. Embedment: Embedment is that material from the bottom of the trench to twelve inches above the pipe, and includes the pipe bedding material (upon which pipe is laid), haunching material (extending from pipe bottom to pipe centerline), and initial backfill material (extending from pipe centerline to 12 inches above pipe). Native soil used for embedment must be free from clods of earth or stones larger than 1 inch in any dimension, organic refuse, debris, frozen soil, and other objectionable material. If the native soil does not meet these criteria, the Contractor shall screen it (as applicable) or import special bedding material.

2. Imported Special Bedding Material: If required, special bedding material shall consist of sand, sandy gravel, or other suitable granular material having a maximum plasticity index of 6, with 100% of the bedding material smaller than 3/4-inches, and no more than 5% passing a No. 200 sieve.

3. Stabilization: Granular stabilization material shall be used to replace soft, spongy, or other unsuitable material, including rock encountered in excavation, to the depths necessary to support the pipe or structure. Stabilization materials shall be underlay bedding material (as applicable) and shall consist of suitable hard, durable granular material having a maximum size of 6-inches, graded so that a maximum of 20% passes a No. 4 sieve. Granular stabilization is not anticipated. If required, a price for granular stabilization shall be negotiated between the Contractor and the Owner.

4. Final Backfill: In general, final backfill will be that material originally excavated from the trench and will extend from 12 inches above the pipe to surface grade. Final backfill material shall be the same as that around the pipe except that the inclusion of a limited amount of stones up to 6-inches in diameter will be permitted.

C. Placement:

1. Embedment: Embedment shall be placed in 6-inch loose lifts and compacted as described herein. If over-excavation is required, bedding material is to be compacted to 95% of the maximum dry density as determined by the Standard Proctor density test (ASTM D-698). Haunching material shall be placed by hand and worked under the pipe haunch to provide adequate side support for the pipe. Haunching and initial backfill material shall be compacted to 95% of the maximum dry density as determined by the Standard Proctor density test (ASTM D-698).
2. Final Backfill: Final backfill shall not be placed until the embedment material is placed and compacted, and the Owner or Owners Representative have inspected and approved the installation. Final backfill shall be placed in lifts not to exceed 12-inches unless otherwise approved by the Owner or Owners Representative. Compaction shall be as defined in the Compaction Requirements, Methods, and Testing section.
3. Backfill for Road Subgrade: Under existing and proposed roadways, to a distance of 10-feet on either side of the road, bedding and backfill materials shall be carefully deposited in layers not more than 6-inches thick, loose measurements, wetted to optimum moisture content and mechanically compacted as described in the Compaction Requirements, Methods, and Testing section.
4. In areas where pavement is to be replaced, or in roads that are to be paved, no rocks or stones that will interfere with subgrade preparation shall be included in the backfill within 12-inches of the finished subgrade elevation. The upper 12-inch layer, forming the subgrade for pavements, shall be compacted to a density of at least 95% (ASTM D-698 - Modified Proctor Test). See Section 11 of the Technical Provisions where this is required.
5. Cement slurry can be substituted for compacted native backfill and subgrade if approved by Owner or Owner's Representative. The cement slurry shall consist of one sack of cement to one cubic yard of concrete sand and shall be placed from the concrete truck at a slump of 6 to 8 inches. Steel plates 5/8" thick are to be placed over the trench with at least 6 inches overlap on each side and edged with asphalt to prevent traffic movement. The backfill shall be allowed to set for a minimum of 12 hours before completing the asphalt patch. Slurry can typically be installed from the trench bottom to ground surface and no intermediary subgrade material is required for placement of asphalt patch.
6. Where trenches cross roads, streets, or driveways, backfilling shall be completed immediately following excavation and inspection. No trenches across roads shall remain open overnight. All crossings shall be backfilled, compacted and open to traffic at the end of each day's work. Major road crossings shall be excavated and backfilled in half widths of the traveled way so that at least one-half of the roadway is open to controlled traffic at all times during the work.

7. **Backfill Around Structures:** Backfill around structures shall conform to the same requirements as those for backfill around piping in unpaved areas, unless more stringent requirements are indicated in other sections of these specifications.

**TP-109 COMPACTION REQUIREMENTS, METHODS, AND TESTING:**

A. **Minimum Density:** Unless otherwise specified by applicable permits initial and final backfill and gravel resurfacing shall be compacted to the following minimum requirements. The minimum acceptable percent of compaction is the in place dry density divided by the reference density times 100. Compacted soil shall also be at plus or minus 2% of optimum moisture content.

TYPE	LOCATION	REQUIRED COMPACTION
I	Under any existing or proposed pavement, curb Gutter, sidewalk, roadway, shoulder, alley, slab, Footing, canal embankment, or when within 2 feet of above.	95%
II	Within any gas, electric, or telephone utility easement,  Or within any street or road right-of-way outside the  limits defined above as Type I.	90%
III	All other locations not defined above as Type I or Type II.	80% (or 100% of adjacent natural ground)

B. **Reference Densities/Baseline Testing:** The Contractor, at his expense, shall provide the reference densities for the various bedding and backfill materials used. All tests shall be performed by a certified soils testing laboratory approved by the Owner or Owner’s Representative. If reference to natural ground is used, a nuclear gauge may be used to measure the density of the natural ground. The reference densities for compaction tests shall be established in accordance with ASTM D-698, Modified Proctor Test. The Contractor shall submit for approval a testing plan identifying proposed testing locations prior to the start of any excavation work.

Contractor shall provide copies of the Modified Proctor Tests with 5 point minimum moisture vs. density curves.

The contractor shall coordinate the collection of soil samples for proctor testing with the IHS construction inspector such that both parties are on-site during the collection of soil samples. This will ensure that enough samples are collected to provide for accurate density testing during construction by providing reference density for differing soil conditions within the project area.

C. Methods: Mechanical compaction is permitted. Water jetting methods are not permitted. The backfill shall be uniformly moistened to plus or minus 2% of optimum moisture content, placed in sufficiently thin layers to obtain the specified results, and compacted with hand and/or pneumatic tamp, roller, hydrohammer, or other device which will obtain the specified density without injury to the pipe or related structures.

D. Density Tests: Backfill density tests shall be performed in accordance with the latest versions of ASTM D-1556 (Sand Cone Method), ASTM D-2167 (Rubber Balloon Method), ASTM D-2216 (Moisture Content), ASTM D-2922 (Nuclear Density), and ASTM D-3017 (Nuclear Moisture Content). The Contractor will perform initial field density tests for each location listed in the next paragraph at the expense of the Contractor. Any additional tests due to failure of initial tests shall be at the expense of the Contractor.

The Contractor will perform at least one (1) compaction test every other lift at each two hundred and fifty (250) linear feet of Type I location. One compaction test will be performed every other lift on each five hundred (500) linear feet of trench at Type II or III locations. A minimum of one (1) compaction test shall be performed under each lift station base and a minimum of four (4) compaction tests shall be performed on each lift of material under proposed foundations or tanks. The exact test locations shall be specified by the Owner or Owner's Representative. The Owner may perform additional tests. If the results of any of the compaction tests indicate insufficient compaction, the area in question shall be reopened to a depth required for proper compacting, then refilled, compacted and retested, at the expense of the Contractor, until the compaction tests indicate that the necessary compaction requirements have been met. Two copies of the test results of any retesting performed by the Contractor shall be provided to the Owner, for approval, prior to any permanent surfacing. Any improperly placed backfill, or locations where settlement occurs, shall be reopened to the depth required for proper compaction, then refilled and compacted at the expense of the Contractor. The surface shall be restored and resurfaced, if necessary to the required grade.

**TP-110 DISPOSAL OF EXCESS MATERIAL:**

Excess material, including rock, broken concrete, bituminous materials, debris or other materials not suitable for backfill, shall be removed from the site and wasted in the disposal areas selected by the Contractor and approved by the Owner or Owner's Representative.

The disposal of such excess materials will not be paid for separately, but shall be considered as incidental to and a part of the cost for the applicable contract bid item.

**TP-111 CLEANUP:**

Upon completion of the work, the entire site shall be cleared of all debris, and ground surfaces shall be finished to smooth, uniform slopes and shall present neat and workmanlike appearance. All slopes shall be trimmed and dressed, and all surfaces graded such that effective drainage is assured.

Unpaved streets shall be graded smooth to the satisfaction of the Owner or Owner's Representative.

**TP-112 TRENCH MAINTENANCE:**

The Contractor shall, for a period of one year after completion and final acceptance of the work, maintain and repair any trench settlement that may occur and shall make suitable repairs to any pipe, pavement, or other structures that may become damaged as a result of backfill settlement.

**TP-113 STORM WATER POLLUTION PREVENTION PLAN (SWPPP):**

The Contractor shall prepare a Storm Water Pollution Prevention Plan (SWPPP) in accordance with the latest requirements of the Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) General Permit for Discharges from Large and Small Construction Activities. The SWPPP must be prepared in accordance with good engineering practices and must 1) Identify all potential sources of pollution which may reasonably be expected to affect the quality of storm water discharges from the construction site; 2) Describe practices to be used to reduce pollutants in storm water discharges from construction site; 3) Assure compliance with the terms and conditions of the NPDES General Permit.

If the Contractor is not experienced in the preparation of SWPPP, the contractor shall retain the services of an environmental firm regularly engaged in the preparation of

SWPPP to perform said service. The completed SWPPP must be approved by the Owner or Owner's Representative at least 14 calendar days before the start of construction so that a Notice of Intent can be sent to EPA.

The Contractor shall fully implement the SWPPP from the commencement of construction until final stabilization, as defined in the NPDES General Permit is achieved.

The Contractor shall maintain and update the SWPPP, as required in the NPDES General Permit, for the life of the project. Updates shall include amendments required as a result of the ineffective controls discovered through the course of inspections or investigations conducted by the Owner or Owner's Representative, site staff, or by local, state, tribal or federal officials. The Contractor shall submit a Notice of Intent to EPA to obtain permit coverage, modify the coverage as necessary, and terminate permit coverage once final stabilization is achieved.

#### TP-114 LINES AND GRADES:

The Engineer will give all lines, grades and building locations on the plans and will supply the contractor with the AutoCAD drawing to stake out the facilities to be installed. The CONTRACTOR shall be responsible for staking out pipeline centerlines with a lath every 200 feet or line-of-sight whichever is less. Bends, intersections, manholes, lift station centers and fence corners shall be staked by the CONTRACTOR and provided with two offsets for alignment. Elevation references will be provided as shown on the plans, at lift station and for sewer manholes. The Contractor shall be responsible for the preservation of the location and line and grade stakes when set, and if disturbed, shall have such stakes replaced.

#### TP-115 CLEARING & GRUBBING:

It is the contractor's responsibility to clear and grub the site prior to or during construction. The contractor shall remove all trees along the water and sewer main alignments. Trees may either be chipped with a woodchipper and placed over the trench for erosion control or disposed of at the Contractor's expense. Clearing and grubbing shall be done at the contractor's expense.

#### TP-116 SEEDING:

All disturbed areas shall be returned to their pre-construction vegetative state. The contractor shall submit a seed mix that is equivalent to the native vegetation in the

area of construction. The contractor shall protect the seed after it is placed with hay mulch, straw mulch, wood cellulose mulch, or as approved by the project engineer. A minimum of 20 pounds of seed per acre shall be placed. Seed shall be placed by either drill seeding at a depth of approximately 1 inch or broadcast seeding. If broadcast seeding is utilized, the contractor shall apply twice the minimum seeding rate (40 pounds of seed per acre). The contractor shall perform maintenance as needed to ensure that adequate vegetative growth and stabilization has taken place to minimize erosion after construction is completed.

#### TP-117 FROST PROTECTION:

- A. Materials: The insulation shall be rigid extruded polystyrene insulation board, having a minimum compressive strength of 25 psi. The width shall be 2 feet for mains, service lines and effluent discharge lines less than 6-inches (nominal diameter). The thickness shall be 2-inches.
- B. Placement: When indicated on the drawings and in the bid schedule, insulation shall be placed in areas where water lines, sewer lines, or effluent discharge lines are susceptible to freezing. The insulation shall be centered over the main with no more than 6 inches of compacted fill between the pipe and insulation. The Contractor shall grade fill so insulation lays flat and maintain a straight alignment of insulation. The Contractor shall lap insulation by 6 inches or stagger by 6 inches if composed of two layers. The thickness for the first lift of backfill over the insulation shall be a minimum of 8 inches. The Contractor shall not operate construction equipment directly on insulation and not compact the first lift with the backhoe-mounted compactor, or any other large compaction equipment. The remaining backfill shall be compacted using normal construction practices.

#### TP-118 REPAIRS TO DAMAGED UTILITIES

The contractor is responsible for repairing any utilities that they damage during construction at no cost to the Owner. Repairs shall be made in accordance with the requirements of each utility. Below are the requirements for making repairs to damaged water and sewer utilities.

Water Mains: If the damage is small a small crack or hole in the water main, the contractor shall install a stainless steel repair coupling equal to a Romac SS1, SS2, or SS3. If the damage is too large to repair with a repair coupling, the Contractor shall install new water main to replace the damaged water main. The repair must result in a watertight water main that does not leak. The new water main shall be DR-18, Class 235, C900 PVC water main per TP-4. The new water main shall be connected to the existing water main using restrained joint solid sleeve couplings equal to

Romac Alpha series restrained couplings.

Water Service Lines: If the damage is small a small crack or hole in the water service line, the contractor shall install a stainless steel repair coupling equal to a Ford Small Repair Clamp with Full Wrap Gasket FSC. If the damage is too large to repair with a repair coupling, the Contractor shall install new water service line to replace the damaged water service line. The repair must result in a watertight water service line that does not leak. The new water service line shall be 200 psi rated polyethylene water service line meeting TP-5 requirements. The new water service line shall be connected to the existing water service line using stab joint, compression joint, or pack joint brass fittings as specified in TP-5.

Sewer Mains & Service Lines: If the damage is small a small crack or hole in the sewer main or service line, the contractor shall install a stainless steel repair coupling equal to a Romac LSS1, LSS2, or LSS3. If the damage is too large to repair with a repair coupling, the Contractor shall install new sewer main or service line to replace the damaged sewer main. The repair must result in a watertight sewer main or service line that does not leak. The new sewer main shall be SDR-35 PVC sewer main meeting TP-6 requirements and the new sewer service line shall be SDR-35 PVC sewer service line meet TP-7 requirements. The new sewer main or service line shall be connected to the existing sewer main using solid sleeve couplings equal to Romac 501 sewer couplings.

#### TP-119 AS-BUILT DRAWINGS:

- A. General: The as-constructed drawings shall be a record of the construction as installed and completed by the Contractor. They shall include all the information shown on the Contractor's set of drawings and a record of all deviations, modifications or changes from those drawings, however minor, which were incorporated in the work, all additional work not appearing on the contract drawings and all changes which are made after final inspection of the contract work.
- B. As-Built Drawings: The Contractor shall mark up one set of paper prints to show the As-Built Drawing information. These Asbuilt Drawing prints shall be kept current and available on the job site at all times. All changes from the contract plans which are made in the work or additional information which might be uncovered in the course of construction shall be accurately and neatly recorded as they occur by means of details and notes. No construction work shall be concealed until the necessary record data has been recorded. The Asbuilt Drawing marked prints will be jointly inspected for accuracy and completeness by the Owner and a responsible representative of the construction Contractor prior to submission of each partial payment, as evidenced by the issuance of a receipt by the Owner indicating the adequacy of the information. Failure to keep the as-constructed marked prints on a



current basis shall be sufficient justification to withhold approval of request for payment or suspend pay estimates. The drawings shall show the following information, but not limited thereto.

1. The location and description of any utility lines or other installations of any kind or description known to exist within the construction area. The location includes dimensions to permanent features.
2. The location and dimensions of any changes from the contract drawings.
3. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor including but not limited to fabrication, erection, installation plans, and placing details, pipe sized, insulation materials, dimensions of equipment foundations, etc.
4. All changes or modifications which result from the final inspection.
5. All information as required in the technical provisions.

C. Electronic/Surveyed As-built Drawings: The contractor shall obtain the services of a surveyor licensed in the State of New Mexico to survey in the locations of all sanitation facilities installed by the project being constructed. The number and location of surveyed points must be sufficient to provide enough detail to accurately identify the location of the installed sanitation facilities. Points to be surveyed shall include, but not be limited to:

Water Mains & Services: gate valves, fire hydrants, flush hydrants, water meters, air/vacuum release valves, water/sewer crossings, water main bends, water service line connection, water main intersections, casing pipe, water main reducers, and other water main components installed under this project.

Other Water Facilities: wells, booster pumps, valve vaults, building corners, fence corners, water tanks (including base and overflow elevations), and other water main components installed under this project.

Sewer Mains & Services: manholes (including rim elevation, invert in elevation, and invert out elevation), terminal sewer main cleanout rim and invert, sewer service cleanout, new sewer service line connection, and other sewer components installed under this project.

Other Sewer Facilities: lift stations (including base elevation, rim elevation, invert in elevation, lead/lag pump on elevation, all pump off elevation, and high/low alarm elevation), valve vaults, gate or plug valves, air/vacuum valves, building corners, fence corners, treatment tanks (including rim elevations, invert in elevations, and

invert out elevations), treatment units, lagoons (including floor elevation, top of berm elevation, and invert elevations of all piping in transfer structures), and other sewer components installed under this project.

The contractor shall furnish the Owner with electronic asbuilts of the facilities installed on this project in ACAD format (dwg file). The project engineer will furnish the contractor with an electronic copy of the contract drawings in ACAD format and will provide control points for use by the contractor to draft the electronic asbuilt drawings. The labeling, linework, and format of the electronic asbuilts shall be similar to that of the contract drawings.

- D. Review and Approval: One set of the preliminary As-built Drawings marked prints shall be delivered to the Owner before final inspection for his review and approval. The review by the Owner will be expedited; however, the Owner cannot guarantee to review more than one complex mechanical or electrical Record drawing sheet per working day. Upon disapproval of the As-built Drawings one set of marked prints will be returned to the Contractor for further work and resubmitted to the Owner.
- E. Other: All costs incurred by the Contractor in the preparation and furnishing As-built Drawings shall be included in the contract price and no separate payment will be made for this work.

#### TP-119 MEASUREMENT AND PAYMENT:

- A. General: Except for the following items, the cost of all work done by the Contractor as required under Section 01 of the Technical Provisions shall be merged with the pay items defined within the Measurement and Payment portions of other Sections of this contract.
- B. Rock Excavation: Payment for rock excavation shall be at the unit price listed in the Bid Schedule based on the computed number of cubic yards removed. No differentiation payment will be made between solid or loose rock excavations.
- C. Dewatering: Dewatering shall be based on the actual number of lineal feet completed. Payment for dewatering shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for a complete dewatering installation.
- D. Mobilization/Demobilization: Payment for mobilization/demobilization shall be at the unit price listed in the bid schedule. 60% of this line item may be requested upon complete mobilization to the job site and the remainder may be requested upon demobilization from the job site.

E. Storm Water Pollution Prevention Plan: Payment for the preparation and implementation of the SWPPP shall be paid on a lump sum basis as shown on the Bid Schedule. Payment shall be full compensation for plan preparation including required revisions for Owner's acceptance, updates to the SWPPP for the life of the project, permit application, inspections, installation and maintenance of controls, modification of controls as determined by inspections, removal of pollutants due to failed controls, and permit termination.

F. Seeding: Seeding shall be paid for on a lump sum basis to seed the site in accordance with these specifications. Payment for seeding shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for complete installation.

G. Exploratory Time: Exploratory time shall be measured on an hourly basis for an actual period spent on locating the existing utility line exceeding two hours. Contractor shall follow these steps:

1. Call the representative from the operating Utility and make every effort to locate the existing utility line prior to excavation.
2. Locate the existing utility line for two hours at the Contractor's expense.
3. If the Contractor is unable to locate the existing utility line within two hours, the Contractor shall notify the Owner or Owner's Representative and both agree upon a start time. The start time shall be recorded. When the Contractor locates the existing utility line, the end time shall be recorded.

If the Contractor fails to notify the Owner or Owner's Representative when the Contractor will start locating the existing utility line, the Contractor will not be compensated. Payment for exploratory time shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for locating the existing utility line.

H. Frost Protection: Payment for frost protection shall be based on the actual number of lineal feet completed. Payment for frost protection shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for a complete installation.

#### TP-120 APPROVALS:

- A. Stabilization material, if required
- B. Bedding material, if required

- C. Rock excavation method, if required
- D. Dewatering procedures, if required
- E. Baseline Proctor density test results (5 point moisture density curves)
- F. Baseline testing location plan
- G. Soil Testing Lab Certification
- H. Stormwater Pollution Prevention Plan, if required
- I. Blasting contractor and credentials, if required
- J. Seed Mix
- K. Insulation, if required
- L. Traffic control plan, if required

TECHNICAL PROVISIONS

SECTION 02- CONCRETE

TP-201 SCOPE

Furnish all labor, materials, equipment, and incidentals as required, and perform all operations in connection with the placement of concrete in accordance with the applicable drawings and these specifications.

TP-202 MATERIAL:

- A. Cement: Portland cement shall conform to ASTM C150 Cement, Portland Type I, Type IA, Type II, Type IIA, Type III, or Type IIIA.
- B. Aggregate: Aggregate shall be composed of clean, hard, durable, uncoated grains and crushed stone, free from detrimental amounts of clay, dust, soft or flaky particles, loam, shale, schist, slate, alkali, disintergrated stone, organic matter or other deleterious matter.
- C. Water: All water used for concrete shall be of potable quality.

TP-203 CONCRETE REQUIREMENTS

<u>Property</u>		<u>Minimum</u>	<u>Maximum</u>
Cement Factor	(sacks per cu. Yd.)	6.0	---
Water-Cement Ratio	(gal. Per sack)	---	6.0
Entrained Air	(percent)	2.0	6.0
Slump	(inches)	1.0	4.0
<u>Compressive Strength</u>			
7 day	(psi)	1,800	
28 day	(psi)	3,000	

Concrete shall be uniformly plastic, cohesive and workable, i.e., can be placed without honeycomb and without voids in the surface. Workability shall be obtained without producing a separation of ingredients such that free water appears on the surface. In general, minimum amount of water required to produce a workable mixture shall be used.

#### TP-204 FREEZING WEATHER:

No concrete work shall be done if the air temperature is below 40 degrees <sup>0</sup>F, except with the approval of the Owner or Owner's Representative. If approval is given to work, the water and aggregate shall be heated to at least 80 degrees <sup>0</sup>F, before mixing.

In all cases where the air temperature is predicted to be below 40 degrees <sup>0</sup>F, the concrete shall be insulated for at least 72 hours by straw, blankets or other approved methods. No concrete shall be poured against frozen ground.

The use of salt or other compounds to prevent concrete from freezing shall not be permitted. Any work that has been injured by freezing shall be removed and replaced at the Contractor's expense.

#### TP-205 CURING:

Fresh concrete shall be adequately protected from heavy rains and mechanical injury. Concrete surfaces shall be kept moist by spraying with liquid membrane coating. Foundations and thrust blocks may be cured by covering with water saturated soil or backfill. All concrete shall be cured at least three days prior to stripping forms or structural loading.

#### TP-206 TRANSIT MIXED CONCRETE:

Ready-mixed concrete from a central batching plant and mixed in transit will be permitted with the Owner or Owner's Representative's approval. A plant batch certification sheet shall be provided by the concrete supplier listing the batch components for approval by the Owner or Representative.

#### TP-207 FIELD TESTING:

Four cylinders shall be taken for each 50 cubic yards of concrete placed or portion thereof. If the Owner or his/her representative suspects, by visual inspection, slump, or other tests, that any other concrete appears substandard, additional test cylinders shall be required. The Contractor shall provide cylinder molds at the construction site and shall have the cylinders tested by an approved laboratory, with the Contractor bearing all costs. If any test cylinder falls below 3000 psi at 28 days, this shall be sufficient cause to reject that portion of concrete. The Contractor shall remove and replace defective concrete with acceptable material at his own expense. The test cylinders shall comply with ASTM C31 for making and curing test specimens in the field. Additional information concerning testing is found in the SPECIAL PROVISIONS.

In addition, the contractor shall perform one slump test and one air entrainment test for each concrete truck.

Field testing will not be required for non-structural concrete placement such as pre-cast manhole bases, concrete collars, yard hydrant concrete pads, fence post concrete anchors, monitoring well

concrete pad, control panel concrete pad, cleanout collars, manhole collars, and drop manhole concrete encasements.

#### TP-208 PLACING CONCRETE:

Before placing concrete, the Contractor shall give 72-hour advance notice to permit proper inspection of forms and reinforcement by the Owner or Representative.

After completion of the mixing, the concrete shall be rapidly conveyed to and deposited in the forms. Consolidate the concrete, immediately after placing, by mechanical vibrating equipment, supplemented by hand-spading, roding, or tamping. Use equipment and procedures for consolidation of concrete in accordance with ACI recommended practices.

The concrete shall be placed in such a manner as to prevent excessive crawling and segregation of the aggregate. No concrete shall be used that has partially set before final placing, nor shall retempering of the concrete be permitted. All concrete shall be placed in the forms no more than 90 minutes after mixing.

#### TP-209 FORMS:

The Contractor shall provide forms that will produce correctly aligned concrete. The centering of the forms shall be true and rigid and thoroughly braced both horizontally and diagonally. Forms shall be sufficiently strong to carry the dead weight of the concrete as a liquid without deflection, and tight enough to prevent leakage of mortar. The inside of forms shall be coated with an approved oil or thoroughly wetted. The Owner or Representative shall be notified prior to removal of form work.

The final concrete structure shall be inspected for alignment, elevation, and concrete quality. Final concrete structure alignment and elevation shall be checked by use of land surveying instruments.

Should the concrete structure alignment, elevation, and/or quality test results be determined unsatisfactory by the Owner or Owner's Representative, the entire structure or parts of the structure will be rejected. All further alignment or elevation corrections, or any concrete removal and/or replacement, shall be at the Contractor's expense.

Honeycombed and void areas in the concrete shall be removed and patched to produce a sound concrete product by a method selected by the Contractor and approved by the Owner or Owner's Representative.

#### TP-210 MORTAR:

Mortar shall be made of one part masonry cement, three parts sand, and only a sufficient amount of water to make a workable plastic mix. Retempered mortar shall not be used.

TP-211 GROUT:

Grout shall be made of one part Portland cement, two parts sand, and only a sufficient amount of water to make a workable plastic mix. Retempered grout shall not be used.

TP-212 MEASUREMENT AND PAYMENT:

Concrete and other work or materials required by this section shall not be measured and paid separately. Rather, they shall be included in the unit or lump sum bid prices of those items shown on the Bid Schedule that require the inclusion of such materials or work, even if not specifically mentioned within the measurement and payment sections of those particular pay items.

TP-213 SUBMITTALS:

- A. Concrete testing laboratory
- B. Certification of concrete strength by the concrete supplier and/or proposed concrete mix
- C. Curing Compound



## TECHNICAL PROVISIONS

### SECTION 03 - REINFORCING STEEL

#### TP-301 SCOPE:

Furnish all labor, materials, equipment, and incidentals as required and perform all operations in connection with the placement of reinforcing steel and wire fabric reinforcing, complete, in strict accordance with the applicable drawings and these specifications.

#### TP-302 MATERIAL:

Reinforcing bars shall meet the requirements of the Standard Specifications for Billet-Steel Bar (intermediate grade) for Concrete Reinforcement, ASTM A615. Welded wire mesh shall meet the requirements of the Standard Specifications for welded Steel Wire Fabric for Concrete Reinforcement, ASTM A185.

The use of cold twisted bars will not be permitted. Wire fabric shall be used only when specified and shall be the type shown on the drawings and approved by the Owner or Owner's Representative.

#### TP-303 METHOD OF CONSTRUCTION:

When placed, all reinforcement shall be free from dirt, oil, paint, grease, mill scale, loose or thick rust. When bending is required, it shall be accurately done without the use of heat, and bars having cracks or splits at the bends shall be rejected. All reinforcement shall be placed in the exact position shown on the drawings, and shall be securely held in position by wiring to, and blocking from, the forms, and by wiring together at intersections, such that it will not be displaced during depositing and compacting of concrete. Precast concrete blocks, plastic chairs or metal chairs shall be used for supports where applicable. Rock supports will not be allowed.

Placing and fastening of reinforcement in each section of the work shall be approved by the Owner or Owner's Representative before any concrete is deposited in the section. Cutting and bending, placement, handling and storage, and installation of reinforcement shall be in accordance with American Concrete Institution (ACI) standards.

#### TP-304 MEASUREMENT AND PAYMENT:

Reinforcing steel shall not be measured and paid separately. Rather they shall be included in the unit or lump sum bid prices of those items shown on the Bid Schedule that require the inclusion of reinforcing steel, even if not specifically mentioned within the measurement and payment sections of those particular pay items.

## TECHNICAL PROVISIONS

### SECTION 06 – GRAVITY SANITARY SEWERS

#### TP-601 SCOPE:

The work covered by this section consists of furnishing all plant, labor, equipment, materials and incidentals, in connection with the construction of gravity sewer mains and appurtenances, in accordance with these drawings and specifications.

#### TP-602 GENERAL:

All facilities shall be constructed in the locations to the grades and of the sizes shown on the drawings. Excavation, trenching and backfilling shall be in accordance with Section 01 of these Technical Provisions. Any section of sewer that is found defective in material, alignment, grade or joint shall be corrected so as to meet these specifications and drawings.

#### TP-603 MATERIALS:

##### A. Pipe, Joints and Fittings

1. PVC Gravity Sewer Pipe: Sewer pipe shall be PVC and shall conform to all requirements of product standard ASTM D3034 for pipe diameters up to 15 inches and ASTM F679 for 18-inch to 48-inch diameter sewer mains. Sewer pipe shall meet the pipe compound requirements of ASTM D1784 and shall be made with PVC 1120 resin, Type I, Grade I. Pipe stiffness shall meet ASTM D2412. Pipe shall be nominal size, SDR-35. Joints shall be furnished with one end belled. The joint shall be integral bell and spigot with a Rieber rubber gasket. The integral bell shall meet ASTM D 3212. The gaskets shall be as recommended by the pipe manufacturer and shall meet ASTM F477.

Plastic pipe with scratches, gouges, or grooves deeper than 10 percent of the wall thickness shall be rejected.

2. Services Wyes and Risers: PVC fittings utilized shall be single gasketed bell and spigot push-on type, meeting ASTM 3034.
3. Ductile Iron Pipe: All ductile iron pipe shall be in accordance with AWWA C151 and shall be in 18 to 20 foot lengths with single rubber gasket (push-on) joints in accordance with AWWA C111. Pipe shall be 350 psi rated. All ductile iron pipe used for sewer shall be cement-mortar lined in accordance with ASTM A746 and AWWA C104.

## B. Manholes

1. General: All concrete used in constructing the manhole shall conform to Section 02 of the specifications. All concrete used for manholes shall be batched with a chemical resistant admixture for protection against hydrogen sulfide gas. The admixture shall be equal to Moxie 1800 Super-Admix as manufactured by Moxie International. Reinforcing steel shall conform to Section 03 of these Technical Provisions. Steps shall be aluminum, equal to Alcoa No. 12653 A, or 1/2-inch Grade 60, steel reinforced copolymer polypropylene plastic, M. A. Industries or approved equal, not less than 10 inches in width. If the polypropylene steps are utilized, care shall be taken to install them exactly according to the manufacturer's recommendations.
2. Lines and Grades: All manhole locations shall be as shown on the drawings unless field changes are necessary. Sewer line cut stakes shall be provided by the Contractor at each manhole and at the midpoint between each manhole at a minimum. A minimum of 2 offset stakes shall be provided for each cut stake. Further information on staking is found in TP-1.
3. Manhole Frames and Covers: Frames and covers shall be made of cast iron with a combined weight (frames and cover) of not less than 266 pounds. Cast iron frames and covers shall conform to drawings in all essentials of design. The cover shall have a lifting pocket and shall not be vented. Manhole frames and covers shall meet ASTM A48. Before leaving the foundry, all castings shall be thoroughly cleaned after which they shall be dipped twice in a preparation of hot asphalt or coal tar and oil, in such a manner as to form a firm coating. The manhole and covers shall be set such that the top of the cover shall be 3 inches above unpaved roads where paving is expected later or ground level as shown on the drawings or as directed by the Owner or Owner's. Frames and covers shall be East Jordan Iron Works, Inc. Product No. 00202301, Catalog No. 2023A and 2023Z1, Reference Product No. 00202313 and 00202351, or approved equal.
4. Manhole Bases: Bottom manhole sections shall have integral precast base or floor slabs. Manhole bases shall be a minimum of 6 inches thick for 48 inch diameter manholes and a minimum of 8 inches thick for manholes larger than 48 inches. If precast concrete manhole bases are used, they shall be bedded on 8 inches of crushed rock or gravel meeting the following requirements: 100% passing a 40 mm screen and not more than 10% passing a No.40 sieve, with uniform grading. Precast bases with precast channels shall be pre-approved on a case-by-case basis by the Owner or Owner's representative. Cast in place base slabs shall be constructed with reinforced concrete as shown in the detail plans. The contractor shall submit detail drawings showing the size, placement, and spacing of reinforcing bars for manhole

bases. This requirement applies for both pre-cast and cast-in-place manhole bases. Cast in place base slabs shall be constructed with a keyed joint for the manhole barrels to be installed into as shown on the detail drawings.

5. Standard Manholes: Standard manholes are those which have a depth, measured from the invert of the outlet pipe to the top of the cover, greater than 6 feet. Standard manholes shall be constructed of 4 feet inside diameter, 5 inches thick precast concrete manhole sections. Cone sections shall be eccentric, 5 inches thick precast concrete. Standard manholes shall have a 6 inch thick concrete base slab, and shall be constructed as shown on the detail drawings.
  6. Shallow Manholes: Shallow manholes shall have a depth of 6 feet or less, and shall be constructed of 4 feet inside diameter, 5 inches thick precast concrete sections with 8 inch thick reinforced concrete flat top cover and 6 inch thick base slabs. Shallow manholes shall be constructed as shown on the detail drawings.
  7. Inlet Manholes: Inlet manholes shall have a depth of 6 feet or less, and shall be constructed of 4 feet inside diameter, 5 inches thick precast concrete sections with 6 inches reinforced concrete cover and base slabs. The inlet manhole shall be constructed as shown on the detail drawings.
  8. Diversion Manholes: Diversion manholes shall have a depth of 6 feet or less, and shall be constructed of 4 feet inside diameter, 5 inches thick precast concrete sections with 6 inches reinforced concrete cover and base slabs. Diversion manholes shall be constructed as shown on the detail drawings. Each diversion manhole shall be provided with a fiberglass gate frame and gate. The fiberglass gate frame shall have a thickness of 3/16-inch. The gate frame shall have a channel that is 1/4-inch. The fiberglass gate shall be 1/4-inch thick. The gate frame and gate shall be constructed as shown on the detail drawings.
  9. Waterstops: All pipe penetrations through the manhole shall be equipped with waterstop devices. Waterstop devices shall be equal to concrete manhole adapter as manufactured by Fernco. All penetrations shall then be grouted to provide a watertight penetration.
- C. Terminal Sewer Main Cleanouts: Such cleanouts shall be of the same material as the gravity sewer main and sized as called for on the bid schedule. Cleanouts are to be constructed as shown on the detail drawings. Frame and lid shall be equal to East Jordan Iron Works, Inc. Product No. 00157804, Catalog No. 1578ZPT and 1578APT with a locking cover. Covers shall be marked "SEWER. The open pipe inside the locked cover shall be plugged with a Cherne Original Gripper, or equal.

- D. Warning Tape: Warning tape shall be green in color with "Caution - Buried Sewer Line Below" continuously printed on it. Tape shall be a minimum of 3-inches wide, 5 mils total thickness, composed of plastic with a metal foil core, and equal to Traceline Underground Utility Marking Tape. The warning tape shall be installed above the pipe with an 18-inch maximum bury depth. This tape shall also be installed on sewer service lines.
- E. Marker Post: 2-1/2 inch diameter aluminum or steel utility markers with stampable brass or aluminum caps shall be installed to mark the location of all manholes and terminal sewer main cleanouts. Marker posts shall be painted with a minimum of 2 coats of yellow paint designed for outdoor commercial use. The marker posts shall be properly cleaned and the surface prepared in accordance with the paint manufacturer's recommendations prior to painting. Markers shall be 60-inch long, 2.5 inch diameter, Bernsten Model A1NBF60-OS aluminum posts, or approved equal. Marker posts shall be installed, to leave 36 inches exposed above ground. Where possible, the markers shall be located immediately above the indicated item. The Owner will specify the location for markers requiring offset installation. The Contractor shall be responsible for accurately stamping the location, orientation and size of the sewer main, manholes, terminal cleanouts, and appurtenances on the cap. Installation and stamping of marker posts shall be considered incidental to installation of sewer main, manholes, terminal cleanouts, and appurtenances.

Under no circumstances shall marker posts be installed within the right-of-way of any roadways, unless specifically indicated on a right-of-way permit. Instead, the contractor shall install carsonite marker posts to mark the locations of valves, vaults, bends, tees, crosses, interconnections, etc. within the right-of-way of roadways. Carsonite markers shall be 72 inches in length, 3.75 inches in width, blue in color, model CRM306607 with anchor barb and "Caution Sewer Pipeline" text on the marker as manufactured by Carsonite Composites, or equal. The carsonite markers shall be installed directly over the item that it is marking with a 24 inch bury depth.

#### TP-604 TRENCH EXCAVATION AND BACKFILL:

Trenching and backfilling operations shall be performed as specified in Section 01 of the Technical Provisions.

#### TP-605 INSTALLATION OF GRAVITY SEWER LINES:

The bottom of the trench shall be shaped to give uniform support to the pipe. Pipe laying shall proceed upgrade, with the spigot end pointing in the direction of the flow. Each pipe shall be laid true to line and grade as shown on the drawings, and in such a manner as to form a close concentric joint with the adjoining pipe. As the work progresses, the interior of the sewer shall be cleared of all dirt and extraneous materials of every description. If the maximum width of the trench at the top of the pipe specified in Section 01 of these Technical Provisions is exceeded for any reason other than at the direction of the Owner or Owner's representative, the Contractor shall install such concrete

cradling, encasement, gravel base or other bedding as may be required to satisfactorily support the added load of the backfill. Trenches shall be kept free from water and the pipe shall not be laid when conditions of the trench or weather are unsuitable for such work. At all times when work is not in progress, all open ends of pipe and fittings shall be securely closed so that no trench water, earth or other substances will enter the pipe.

TP-606 WATER AND SEWER LINE SEPARATION REQUIREMENTS:

- A. General: Water lines located near sewers present conditions for serious potential cross contaminations. Protection from cross contamination can be provided by separation of the facilities and use of special piping materials. For measuring separation between pipes, all measurements shall be the clearance between pipes (pipe O.D. to pipe O.D.).

For the purposes of this section, the term “lines” shall include mains, laterals, and service lines for both water and sewer.

- B. Horizontal Separation of Water and Sewer Lines: When water and sewer lines are laid parallel to each other, the horizontal distance between the water and sewer lines shall be at least 10 feet. Each line shall be laid in a separate trench.

When physical conditions, such as an existing obstruction, will not allow the required 10 foot horizontal separation, the water and sewer lines may be laid closer than 10 feet if the bottom of the water line is at least 18 inches above the top of the sewer line.

- C. Vertical Separation of Water and Sewer Lines: When water lines cross sewer lines, the water line should be above the sewer line with no less than 18 inches vertical clearance (Measuring pipe O.D. to pipe O.D.).

Whenever possible the water line shall be above the sewer line. If the minimum 18 inch clearance cannot be obtained with the water line above the sewer, the water line must be installed under the sewer line.

Where a water line must cross under a sewer line, a vertical clearance of at least 18 inches between the bottom of the sewer line and the top of the water line shall be maintained. The water main shall be the normal water distribution pipe as specified on the construction drawings, with a 20 foot pipe section centered on the sewer crossing. No joints in sewer lines shall be permitted within 9 feet of a water line.

Where a water line must cross sewer service lines or mains, and the water line is not a minimum of 18 inches above the sewer service line or main, special protection is required. In these instances, the sewer service line or main shall be reconstructed of ductile iron pipe of the same size as the original sewer service line or main for a distance of 10 feet on either side of the water/sewer crossing point. As an alternative method of providing special protection, the contractor may place concrete a

minimum of 8" greater than the outside diameter of the pipe (i.e. 4" of concrete all the way around the pipe) for a length of 20 feet (10 feet on either side of the water/sewer crossing point), if approved by the project engineer. Concrete shall meet TP-2 requirements. All existing sewer grades shall be maintained.

- D. Water Main Separation from Sewer Manholes: No water pipe shall pass through, under, or come into contact with any part of a sewer manhole.
  
- E. Separation Between Water Lines and Components of the Sewage Disposal System: Water lines shall not be installed within 10 feet of a septic tank, within 25 feet of a drainfield, or 50 feet from an outhouse. Also, waterlines shall not be installed within 100 feet of the perimeter fence of an individual lagoon, or within 500 feet of the perimeter fence of a community lagoon.

#### TP-607 CONCRETE ENCASUREMENT OF SEWER MAIN:

Sewer line sections indicated on the plans as requiring concrete encasement shall be constructed in accordance with the detail drawings. Transition from PVC to DI sewer pipe shall be accomplished with approved a transition boot. DI piping shall extend a minimum of 6-1/2 feet beyond the limits of indicated concrete encasement unless otherwise directed in the plans and detail drawings. Concrete requirements shall be as indicated in Section 02 of these Technical Provisions.

#### TP-608 INSTALLATION OF MANHOLES:

Manhole invert channels shall be smooth and semi-circular in shape, conforming to the inside of the adjacent sewer pipe section. The invert shall be finished smoothly with a semi-circular cross section. Flat-bottomed inverts shall not be acceptable. Inverts with humps or low spots or roughness of finish which will catch solid materials will not be acceptable. Inverts shall not be brush finished. A minimum invert elevation drop of one-tenth of a foot from the entrance to the outlet shall be provided in all manholes where there is a change in direction, or change in grade. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. S-curves will not be acceptable. Changes in sizes and grade of the channels shall be made gradually and evenly. The manhole shall be positioned such that the pipes intersect in the center of the manhole circle. The invert channels will be formed directly in the concrete. For those manholes where the sewer pipe does not change grade or slope, the invert may be constructed by laying a full section of sewer pipe through the manhole and cutting out the top half after the surrounding concrete has hardened.

The floor of the manhole outside the channels shall be smooth and shall slope toward the channel at a 15 percent grade. Manholes shall be provided with aluminum or copolymer polypropylene steps, installed as shown on the drawings. Any deviation of alignment of more than 3 inches for any step shall be cause for it to be reinstalled at the Contractor's expense.

The tops of all manholes shall have a concrete collar of the dimensions shown on the drawings. Manholes shall be installed at the locations and elevations shown on the site plans or as directed by the Owner or Owner's representative in the field. Joints between precast manhole sections shall be sealed with "Ram Nek" bituminous rope type sealer or equal. The sections shall then be grouted to a smooth finish on the interior and exterior of the manhole. Grout for jointing shall be as specified in Section 02 of the Technical Provisions. Manhole sections, and adjustment rings if required, shall be grouted in place when the manhole is constructed. The grout shall be spread evenly over the entire mating surface. The maximum number of adjustment rings shall be as indicated on the plans. The jointing and sealing materials shall be approved by the Owner or Owner's representative prior to installation.

Any drop manholes shall be constructed at the locations shown on the plans in accordance with the details shown on the construction drawings. Bases, walls and cones shall conform to the drawings. The manhole covers shall be set to the elevations shown on the drawings.

All connections between sewer pipe and manhole walls shall be sealed with non-shrinking grout in such a manner to make the manholes water tight.

Manholes shall not be acceptable if any evidence of infiltration into them is found. The Contractor shall take whatever actions are necessary, at his expense, to ensure that the manholes are completely watertight.

Precast manholes shall not be altered or modified in anyway. Precast manhole bases, barrel sections, etc. shall be installed in their precast condition. Chipping or altering the concrete shall not be allowed.

#### TP-609 CONNECTION TO EXISTING MANHOLES:

Connection of newly constructed sewer mains to existing manholes shall be of either the drop or at-grade type as indicated in the drawings and listed on the bid schedule. Reconstruction of manhole bases and inverts, all necessary piping, and associated work required to complete the connection shall comply with the provisions of Section TP-608.

All pipe entrances into the existing manhole shall be core bored, and a waterstop and watertight sealer shall be installed on each pipe penetrating into the manhole. All voids shall be repaired with non-shrink grout. Grouted areas shall be painted with bituminous coating on exterior. The invert shall be constructed as specified in TP-608 Installation of Manholes. Chipping and altering existing concrete inverts to connect the new sewer main pipe into the manhole is allowed.

#### TP-610 TESTING:

- A. Sewer Main Alignment: After the gravity sewer lines have been completely backfilled and the contractor has verified the line as ready for testing, the Owner or his/her representative will check the alignment by shining a light between manholes.



Any deviation from true line or grade may be cause for rejection of the line. Any deviation from true line or grade which prevents water from draining by gravity from the sewer system, including manholes, shall be corrected such that the facilities meet these specifications and drawings. For horizontal alignment only, a deviation allowance of one-quarter of the inside diameter of the pipe may be excepted by the Owner or Owner's representative.

B. Sewer Main Water Tightness:

Testing for water tightness in gravity sewer mains may be accomplished by either of the following two methods:

1. Exfiltration/Infiltration: Tests for water tightness in the gravity sewer mains shall be made by the Contractor in a manner approved by and in the presence of the Owner or Owner's representative. The sewer and manhole connections shall not leak under either external or internal water pressure in excess of 10 gallons per day per inch diameter per 1000 feet of sewer. The test shall be run for a minimum of a four hour period.

Infiltration testing shall be completed under existing ground water conditions. Exfiltration testing shall be conducted under an internal pipeline test pressure generated by a manhole water level at least 1 foot above the highest elevation of the sewer main to be tested. Leakage by either infiltration or exfiltration greater than specified above shall be corrected by the Contractor at his expense. All equipment and water for these tests shall be furnished by the Contractor. This test will be made after the line has been completely backfilled.

2. Low Pressure Air Test:

- Test Requirements & Setup:
  - a. Test each newly installed section of gravity sewer line between manholes.
  - b. Slowly introduce air pressure to approximately 5.0 psig.
  - c. Allow pressure to stabilize for at least five (5) minutes. Adjust pressure to 5.0 psig or the increased test pressure as determined below if groundwater is present. Start the test.
- Test Procedure:
  - a. Determine the test duration for a sewer section with a single pipe size from the table below:

Low Pressure Air Test – Test Times	
Sewer Main Diameter (inches)	Test Time (Minutes/100 Feet of Sewer Main)
8	1.2
10	1.5
12	1.8
24	3.6

- b. Record the drop in pressure during the test period. If the air pressure has dropped more than 1.0 psig during the test period, the line is presumed to have failed. If the 1.0 psig air pressure drop has not occurred during the test period, the test shall be discontinued and the line will be accepted.
  - c. If the line fails, determine the source of the air leakage, make corrections and retest. The Contractor has the option to test the section in incremental stages until the leaks are isolated. After the leaks are repaired, retest the entire section between manholes.
  
- C. Flushing: The Contractor shall flush all sewer lines before pre-final inspection to remove sand, silt and other foreign material which might have entered the pipe during construction. Water used for flushing shall be domestic quality or as approved by the Owner or his/her representative. All equipment and water for the flushing shall be furnished by the Contractor. This test will be made after the line has been completely backfilled. The Contractor shall dispose of all water and foreign matter after flushing in an approved manner.
  
- D. Deflection Test: The maximum allowable deflection (reduction in vertical inside diameter) for PVC pipe shall be five percent. However, up to seven and one half percent may be allowed 30 days after final backfilling. Deflection testing is required in all cases between all manholes. All locations with excessive deflection shall be excavated and repaired by re-bedding or replacement of the pipe. Acceptable methods of deflection testing include use of properly sized go-no-go mandrels or deflectometer. Deflection testing is not required for ductile iron sewer mains.
  
- E. Manhole Testing: All manholes shall be tested for watertightness. Each manhole shall be tested immediately after assembly and prior to backfilling. All lift holes shall be plugged with an approved non-shrink grout. All pipes entering the manhole shall be plugged, taking care to securely brace the plug. If the manhole fails the initial test, necessary repairs shall be made and the manhole shall be retested. One of the following methods shall be used.
  - 1. Vacuum Testing: Vacuum testing should be conducted in accordance with ASTM C-1244 (Vacuum Test for Concrete Manholes), except as modified below. The vacuum test head shall be placed inside the top section and the seal inflated in accordance with the manufacturers' recommendations. A

vacuum of 10 inches of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum to drop to 9 inches. The manhole shall pass if the time is greater than 60 seconds for 48-inch diameter, 75 seconds for 60-inch, and 90 seconds for 72-inch diameter manholes.

2. Hydrostatic Testing: Hydrostatic testing shall be conducted in accordance with ASTM C-969 except as modified below. The mains into and out of the manhole shall be stoppered with a suitable device such as a tethered pneumatic plug. The manhole shall be filled with water to the ring. After a period of at least one hour to allow for concrete absorption and to allow the water level to stabilize, the manhole shall be refilled and the water level shall be checked. The hydrostatic test shall then begin and shall be administered for a period of 4 hours. If the water level is found to drop more than ¼ inch per foot of depth of the manhole over this 4 hour duration, then the leakage shall be considered excessive and the Contractor shall be required to make all necessary repairs and retest the manhole. The exterior of the manhole shall be inspected during this period for visible evidence of leakage. Visible moisture, sweating, or beads of water on the exterior of the manhole shall not be considered leakage, but any water running across the concrete surface will be considered leakage and shall be repaired to the satisfaction of the Engineer regardless of the volume of water lost during the test.

#### TP-611 CLEANUP:

Upon completion of the work, the entire site shall be cleared of all debris, and the ground surface shall be finished to smooth and uniform slopes. All fences, clotheslines, gravel driveways or other obstructions removed during construction shall be left in a condition at least equal to their condition prior to construction. Cleanup shall be considered an incidental item and no additional payment shall be made for it, but rather its costs shall be merged with the applicable pay item irregardless of whether cleanup is specifically included in the measurement and payment section.

#### TP-612 MEASUREMENT AND PAYMENT:

- A. Gravity Sewer Main: Gravity sewer main shall be measured in linear linear feet along the centerline of the pipe, center to center of the manhole without deduction for fittings or diameter of manholes, for each of the various sizes and types of pipe installed. Payment for sewer pipe shall be at the contract unit price for the various sizes and types of sewer main installed as shown on the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, exfiltration/infiltration testing, and incidentals required for a complete installation, including but not limited to excavation, bedding, stabilization material, laying and jointing pipe, exfiltration/infiltration testing or air testing, supplying water, plugging, measuring, flushing, backfilling, as-builts, and final cleanup.

- B. Shallow Manholes: Shallow manholes shall have a depth of 6 feet or less when measured from the invert of the outlet pipe to the top of the cover, and shall be measured each. Payment shall be at the contract unit price shown on the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, steps, adjustment of height, invert forming, connection to sewer lines, backfilling, as-builts, and final cleanup.
- C. Standard Manholes: Standard manholes shall have a depth greater than 6 feet when measured from the invert of the outlet pipe to the top of the cover, and shall be measured each. Payment shall be at the contract unit price for the various depths of manholes installed as shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, steps, adjustment of height, invert forming, connection to sewer lines, backfilling, as-builts, and final cleanup.
- D. Drop Manholes: Drop manholes shall be measured each. Payment shall be at the contract unit price shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, steps, adjustment of height, invert forming, connection to sewer line, backfilling, as-builts, and final cleanup.
- E. Inlet Manholes: Inlet manholes shall be measured each. Payment shall be at the contract unit price shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, gate frame and gates, steps, adjustment of height, invert forming, piping, connection to sewer line, backfilling, as-builts, and final cleanup.
- F. Diversion Manholes: Inlet manholes shall be measured each. Payment shall be at the contract unit price shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, gate frame and gates, steps, adjustment of height, invert forming, connection to sewer line, backfilling, as-builts, and final cleanup.
- G. Terminal Sewer Main Cleanouts: Sewer main cleanouts installed at the terminal end of a sewer main shall be measured each. Payment shall be at the contract unit price on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, fittings, backfilling, as-builts, and final cleanup.

- H. Connection to Existing Manhole: Connections to existing manholes shall be measured each. Payment shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, cutting into the existing manhole, grouting, fittings, removing the existing invert, pouring and forming a new invert, backfilling, as-builts, and final cleanup.
  
- I. Water and Sewer Main Crossings - Sewer Mains: All costs associated with completion of water and sewer main crossings shall be merged with other bid items and will not be considered a separate item for payment. No additional payment will be made for installation of ductile iron pipe associated with water and sewer main crossings.
  
- J. Concrete Encasement: The concrete encasement shall be measured in linear feet along centerline of the encased pipe, beginning to end of encasement. Payment shall be at the contract unit price shown in the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for a complete installation.

TP-613 SUBMITTALS:

- A. PVC sewer pipe and fittings
- B. Ductile iron sewer pipe and fittings
- C. Manhole ring and cover
- D. Manhole steps
- E. Pre-Cast Manhole including base and pre-cast channels
- F. Sewer main warning tape
- G. Cleanout frame and lid
- H. Exfiltration/Infiltration/Air testing method
- I. Fiberglass gate frame and gates
- J. Detail drawing of size, placement, and spacing of reinforcing bars for manhole bases

## TECHNICAL PROVISIONS

### SECTION 40 - SEWAGE TREATMENT LAGOON CONSTRUCTION

TP-4001 SCOPE: The work within this section consists of furnishing all labor, equipment, materials, and incidentals in connection with the sewage lagoon improvements in strict accordance with the construction drawings, construction detail drawings, construction notes and these specifications.

TP-4002 GENERAL: The work consists of the installation of an HDPE lined lagoon system including all appurtenances as shown on the drawings.

TP-4003 MATERIALS:

A. Pipe, Joints, and Fittings:

1. PVC Piping for Appurtenant Structures: PVC pipe and joints shall conform to the requirements of AWWA C900 or C909, DR18, Class 235 (minimum), Standard for Polyvinyl Chloride (PVC) Pressure Pipe, with gaskets meeting ASTM F477 and joints in compliance with ASTM D3139 or as otherwise defined on the Bid Schedule.
2. Ductile Iron Pipe for Appurtenant Structures: All ductile iron pipe and fittings shown on the drawings shall be in accordance with AWWA C151 and shall be in 18 to 20 foot lengths with single rubber gasket (push-on) joints in accordance with AWWA C111. Pipe shall be 350 psi rated. All ductile iron pipe used for sewer shall be cement-mortar lined in accordance with ASTM A746 and AWWA C104.
3. Gate Valves and Boxes: Gate valves shall be of cast iron or ductile iron body construction, bronze mounted, solid wedge, resilient seal, with 2-inch square operating nut, 200 psi operating pressure or higher, counterclockwise opening, inside screw, non-rising stems with O-ring seals, and conform to AWWA Specification C509 or C515. All valves shall be equal to the Mueller A-2360 or American Flow Control Series 2500, appropriately sized and with the correct connectors for the type of pipe in use.

All valve boxes shall be cast iron and of the sliding type, sized for use with the appropriate valve. All boxes shall extend from the body of the valve to the finished grade. Valve boxes shall be Tyler 6855, or equal. All valve boxes shall be provided with locking covers. Lids shall be marked "SEWER" for gate valves. Debris plugs equal to a standard mud plug as manufactured by In Fact Corporation shall be installed inside each gate valve. Debris plugs shall be a push-in/pull-out plug made in the USA of 1.2 or 1.7 pound density closed cell polyethylene material and shall be

flexible, non-cracking, and shall not absorb water. The debris plug shall conform to the interior sides of the gate valve box without the need for any tightening mechanism. The device shall come complete with a 200 pound test polypropylene handle.

One valve key shall operate all valves and the Contractor shall furnish one such key to the Owner.

All valves shall be set and jointed to the pipe in the manner as set forth in the AWWA Standards for the type of connecting ends furnished. Before installing the valve, care shall be taken to see that all foreign material and objects are removed from the interior of the valve. All valves shall be set in and tied to poured-in-place concrete support blocks. Valve installation shall be as shown on the standard detail.

Valves and valve boxes shall be set plumb and valve boxes shall be placed over the valve or valve operator in such a manner that the valve box does not transmit shock or stress to the valve. Backfill shall be placed around the valve box and the valve shall be opened and closed to see that all moving parts are in working order. The cast iron valve box cover shall be set flush with the finished grade.

After installing the gate valve box, the contractor shall compact the area around the gate valve prior to installing the concrete collar to ensure that there is no settlement. A 2 foot diameter by 4 inch thick reinforced concrete collar shall be poured around each valve box. Before the concrete has hardened, the Contractor shall neatly scribe in the concrete pad the size of the valve and orientation of the pipe with two arrows.

4. Lagoon Level Gauge: Lagoon level gauge shall be 2-1/2" width, and of sufficient length to measure the entire depth of the lagoon. Gauges shall be equal to a Watermark Style "C" stream gauge graduated to hundredths and marked at every foot and every tenth. The contractor shall fill a 12 inch diameter AWWA C-900, DR-18, PVC pipe with concrete and embed pipe 3 inches into concrete block footing at center as shown in construction drawings. The bottom 6 inches of the lagoon level gauge shall be removed and place on top of 4 ft x 4 ft x 6 inch epoxy coated concrete footing with reinforcement bars as shown in construction drawings. The epoxy coating shall be fast cure, high solids, high build, marine coating equal to Macropoxy 646 coating by Sherwin Williams. Epoxy coating shall be applied in 2 coats with a total dry film thickness of 5 to 10 mils. Surface preparation and epoxy application shall be done in accordance with manufacturer's recommendations. An additional layer of lagoon liner measuring 10 feet by 10 feet shall be installed under the level gauge. The lagoon level gauge shall be strapped to pressure treated 2x4 lumber and PVC pipe with 1/2" wide minimum stainless steel straps at every 2 ft.

B. Concrete: Concrete shall be as specified in Section 2.

- C. Reinforcing Steel: Reinforcing steel shall be as specified in Section 3.
- D. Road Aggregate Base Course: Aggregate base course material shall for access road, top of berm and other driving surface shall be installed as shown on the drawings. Road aggregate base course shall consist of clean, hard durable pit-run gravel that has been screened to the following gradation prior to compaction:

% Passing by Weight		
Sieve Size	Min.	Max.
3/4-inch	100	---
No. 4	30	65
No. 8	25	55
No. 200	3	12

The material passing the No. 4 Sieve and retained on the No. 200 Sieve shall be uniformly graded.

The plasticity index of the material passing the No. 40 Sieve shall not be greater than 6 as determined by ASTM D424 latest revision.

TP-4004 LAGOON EARTHWORK:

- A. Soils Testing and Inspection: Soils for lagoon construction shall be compacted during construction and prior to compaction testing and the installation of the lagoon liner. Soil testing shall be performed for the lagoon construction in accordance with TP-1. Required soil compaction testing frequencies are listed below for the lagoon construction:

<b>Soil Compaction Testing Frequencies for Lagoon Construction</b>		
<b>Location</b>	<b>Testing Frequency</b>	<b>Required Compaction</b>
Lagoon Bottom (Floor)	4 tests per 8" lift per acre	95%
Lagoon Berm Foundation (Area under Berm)	2 test per 6" lift per 250 linear feet of berm foundation spaced equally in the width of the berm	95%
Lagoon Berm	2 test per 6" lift per 250 linear feet of berm spaced equally in the width of the berm	95%
Pipe and Piping Structures in Lagoon Berm	1 test per pipe or pipe structure every other lift	95%



B. Excavation:

1. Surface Excavation (Strip and Grub): The area within the limits shown on the drawings shall be cleared of all spoil material including stumps, logs, brush, vegetation, existing sludge layer (if applicable), existing piping and concrete structures, and other foreign material. In addition, the finished grade surface where the liner will be placed shall be free of cobbles and stones to meet the requirements of the liner manufacturer. No trees shall be removed without prior approval of the Engineer. Such clearing shall be accomplished by stripping the indicated area to a depth not exceeding six inches (6") except as noted below for removal of large stumps and roots. Such material, shall be considered unsuitable for berm construction and shall be hauled and disposed of in a state licensed landfill at the contractor's expense. Any existing sludge may be disposed of by an alternate method if indicated on the plans and approved by the Owner or Owner's representative.

Stumps and roots larger than two inches in diameter in cuts and in berms three feet or less in depth shall be removed to a depth of eighteen inches (18") below subgrade. Outside of the slope limits and under berms more than three feet deep, all stumps, and brush shall be cut off approximately level with the surface. No trees will be removed without prior approval of the Engineer.

2. Construction Excavation: Excavation of material to be used in the construction of berms (all material except that designated under item 1 above) shall be performed at such locations as are indicated on the drawings and shall be to the lines, grades and elevations shown.

During the process of excavation, the grade shall be maintained in such condition that it will be well drained at all times. When necessary, temporary drains and drainage ditches shall be installed to intercept or divert surface water which may affect the prosecution or condition of the work.

The rough excavation shall be carried to such depth that sufficient material will be left above the designated grade to allow for compaction to this grade. Should the Contractor through negligence or other fault, excavate below the designated lines, he shall replace such excavation with approved material in an approved manner and condition, at his own expense.

All soft or unstable material, and material which will not readily compact when rolled or tamped, shall be removed as directed by the Engineer, and replaced with suitable material. The top six inches of excavated areas comprising the structural grade shall be compacted to a density equal to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision.

- C. Excess Material Hauled to Waste: All excavated material not utilized or unsuitable for berm construction, including all strip materials, grub materials, and sludge shall be wasted off site in an area designated by the Owner and Engineer. Refer to TP-1 regarding requirements for traffic control per the Manual on Uniformed Traffic Control Devices (MUTCD) to ensure that hauling is performed in a safe manner. These materials shall be evenly spread over the designated area to a height not exceeding five feet over the existing ground elevation and wheel compacted.
- D. General Fill Methods: Prior to placement of fill in any section, if required, the foundation of such section shall be loosened thoroughly by scarifying, plowing, or harrowing to a depth of six inches, except for the lagoon bottom which shall be 8-inches (see F. below). After removal of roots or other debris turned up in the process of loosening, the entire surface of the area shall be compacted to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision. The finished grade surface where the liner will be placed shall be free of cobbles and stones to meet the requirements of the liner manufacturer.

Fill materials shall be mixed as required to break up and blend the materials to obtain a uniform soil composition with uniform moisture content. Mixing can be performed either before or after placement of the material in a manner subject to the approval of the Owner or Owner's Representative. When mixing of the fill material is satisfactory, the lift shall be compacted to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision. Backfill placed adjacent to structures shall be compacted to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision. Portions of the fill which are not accessible to the roller shall be placed in 6-inch layers and compacted to the required density by approved mechanical tampers.

- E. Berms: The berms shall be constructed with approved excavated material obtained from the lagoon site and shall be placed in 6-inch thick layers and compacted to a density equal to 95% of the maximum dry density as determined by the Modified Proctor Test, ASTM D1557 or latest revision.

All berms shall be filled and compacted as specified above, to the lines, grades and elevations as shown on the plans or as directed by the Engineer, with all surfaces trimmed and fine graded so as to produce a neat, regular appearance.

Rolling of the berm areas shall be done with an approved power roller weighing not less than ten tons. Any irregularities or depressions that develop under rolling shall be corrected by loosening the material at these places and adding, removing or replacing material until the surface is smooth and uniform. Any portion of the area which is not accessible to a roller shall be compacted to the required density by approved mechanical tampers.

All soft or unstable material and material which will not readily compact when rolled or

tamped, shall be removed as directed by the Engineer, and replaced with suitable material. The top six inches of excavated areas comprising the final berm shall be compacted to a density equal to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision.

The top of the berms shall be sterilized and covered with geotextile and base coarse. The area shall then be sprayed with an approved soil sterilant, equal to Primatol 25E Herbicide, to prohibit vegetation growth and shall be applied at a rate that is in accordance with the manufacturer's recommendations. The treated ground surface shall be completely covered with one layer of GCI 381 geotextile or equal. Geotextile shall be 3.8 oz per square yard, 35 mil thick non-woven geotextile. Any geotextile joints shall overlap a minimum of 12 inches. After placement of the geotextile, the entire area shall be covered with a 3 inch uniform layer of base coarse.

- F. Lagoon Bottom: The lagoon bottom shall be constructed to the finished grade as shown on the drawings. The bottom of the lagoon shall be checked for smoothness and accuracy with surveying instruments, and if any portion is found to vary more than two tenths (0.20) of a foot above or below the finished grade, such portions shall be scarified, reshaped and recompacted until the required accuracy is obtained.

The 8-inches immediately below the HDPE liner shall be scarified by discing or using rippers on a grader, dozer, or other approved equipment and compacted to a density equal to 95% of the maximum dry density as determined by the Modified Proctor Test, ASTM D1557 or latest revision. Compaction and rolling shall conform to all provisions as specified under "Berms." All soft and yielding material, and material which will not readily compact when rolled or tamped, shall be removed, and replaced with suitable material as directed by the Engineer.

TP-4005 SLUDGE REMOVAL, HAULING AND PLACEMENT: If shown on the drawings and on the bid schedule, sludge removal, hauling, and placement is required. The contractor shall remove existing dried sludge in lagoon cell bottom as shown on the construction drawings. The contractor shall satisfy himself/herself as to the actual quantity of sludge material for removal and placement. The contractor shall apply a maximum of 1 inch dry sludge layer at a rate of 8-12 tons/acre across the biosolids land application site as shown in construction drawings. Prior to placement of dry sludge material, the contractor shall coordinate with Tribe to establish the boundaries of the land application site. Refer to TP-1 regarding requirements for traffic control per the Manual on Uniformed Traffic Control Devices (MUTCD) to ensure that hauling is performed in a safe manner.

TP-4006 MOISTURE CONTROL: The materials in each layer of the fill shall contain the amount of moisture, within the limits specified below, necessary to obtain the desired compaction. The moisture content shall be as uniform as practicable throughout any one layer of selected materials. The upper limit of moisture content in selected materials shall be that which will permit hauling, placing, and proper compaction with the Contractor's equipment without excessive deformation of

any fill area. The lower limit of moisture content shall not be less than 95% of the optimum. Material that is too wet shall be spread and permitted to dry, assisted by discing or harrowing, if necessary, until the moisture content is reduced to an amount within the specified limits. When material is too dry, the Contractor shall be required to wet each layer of the fill and harrowing, or other approved methods, shall be required to work the moisture into the material until a uniform distribution or moisture is obtained. Water applied on a layer of fill shall be accurately controlled in an amount so that free water shall not appear on the surface during or subsequent to rolling. Should too much water be added to any fill so that the material is too wet to obtain the desired compaction, the rolling and all work on that section of the fill shall be delayed until the moisture content of the material is reduced to an amount within the specified limits.

If, in the opinion of the Engineer, the top or contact surfaces of a partial fill section become too dry to permit a suitable bond between these surfaces and the additional fill to be placed therein, the Contractor shall loosen the dried materials by scarifying or discing to such depths as may be directed by the Engineer and shall dampen the loosened material to an acceptable moisture content, and shall compact this layer in accordance with the applicable requirements.

**TP-4007 PIPING STRUCTURES:**

- A. **Lagoon Transfer Structures (Three Valve Type):** The lagoon inter-connecting structures shall be constructed at the locations shown in the plans and in accordance with the detail drawings. Piping shall be as shown on the detail drawing and shall meet TP-4003 requirements. Materials and construction including inlet/outlet collars shall be as indicated in TP-1, TP-2, TP-3, TP-4003, and the plans and detail drawings. The contractor shall install 2” brass or aluminum caps into the concrete collars for each valve in the transfer structure. The 2” brass or aluminum caps shall be engraved with the following information:

<b>Valve Description</b>	<b>Information to Engrave on Brass/Aluminum Cap</b>
Drain	___” Gate Valve. Normally Closed - Drain.
Mid-Level Draw	___” Gate Valve. Normally Closed – Mid-Level Draw.
High Level	___” Gate Valve. Normally Open – High Level.

- B. **Discharge Manhole (Force Main Discharge Into Lagoons):** Discharge manholes shall have a depth as indicated in the construction drawing details. Discharge manholes shall be 4 feet inside diameter and 5 inches thick precast concrete sections with a 6 inch thick reinforced concrete cover. Manholes shall meet TP-2 requirements for concrete. The manhole shall be equipped with an 8-inch thick reinforced concrete flat top cover with a grated aluminum cover cast into the cover. The grated aluminum cover shall be 30 inches wide by 30 inches long and shall be equipped with an aluminum angle frame with ¼” diameter by 3 inch long anchors, and automatic hold-open arm and cover release, a spring assisted grated aluminum door, and shall be capable of opening to a 90 degree angle as manufactured by Ohio Gratings, Inc. or equal. Discharge manholes shall be constructed as shown on the detail drawings.

Discharge manhole option #1 (see detail drawings) shall be equipped with a high performance flexible pipe-to-manhole connector (“pipe boot”) on pipe penetrations equal to a PSX Direct Drive as manufactured by Press-Seal Gasket Corporation. The pipe boot shall be installed per the manufacturer’s recommendations. The pipe boot shall be installed in the concrete manhole wall at the same angle as the PVC discharge pipe. This shall be accomplished using foam hole-formers.

Exposed pipe from the discharge manhole into the lagoon shall meet TP-4003 requirements. Exposed PVC pipe shall be coated with 2 coats of paint. Paint shall be equal to Krylon Fusion brand spray paint for plastic. Paint color is subject to the approval of the Owner or Owner’s Representative.

Discharge manholes shall meet TP-6 requirements.

- C. Lagoon Inlet Structure (Above Water Surface Level – Gravity Sewer Main): Lagoon inlet structures that discharge above the water surface level of the lagoon cell shall be constructed as shown on the detail drawings. The pipe shall be supported by concrete filled 12” diameter C900 PVC pipe embedded into 3’x3’x8” thick reinforced concrete pads installed on top of an additional 10’x10’ square section of 60 mil thick HDPE liner. Concrete support pads shall meet TP-2 requirements and shall be spaced such that each pipe bell is supported. The pipe shall be attached to the concrete pad using a ½” thick stainless steel cable or strap attached to the concrete with ½” diameter by 2” long stainless steel concrete drop in anchor and ½” diameter stainless steel bolts. A 4’x4’x6” thick reinforced concrete splash pad shall be installed underneath the pipe termination point as shown on the drawings. All submerged concrete shall be coating with epoxy coating. The epoxy coating shall be fast cure, high solids, high build, marine coating equal to Macropoxy 646 coating by Sherwin Williams. Epoxy coating shall be applied in 2 coats with a total dry film thickness of 5 to 10 mils. Surface preparation and epoxy application shall be done in accordance with manufacturer’s recommendations.
- D. Lagoon Inlet Structure (Bottom of Lagoon Cell – Gravity Sewer Main): Lagoon inlet structures that discharge at the bottom of the lagoon cell shall be constructed as shown on the detail drawings. The pipe shall be supported by 2’x2’x4” thick reinforced concrete pads installed on top of an additional 4’x4’ square section of 60 mil thick HDPE liner. Concrete support pads shall meet TP-2 requirements and shall be spaced such that each pipe bell is supported. The pipe shall be attached to the concrete pad using a ½” thick stainless steel cable or strap attached to the concrete with ½” diameter by 2” long stainless steel concrete drop in anchor and ½” diameter stainless steel bolts. A 4’x4’x4” thick reinforced concrete splash pad shall be installed underneath the pipe termination point as shown on the drawings. All submerged concrete shall be coating with epoxy coating. The epoxy coating shall be fast cure, high solids, high build, marine coating equal to Macropoxy 646 coating by Sherwin Williams. Epoxy coating shall be applied in 2 coats with a total dry film thickness of 5 to 10 mils. Surface preparation and epoxy application shall be done in accordance with manufacturer’s recommendations.

#### TP-4008 HDPE MEMBRANE LINER:

A High Density Polyethylene (HDPE) liner shall be installed on the floor and the side slopes of the newly constructed lagoon cell(s) as shown in the drawings; a textured HDPE liner shall be installed on the side slopes of the cells and on the cell floors.

- A. High Density Polyethylene Material: High Density Polyethylene (HDPE) lining shall consist of 60 mil HDPE sheeting, Permalon PLY-X210 or equal. Polyethylene shall have a minimum density of 0.94 g/cm<sup>3</sup> (ASTM D 1505, a minimum yield strength of 2200 psi (ASTM D 638), and a carbon black content of 2%-3%. The materials supplied under these specifications shall be first quality products manufactured specifically for the purposes of this work and have been satisfactorily demonstrated by prior use to be suitable and durable for use in lining hydraulic structures. The liner must have good surface quality and be free of pinholes, striations, roughness, and blisters. Manufacturer's certification that all material standards are met shall be provided to the Engineer.
- B. Field Installation: Field installation shall be performed by a factory authorized installation contractor. A representative of the liner manufacturer shall be in attendance during all phases of liner installation. The surface (substrate) to receive the liner shall be smooth and free of sharp objects that could puncture the lining. All vegetation and organic material shall be removed. The liner shall be installed over the prepared surfaces in accordance with factory recommendations for minimum handling and using methods that will not crimp, bend, or otherwise damage the material. Excessive wrinkles are to be removed prior to seaming. Horizontal field seams on slopes shall not be allowed.

The liner shall be sealed to all structures and intruding pipes in accordance with the manufacturers recommendations and the detail drawings. Any portion of the liner damaged during installation shall be removed or repaired as recommended by the on-site factory representative. The liner shall be installed in a relaxed condition and shall be free of stress or tension upon completion of the installation. Stretching of the liner shall not be allowed.

All joints, on completion of the work shall be tightly bonded. Any lining surface showing injury due to scuffing, penetration by foreign objects, distress from rough subgrade, or any seams not passing the required tests shall be replaced or covered and sealed with an additional layer of the same material of a proper size. All liners shall be terminated in an anchor trench as shown in the plans and detail drawings and in accordance with the manufacturer's recommendations. Gas vents shall be constructed in accordance with the detail drawings at locations and intervals as recommended by the liner manufacturer.

- C. Material Seaming: Wherever possible, field seams shall be made by using a heat fusion (wedge) method as recommended by the liner manufacturer. Wedge welded seams shall consist of a double seam with an air channel between the seams. Extrusion welding will be allowed only for detail work, repairs, and in other areas where wedge welding cannot be

used. The contact surfaces of the panels shall be wiped clean to remove all dirt, dust or other foreign substances. The manufacturer's recommendations for field seams shall be strictly adhered to.

Test seams shall be made for each seaming machine each day prior to seaming any permanent liner materials, any time the seaming machine is turned off for more than 15 minutes, or if a substantial change in weather conditions occurs. A minimum of two shear and two peel tests are to be conducted on each test seam by using a field tensiometer furnished by the installer. Test seams must meet the manufacturer's requirements and all results recorded. No seaming shall be done until a successful test seam has been completed and recorded. Test records, along with manufacturer's minimums, shall be made available to the Engineer upon request.

1. Testing: The Contractor shall test all completed seams prior to acceptance. Pressurizing the air channel to a stabilized pressure of 30 psi shall test wedge seams. After a minimum of five minutes, a final pressure reading shall be taken. The maximum allowable pressure drop is 4 psi. All extrusion welds shall be tested visually by use of a soap solution and a vacuum box. In areas where this method is not possible (e.g. on pipe boots), the contractor shall perform a spark test to ensure that the extrusion weld is watertight. All test results are to be recorded and made available to the Engineer.
  2. Safety Rope: The Contractor shall install a safety rope in every corner of the finished HDPE lined lagoon cell. The rope shall be multifilament twisted polyester rope or equal. The rope shall be 5/8- inch minimum diameter and shall have knots located every two feet. The Contractor shall attach the rope to a 1/2" stainless steel lag ring bolt placed in the center of a 12" x 12" x 24" thick concrete block buried flush with grade at the top of the berm. The rope shall extend from the top of the berm to the floor of the cell after the knots have been tied.
- D. Warranty: Upon acceptance of the project, the Contractor shall provide a liner system warranty which shall cover all appropriate items that would cause the pond to leak greater than 500 gal./acre/day. Examples of such items would be rock penetration, abrasion, settlement, seaming, construction technique, ice, etc. This warranty shall be of sufficient dollar value to cover labor and materials to fully repair the liner and remedy the problem. This shall include, but not be limited to, detection of the leak, removal and replacement of liner and subgrade preparation. The minimum time period for a prorated warranty shall be twenty (20) years for materials and one (1) year for workmanship (such as field-seaming).

#### TP-4009 GEOCOMPOSITE GAS VENTING LAYER (GGVL)

Where shown on the drawings and indicated on the bid schedule, the contractor shall install a GEOCOMPOSITE GAS VENTING LAYER (GGVL) to aid in the venting of gases under the liner.

The GGVL shall be installed, including all necessary and incidental items, in accordance with the construction drawings and these specifications to provide a complete gas venting system for the liner.

A. MATERIALS:

1. The geonet of the GGVL shall be a tri-planar structure manufactured by extruding three sets of high density polyethylene strands to form a three dimensional structure to provide planar liquid flow. The geonet shall meet the property requirements listed in Table 1.
2. The geotextile of the GGVL shall be UV resistant, needle punched, and nonwoven polypropylene geotextile. The geotextile shall meet the property requirements listed in Table 1.
3. GGVL shall be Tenflow AirMax 350 mil composite manufactured by GSE Environmental Company (1800-435-2008), or engineer approved equivalent.
4. Labels on each roll of GGVL shall identify the length, width, lot and roll numbers, and name of Manufacturer.



**TABLE 1: REQUIRED GGVL PROPERTIES**

PROPERTY	TEST METHODS	UNITS	VALUE	QUALIFIER	FREQUENCY
<b>TRI-PLANAR GEONET<sup>1</sup></b>					
Thickness	ASTM D 5199	mil (mm)	350 (8.9)	MAV	50,000 sf
Density	ASTM D 792	g/cm <sup>3</sup>	0.94–0.96	Range	50,000 sf
Melt Flow Index	ASTM D 1238	g/10 min	1.0	MAX	50,000 sf
Carbon Black	ASTM D 4218	%	2-3	Range	50,000 sf
Thickness Retained From 10,000 hour creep test under 2,000 psf, and 20°C temperature	GRI-GC8	%	92	-	-
Creep Reduction Factor From 10,000 hour creep test under 2,000 psf, and 20°C temperature	GRI-GC8	-	1.05	-	-
<b>GEOTEXTILE<sup>1</sup></b>					
U.V. Resistance (500 hrs)	ASTM D 4355	%	70	MARV	Per formula
Grab Tensile	ASTM D 4632	lbs (N)	160 (710)	MARV	100,000 sf
Grab Elongation	ASTM D 4632	%	50	MARV	100,000 sf
Tear Strength	ASTM D 4533	lbs (N)	65 (290)	MARV	100,000 sf
CBR Puncture	ASTM D 6241	lbs (N)	435 (1,936)	MARV	100,000 sf
AOS	ASTM D 4751	US Std Sieve(mm)	70(0.212)	MaxARV	540,000 sf
Permittivity	ASTM D 4491	sec <sup>-1</sup>	1.4	MARV	540,000 sf
Water Flow Rate	ASTM D 4491	gpm/ft <sup>2</sup> (l/min/m <sup>2</sup> )	110 (4481)	MARV	540,000 sf
<b>GGVL</b>					
Ply Adhesion	ASTM D 7005	lb/in (g/cm)	0.5 (89)	MARV	
Roll Sizes	12.5 ft x 200 ft (3.81 m x 61 m)				
<b>Transmissivity<sup>2</sup> – MD</b>					
Plate/Ottawa Sand/ GGVL/Geomembrane/ Plate, Gradient = 3.0 @ 1,000 psf 24 hour seating period	ASTM D 4716	m <sup>2</sup> /sec	7.0*10 <sup>-4</sup>	MAV	540,000 sf

**B. CONSTRUCTION:****1. Handling and Placement**

- a. After the subgrade has been constructed, tested, and approved by the Engineer, the surface shall be clean and free of excess dirt and debris.

- b. The Contractor and the Installer shall handle all GGVL in such a manner as to ensure it is not damaged in any way. Precautions shall also been taken to prevent damage to underlying layers during placement of the GGVL.

The predominant flow direction of the GGVL is in the machine direction (roll direction), and thus should be installed in the intended direction of flow. This is generally achieved by deploying the product directly down the slope unless an alternative drainage path is specified by the Engineer.

- c. If the project contains long, steep slopes, special care shall be taken so that only full-length rolls are used at the top of the slope
- d. In the presence of wind, all GGVL shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.
- e. If necessary, the GGVL shall be positioned by hand after being unrolled to minimize wrinkles.
- f. If the project includes an anchor trench at the top of the slope, the GGVL shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the GGVL.
- g. If there are any obstructions (such as outlet pipes or monitoring wells) while deploying the GGVL, the GGVL shall be cut to fit around the obstruction. Care shall be taken as to make sure there is no gap between the obstruction and the GGVL. The GGVL shall be cut in a way that the lower geotextile and geonet core is in contact with the obstruction and the upper geotextile has an excess overhang. There must be enough of the upper geotextile to be able to tuck the upper geotextile back under the GGVL to protect the exposed geonet core, and prevent soil particles from migrating into the geonet core flow channels.

## 2. Seams and Overlaps

Each component of the GGVL (geotextile(s) and geonet) shall be secured or seamed to the like component at overlaps.

### a. Geonet Component

- Adjacent edges of geonet along the length of the GGVL, shall be overlapped 3 inches, see Figure 1(a), or if approved by the Engineer based on the site specific conditions, placed with the edges of each geonet butted against each other, see Figure 1(b). These overlaps shall be joined by tying the geonet cores together with white or yellow cable ties or plastic fasteners (minimum tensile strength of 50 lbs). These ties shall be spaced at a maximum of every 5 feet along the roll length, or a maximum of 2 feet if

the GGVL is installed vertically.

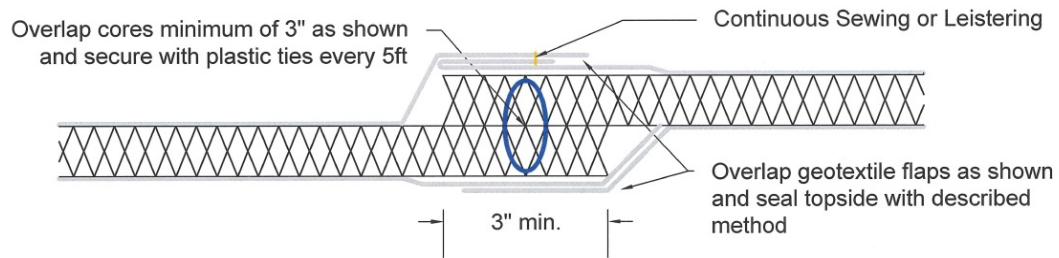


Figure 1(a). Overlap along roll length (side to side)

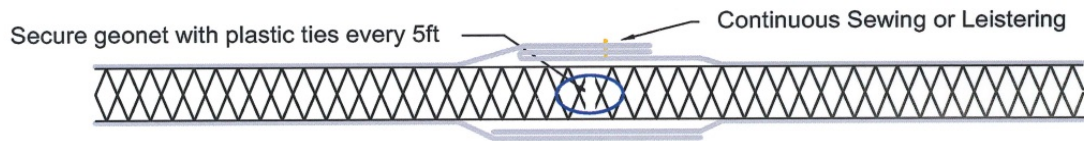


Figure 1(b). Butted along roll length (side to side)

- Adjoining GGVL rolls (end to end) along the roll width shall be shingled down in the direction of the slope, with the geonet portion of the top GGVL overlapping the geonet portion of the bottom GGVL a minimum of 8 inches across the roll width, see Figure 2. Geonet shall be tied every 12 inches across the roll width and every 6 inches in the anchor trench or as specified by the Engineer.

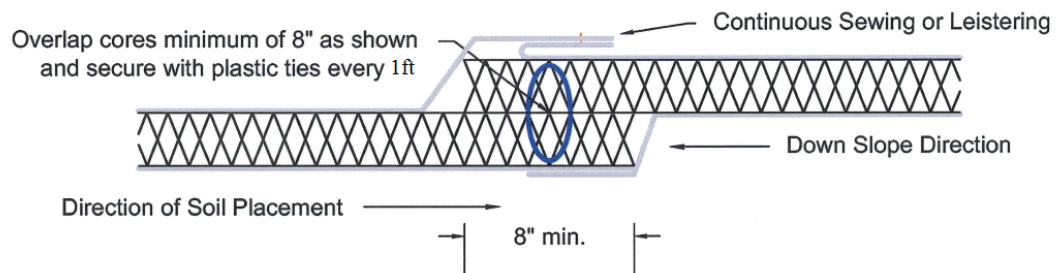


Figure 2. Overlap along roll width (end to end)

b. Geotextile Component

- The bottom layer of geotextile (if any) shall be overlapped.
- The top layers of geotextile shall be sewn together, or at the discretion of the Engineer may be heat bonded or wedge welded. Geotextiles shall be overlapped a minimum of 4 inches prior to seaming or heat bonding. The seam shall be a two-thread, double-lock

stitch, or a double row of single-thread, chain stitch. If heat bonding is to be used, care must be taken to avoid burn through of the geotextile. It is important that the geotextiles be joined continuously along to the roll as to prevent any fugitive particle migration into the geonet core flow channels.

c. Slope Corner

In the slope corners, the direction of the slope changes at the corner diagonal line as illustrated in Figure 3. It's recommended to first place an additional panel along the corner diagonal line of the adjacent slope. The panels from the opposite slope should be placed to extend on top of the additional panel. Then the panel for the slope which contains the additional panel should be placed to meet (butted) the opposite slope panels.

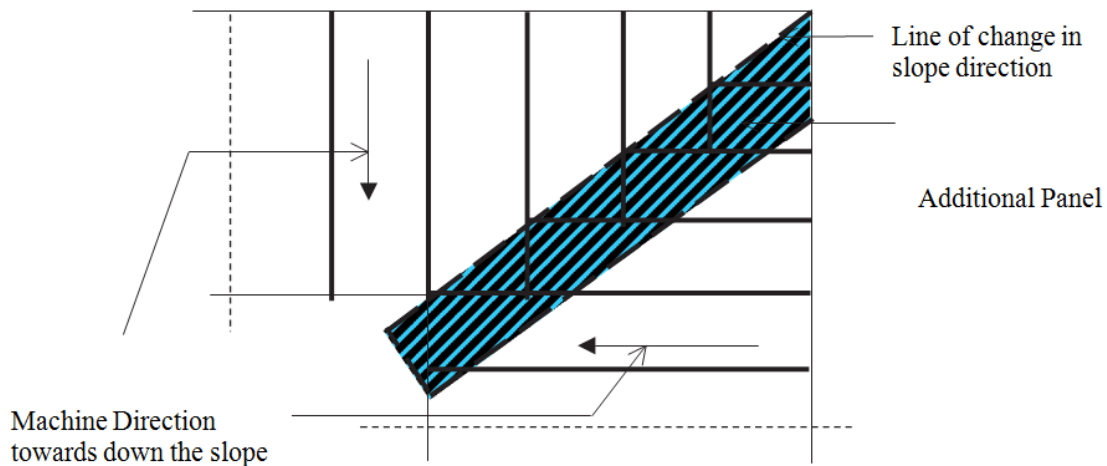


Figure 3. Detail of Slope Corners

3. Repairs

- Geotextile Damage

Any small holes or tears in the top geotextile shall be patched with an 8" x 8" geotextile piece. The patching geotextile shall be the same as the original one. Apply the spray adhesive (*3M Super Hi-Strength 90 adhesive is the recommended*) to one side of the 8" x 8" geotextile patch. Center and apply the 8" x 8" geotextile patch over the blemish, hole, tear or thin spot in the geotextile. Firmly press 8" x 8" textile patch over the repair area. If the damaged area of the geotextile is greater than this standard patch size, a bigger size patch is recommended using a multitude of 8" x 8" patches. If the geotextile is damaged beyond 50 percent of the width of the roll, a continuous piece of fabric the same width as the GGVL may be cap-stripped directly to the adjacent seams by sewing a portion of the new geotextile in place.

- Geonet Damage:  
Any large rips, tears or damage areas on the deployed GGVL core shall be removed and patched by placing a patch extending 12” beyond the edges of the damaged areas. The patch shall be secured to the original geonet tying every 6 inches with approved tying devices. If the hole or tear width across the roll is more than 50% percent the width of the roll, the damaged area shall be cut out.

C. FAILING GGVL Construction Quality Assurance (CQA) TESTS:

In case of any failing CQA tests, “blocking” test on before and after the failing roll(s) shall be conducted to identify the affected rolls in the lot. The rejected rolls shall be excluded from the lot in consideration. The product manufacturer shall be responsible for any cost associated with blocking testing.

TP-4010 CLEANUP: Upon completion of the work, the entire site shall be cleared of all debris, and the ground surface shall be graded and finished smooth, uniform slopes and shall present a neat and workmanlike appearance. Cleanup shall be considered an incidental item and no additional payment shall be made for it, but rather its costs shall be merged with the applicable pay item.

TP-4011 AS-BUILT DRAWINGS: The Contractor shall be responsible for keeping accurate records of all installed items under this section of the specifications and indicating revisions of the government furnished construction drawings in sufficient detail to be accepted by the Engineer for as-built drawings. For the Contractor's information, sufficient detail under this contract means that the Contractor shall take accurate measurements and record them on the drawings to provide the minimum information of at least two swing ties and distances to permanent objects and/or marker posts for the location of any stabilization material placed; the location and depth of rock encountered; the location of any berm center line corners; all centerline distances; berm and bottom elevations at all corners and centers; and control structure elevations. Also to be noted on the plans is the final elevation of all manhole lids, inverts, and the ground immediately adjacent to the manhole lid and the distance and angles between the manholes. Further information on as-builts is contained in the Special Provisions section of these specifications.

The recording of the as-built information is considered an integral part of the progress of this construction and shall be reviewed with the Engineer in determining progress under this contract.

TP-4012 MEASUREMENT AND PAYMENT:

- A. Lagoon Construction: The payment for the lagoon construction as specified herein shall be made at the per job price as listed in the bid schedule. The price will be full compensation for furnishing all labor, tools, equipment, and materials required to complete all excavation, construction, hauling excess material to waste, watering and compaction of the berms and excavated areas, bottom grade preparation of the lagoon, shaping and constructing the

berms, removal of existing sludge and wasting back into the percolation cell area, soils testing, safety rope, and all incidental work necessary to complete the work as shown on the drawings and as herein specified.

The estimated amounts of compacted fill and cut material in cubic yards are indicated on the drawings. They are meant only for estimating purposes and the Contractor shall satisfy himself as to the actual quantity of material required. The lagoon berm as shown on the plans shall be constructed at the lump sum price bid regardless of the actual quantity of materials hauled and compacted. Compensation for all incidentals not specifically listed in the bid schedule but specified under TP-40 shall be included in the lump sum price bid for Lagoon Construction.

The lump sum bid price for the lagoon construction shall also include payment for full compensation for furnishing all labor, equipment, materials, and incidentals required for complete installation of lagoon level gauge, epoxy coated concrete footing, stainless steel straps, wood and materials to complete all the work shown on the drawings and as herein specified.

- B. Sludge Removal, Hauling and Placement: Payment for sludge removal, hauling and placement shall be made at the per job price as listed in the bid schedule for furnishing all labor, equipment, materials, and incidentals required for completion of all work as shown on the drawings and as herein specified. The estimated sludge removal quantity indicated on the construction drawings are based on hand calculations. They are meant only for estimating purposes and the contractor shall also satisfy himself/herself on the actual quantity of sludge material to be removed and placed at land application site within the reservation.
- C. Lagoon Transfer Structures: Payment for construction of each transfer structure shall be at the unit price indicated on the bid schedule. Such payment shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including, but not limited to excavation, form work, concrete, reinforcing steel, piping, liner penetrations, valves, valve boxes, insulation, vents, as-builts, and clean-up required to provide a complete and operational structure as indicated in the plans and detail drawings.
- D. Lagoon Inlet Structures: Payment for construction of each lagoon inlet structure shall be at the unit price indicated on the bid schedule. Such payment shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including, but not limited to excavation, form work, concrete, reinforcing steel, piping, liner penetrations, concrete pipe supports, stainless steel straps and connections, splash pads, additional HDPE liner layer under concrete, as-builts, and clean-up required to provide a complete and operational structure as indicated in the plans and detail drawings.
- E. Discharge Manhole: Discharge manholes shall be measured each. Payment shall be at the

contract unit price shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, hatch, adjustment of height, invert forming, pipe boots, connection to force main, connection of discharge pipe to lined lagoon, backfilling, as-builts, and final cleanup.

- F. HDPE Liner: Payment for the constructed HDPE liner shall be at the contract unit price per acre shown on the Bid Schedule for furnishing all labor, equipment materials and incidentals for fabrication and installation of the lagoon cell liners specified. Such payment shall include, but not be limited to, furnishing materials, surface preparation, field fabrication and placement of liner, sealing and attachment to appurtenant pipes and structures, testing, and final trench anchoring.
  
- G. Geocomposite Gas Venting Layer (GGVL): All work required for GGVL shall be at the contract lump sum price shown on the Bid Schedule for furnishing all labor, equipment materials and incidentals for fabrication and installation of the GGVL. Such payment shall include, but not be limited to, furnishing materials, surface preparation, field fabrication and placement of GGVL, sealing, testing, and final trench anchoring.

TP-4012 SUBMITTALS:

- A. Soils testing laboratory
- B. Piping materials
- C. Lagoon level gauge structure and materials (gauge, epoxy, pipe, concrete, straps)
- D. Piping Structure Materials
- E. Equipment to be used for earthwork
- F. HDPE liner and pipe boots
- G. HPDE liner manufacturer's representative
- H. Geocomposite gas venting layer (GGVL):
  - 1. Accreditations Certificates shall be submitted showing the GGVL manufacture's quality control laboratory is currently and have maintained a minimum of 2 consecutive year's accreditation via the Geosynthetics Accreditation Institute's laboratory accreditation program (GAI-LAP).
  - 2. Quality Control Certificates: For GGVL delivered to the site, quality control certificates shall be provided for every roll of GGVL. Each certification shall have the roll identification number(s), test methods, frequency, and test results.
  - 3. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.
  - 4. GGVL Panel Layout: The predominant flow direction of the GGVL is in the machine (roll) direction. The GGVL shall be installed to maximize its flow capability. The Contractor shall submit and have approved by the engineer a GGVL panel layout prior to placement of the GGVL.
  - 5. Furnish copies of delivery tickets or other approved receipts as evidence for GGVL received.

## SECTION 11375

### FLOATING AERATORS

#### PART 1 GENERAL

##### 1.01 WORK INCLUDED

- A. Floating aerators and appurtenant controls

##### 1.02 RELATED WORK

- A. Electrical (by others)

##### 1.03 SUBMITTALS

- A. Product and Performance Data

- B. Operation and Maintenance Manuals

- 1. In addition, the manual shall contain complete detailed instructions on the balancing procedure to be used for re balancing the propeller after it has been in service for an extended period of time. These instructions shall include, but not be limited to, a general procedural description, a detailed explanation of preparing the unit for balancing, for setting up the dynamic balanced portable balancing technique, a detailed description of the vector chart method of single plane balancing and sample balancing record forms.

- C. All welding is to be performed by welders certified by the A.W.S. in accordance with the requirements set forth in the A.W.S. D1.1 Structural Welding Code. Certification of both the A.W.S. and employment by the manufacturer must be provided with submittals.

- D. All product and welding certifications as specified in this Section (1.03)

##### 1.04 PROJECT SITE CONDITIONS

- A. As shown in the Schedule, Section 3.03.



1.05 QUALITY ASSURANCE

- A. Aerators to be specifically recommended for the designed application by the manufacturer.
- B. Aerators of other manufacturers which meet or surpass the materials and features of construction, and the performance of the selected aerators are acceptable. The ENGINEER shall be the sole judge as to equivalency.
- C. Aerators and all their controls shall be supplied as a unit from a single manufacturer.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Aqua Aerobics Systems, Inc.

2.02 DESIGN CHARACTERISTICS

- A. Drive Motor
  1. Power as shown on schedule, Section 3.03.
  2. Motor shall be wired for 460 volts, 60 cycle, three phase service.
  3. Totally enclosed, fan cooled, and rated for severe chemical duty and 1.15 service factor.
  4. Motor windings: nonhygroscopic with insulation equal to NEMA Class F.
  5. Condensate drain located at the lowest point in the lower end bell housing.
  6. A labyrinth seal shall be provided below the bottom bearing to prevent moisture from penetrating around the motor shaft.
  7. All motor frame parting surfaces shall be deep registered and permatex-sealed.
  8. All through bolts, nuts, and screws: Type 18 8 stainless steel.
  9. Stainless steel nameplate: Provided with each motor, securely fastened thereto. Voltage, speed, insulation class, amperage, service factor, serial number and manufacturer's name shall be steel stamped in nameplate.
  10. Where indicated in the schedule in Section 3.03, furnish aerators with two speed, two winding variable torque motors. Single wound, two speed motors shall not be acceptable.
  11. High Efficiency Motor will be provided.
- B. Motor Shaft
  1. One piece continuous from the top motor bearing through the lower bearing and down to and through the propeller. This shaft will have a minimum diameter of 1-3/4".

2. Manufactured from 17 4 PH stainless steel, or comparable stainless steel having a minimum yield strength of 100,000 psi on units 3 HP and larger.
  3. For one piece shaft arrangements, the following conditions are required:
    - a. Motor support deflector shall utilize a shaft deflector limiter to limit the radial deflection of the motor shaft.
    - b. Shaft deflector limiter: Located in the lower portion of the motor support deflector.
    - c. Deflector limiter: Molded from Delrin and larger through the bore than the diameter of the motor shaft.
- C. Aerators shall operate at no more than 1,200 rpm for motors between 20 HP and 75HP and below 1,800 rpm for motors between 3 HP and 15 HP.
- D. Motor Bearing
1. Regreasable. Sealed bearings not acceptable. Top bearing shall be shielded on the bottom side only. Bottom bearing shall be open.
  2. Two bearing configuration: Top and bottom bearing shall be of the combined radial and axial thrust type and shall be packed at the factory with Chevron SR1 2 or equivalent grease. Lower motor bearing inner race shall be locked to the motor shaft via a special washer and locking nut arrangement. Snap ring type bearing retainers not acceptable.
- E. Diffuser Head
1. Designed to produce a liquid discharge in an angle of 90° to the motor shaft and over a 360° pattern in the horizontal plane.
  2. Epoxy coated nodular iron monolithic casting or stainless steel monolithic casting as scheduled in Section 3.03.
  3. Diffuser head casting shall act as a base for the aerator motor.
  4. Alignment of the motor to motor base shall be controlled by machined index fittings that engage the P Base of the motor. Diffuser motor arrangements that are dependent upon bolt holes only for alignment are not acceptable.
  5. The diffuser head shall absorb all normal and shock loads encountered by the propeller and transmitted to the diffuser head via the motor shaft and lower motor end bell.
  6. The diffuser shall have the minimum weight as scheduled in Section 3.03 in order to minimize vibration and provide adequate strength.
  7. Low trajectory diffuser will be provided.
- F. Flotation
1. Each aerator shall have not less than the reserve buoyancy scheduled in Section 3.03 to ensure stability and provide support flotation required during servicing.
  2. Flotation stability shall be provided by design. No counter balancing or ballast of liquid or solid mass or weight displacement shall be acceptable.
  3. The float shall be a minimum of 71" in diameter and 12" thick, and shall be fabricated of approved fiberglass construction as later described herein.

4. The float shall be constructed so that all stress imposed from wave action and mooring line to another by pulling across the float in such a manner as not to "flex" the structure. Floats of fiberglass construction must have internal reinforcements to transmit those forces. Mooring connections will not be allowed to stress the fiberglass hull in any way.
5. All floats shall be constructed allowing no voids. Only closed cell polyurethane foam having a minimum 2.0 lbs/ft<sup>3</sup> density shall be allowed.
6. All floats shall have a minimum of three mooring points, spaced as shown on Drawings around the outer circumference. No mooring connections will be allowed as imbedments in the upper or lower float covers. Only tension type connections perpendicular to the outer sidewall are acceptable. All mooring connections shall be stainless steel.
7. Floats constructed of polyester fiberglass resins shall have a minimum resin/glass content of 70% resin and 30% glass. A minimum 0.014 inch thick gel coat shall cover the entire outer float shell.
8. A moisture inhibitor, such as N.P.G. (NCO penthal glycol) or equal, and an ultra violet inhibitor, such as UV9 or equal shall be used to protect the float from moisture and sunlight damage.
9. The float construction shall be such that the volute, when encased inside the float, will distribute the load of the entire motor, drive, diffusion head and volute static load plus the entire dynamic load from the propeller thrust and radial forces by spreading these forces uniformly around the full 360 degree circumference of the float's central core. Point connected joints or point stressed connections will not be accepted.
10. The minimum flexural strength of the fiberglass construction materials shall be 26,000 psi and the minimum tensile strength shall be 10,000 psi.

G. Propeller

1. Precision casting of 316 stainless steel, 11-1/2" diameter, specifically designed for the application intended. Self-cleaning type that will not accumulate fibers, rags, or stringy materials. Attachment to the shaft will be by set screws, one through pin and "lock tite."
2. Each propeller blade shall be pitched so that the pitch angle and rake angle are within plus or minus 2 percent of the other blade(s). The propeller shall be pitched so that the drive motor is loaded between 88% and 94% of full load nameplate horsepower.
3. Units using inclined screw impellers will not be acceptable.
4. The propeller must be attached to the motor shaft with a hardened stainless steel pin and set screw. No tapered, threaded shafts with nut fasteners will be acceptable.

H. Volute

1. The propeller shall operate in a volute made of 304 stainless steel and shall be a minimum of 12" in diameter. It shall be round and true so that propeller blade tip clearance is uniform within the volute as it rotates. The

volute shall have a minimum of 3/16 inch wall thickness, and a minimum of four full length stainless steel gussets shall be welded on 90° spacing around the circumference of the volute between the top and bottom flanges.

2. The volute shall have a large machined flange at its top extremity that completely encircles the volute, and this flange shall match a similar flange on the bottom of the diffusion head to provide for a bolted, machined flange-to-flange fit to provide uniform distribution of the dynamic loads generated by the propeller and the static weight of the motor and drive. A 360° machined index in the upper flange shall provide concentric alignment of the propeller in the volute by engaging the inside diameter of the mating flange on the diffusion head. Bolt holes alone will not be acceptable to locate the important alignment of the propeller.
3. Fiberglass volutes or carbon steel volutes that are fiberglass or stainless steel lined are not acceptable.
4. Provide stainless steel draft tube extensions required for proper intake location within the tank as recommended by manufacturer.

I. Electrical Service Cable

1. Each unit shall be furnished with the required footage of four conductor, continuous length (non-spliced) underwater electric service cable. Units with two speed motors shall be furnished with independent service cables for high and low speeds.
2. The aerator manufacturer shall furnish the cable with the motor end sealed into the motor terminal box and wired for 460 volt service. The aerator manufacturer shall be responsible for this watertight seal and electrical connection. The other end of the cable will be wired into the power supply by the installing CONTRACTOR.
3. Only flexible type copper stranded cable with four individually jacketed conductors bound together with a non-hygroscopic filler and sheathed in a PVC. Outer jacket shall be high quality CPE, PVC, TPE or equal, and shall be rated at a conductor operating temperature of not less than 90°C.
4. The cable shall be rated for hard usage outdoor service and shall be resistant to oil, sunlight, ozone, grease, acids, water, abrasion and impact.

J. Mooring

1. The anchor cable shall be installed as recommended by the manufacturer and shown on Drawings so the mixer will have a minimum of lateral movement.
2. The maximum amount of anticipated water level variation is 1 foot.
3. Anchor cable shall be 7 x 19 construction, 304 stainless steel and 3/16-inch diameter.
4. Hardware:
  - a. Mooring hardware (thimbles and clips) shall be of 316 stainless steel.
  - b. Galvanized hardware is not acceptable.
5. Cable floats:

- a. Shall be made so that internal void is filled with closed-cell polyurethane foam of 2.0 lbs/ft<sup>3</sup>; density.
- b. Floats to be attached to the mooring cable with Ty-wraps.
- c. These latches shall be of the clamp type.
- d. No embedment into the fiberglass will be allowed.

K. Balancing and Vibrational Analysis

- 1. Once the power section (consisting of the motor, its support base, extended shaft and propeller) is assembled, the rotating elements of the power section shall be dynamically balanced to 2.0 mils peak to peak maximum amplitude (0.20" per second velocity) measured at the top and bottom motor bearing. Measurements shall be taken at a frequency equal to the motor speed (RPM) and at a frequency equal to the number of propeller blades times the motor speed.
- 2. Aerators that have their rotating elements factory assembled must be tested for vibrational velocity levels at the factory prior to shipping.
- 3. Units that are to have the rotating elements field assembled must also be factory balanced and tested. Documentation of the test results and certification that these results do meet this portion of the specifications shall be furnished to the ENGINEER prior to shipment. Such documentation notwithstanding, the units having rotating elements field assembled shall be field tested for vibration velocity levels after final assembly. These tests shall be conducted by the aerator manufacturer, or his duly appointed representative, and these tests shall, at his option, be witnessed by the ENGINEER.

2.03 AERATION PERFORMANCE

- A. Oxygen Transfer: Minimum of 3.0 lbs/hp/hr as determined by the unsteady state test technique at the standard conditions of 2.0 ppm dissolved oxygen, 1 atmosphere, and 20°C.
- B. Mixing and Dispersing
  - 1. Aerator to provide sufficient kinetic energy to maintain complete mixing and uniform oxygen dispersion within the respective diameter circles scheduled in Section 3.03.

2.04 COLD WEATHER EQUIPMENT

- A. When listed in the schedule in Section 3.03, furnish the following equipment:
  - 1. Heater pack on each aerator, submersible cable with floats to each aerator for heater power, cord grips, boxes, and accessories. Cable shall be the same type as the electrical service cable.
  - 2. Weatherproof temperature sensor and controls for each aerator or for each group of aerators as shown on Drawings.

3. All other hardware and appurtenances necessary for proper cold weather operation.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. As specifically recommended by the equipment manufacturer.

### 3.02 START UP SERVICES

- A. Provide a factory trained service representative to be present to check field installation and operation.
- B. A factory trained service representative to provide a minimum of 4 hours of training to operating personnel on operation and maintenance of aerator equipment.
- C. Certify in writing to the ENGINEER that the equipment has been properly installed, fully functional, and ready to use.

### 3.03 SCHEDULE

- A. Number of aerators: Two
  1. Horsepower of Unit = 10
  2. Equipped with two speed motors = No
  3. Provided with cold weather equipment = No
  4. Diffuser head material = Stainless Steel
  5. Minimum weight of diffuser = 205 lbs
  6. Parts = Stainless Steel
  7. Float hull material = Stainless Steel
  8. Buoyancy reserve capacity = 995 lbs
  9. Mooring cable floats = required
  10. Site Elevation = 6700 feet above MSL
  11. Oxygen Dispersion Diameter = 200' min

END OF SECTION