## VOLUME I

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COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Electrical equipment coordination and installation.
   2. Sleeves for raceways and cables.
   3. Sleeve seals.
   5. Common electrical installation requirements.

1.03 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

A. Product Data: For sleeve seals.

1.05 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2 - PRODUCTS

2.01 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.
   1. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
      b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.02 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.
      e. <Insert manufacturer's name.>

   2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

   3. Pressure Plates: Stainless steel. Include two for each sealing element.

   4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.03 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.
3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.02 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.03 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.04 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION
SECTION 26 05 03

WIRE CONNECTIONS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Wire connections.

1.02 REFERENCES

A. National Fire Protection Association (NFPA).
   NFPA 70 National Electrical Code (NEC)

B. Underwriters Laboratories, Inc. (UL).
   UL 467 Grounding and Bonding Equipment
   UL 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors

PART 2 - PRODUCTS

2.01 TWIST-ON CONNECTOR

A. UL pressure-type, solderless, insulated, wound spring grip twist on connector.

B. Solderless pressure connectors for terminals, taps, and splices.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Follow manufacturers' instructions using manufacturers' recommended tools.

B. Stripping Insulation: Carefully strip, avoid nicking conductor. No "ringing".

C. Design: Connectors shall be designed and approved for the purpose used. Connectors between aluminum and copper shall be listed “AL/CU” for the purpose of preventing electrolytic action.

D. Bare Connectors and Conductor Free Ends: Wrap with insulating rubber or friction tape to equivalent insulation of wire.

E. Ground Continuity to Metallic Surfaces: Remove any paint coating and polish surface beneath connection.
F. Copper conductors may be terminated in any approved compression or mechanical connector, including set screws.

G. No splices or taps permitted in feeder or branch circuit terminating in a single outlet.

H. Branch circuit splices and taps in junction and outlet boxes shall be twist-on connectors.

I. Motor lead connections shall be made by bolting the lug of the motor lead back-to-back with the connector lug. The bolting together shall be with proper size machine screws using flat washers.

J. Motor connections shall be taped with one layer of yellow varnish cambric tape and then covered with insulating rubber to equivalent insulation of wire.

K. Conductor and cable copper shall not be reduced at the terminal for making connections.

L. Slack shall be left at equipment, pullboxes, or outlet boxes to allow for a neat termination.

END OF SECTION
SECTION 26 05 19

WIRES AND CABLES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Wires and cables.

1.02 REFERENCES


ASTM D 1351 Polyethylene Insulated Wire and Cable

B. Federal Specifications (FS).

FS J-C-30 Cable and Wire, Electrical (Power, Fixed Installation)

FS QQ-W-343 Wire, Electrical (Uninsulated), FSC 6145

C. Insulated Cable Engineers Association (ICEA).

D. Institute of Electrical and Electronic Engineers (IEEE).

E. InterNational Electrical Testing Association (NETA).

F. National Fire Protection Association (NFPA).

NFPA 70 National Electrical Code (NEC)


1.03 DELIVERY, STORAGE AND HANDLING

A. Deliver new wire to site in new standard coils or reels with approved tag denoting length, wire size, insulation type, and manufacturer's name.

B. Protect from weather and damage during storage and handling.
PART 2 - PRODUCTS

2.01 MATERIALS

A. Building Wire:
1. 98 percent conductivity copper stranded.
2. 600 volt insulation.
3. Type THWN in sizes No. 8 AWG and smaller.
4. Type XHHW in sizes No. 6 AWG and larger.
5. Wire for high temperature areas shall be as otherwise noted. Provide high temperature wiring for the following:
   a. Connections to equipment such as boilers, furnaces, and the like.
   b. Where conduit and wiring runs in the same enclosed space with piping (whether or not insulated) which contains 200 degrees F (100 degrees C) and higher temperature fluid.
6. In lieu of the previously specified types, conductors with a single or dual type insulation, THWN 75 degrees C wet location application, and THHN for 90 degrees C dry location application may be used where termination provisions at utilization equipment and at distribution and control equipment are based on the use of insulated conductors as defined in UL “Electrical Construction Materials Directory.”

B. Branch Circuit Wiring: Conductors smaller than No. 12 AWG for circuits less than 100 feet in length and smaller than No. 10 AWG for circuits for more than 100 feet in length not permitted.

C. Exterior Wiring: Type XHHW for overhead installation. XHHW or THWN for underground installation.

D. Control panel wiring minimum No. 14 AWG stranded switchboard type MTW or SIS unless otherwise specified on the drawings.

E. Minimum size wiring for emergency systems shall be No. 10 AWG.

F. Motor control wires shall be No. 14 minimum for circuits less than 300 feet in length and No. 12 minimum for circuits more than 300 feet in length.

G. Wire for special areas shall be as specified on the drawings.

H. Grounding conductors and grounded conductors shall be color coded in accordance with the latest edition of the NEC.

I. Instrumentation Cable.
1. Conductor: Stranded bare copper, twisted pair conductors with metalized mylar shield.
2. Insulation: Extruded PVC, temperature of 90 degrees C minimum.
3. Conductor Identification: Color coded black and white with group number printed on each insulated conductor for circuit identification.


5. 12 pair conductors minimum or as noted on drawings.

6. Overall metallic or aluminized mylar tape shield with tinned copper drain wire.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Make conductor length for parallel feeders identical in length, size, type and wire stranding configuration.

B. Lace or clip groups of feeder conductors at distribution centers, pullboxes, and wireways.

C. Provide copper grounding conductors and straps. A ground wire shall be pulled through conduits and used as the equipment grounding conductor. Conduits shall not be used for grounding.

D. Install wire and cable in conduit.

E. Use wire pulling lubricant for pulling No. 4 AWG and larger wire. Lubricant shall be UL approved type only, compatible with all materials in contact with conduit, wiring, and insulation.

F. Install wire in conduit runs after concrete and masonry work is complete and after moisture is swabbed from conduits.

G. Splice only in accessible junction or outlet boxes. Splices in feeders and services shall not be permitted. Splices or taps in branch circuits permitted only in junction boxes where circuits divide.
H. Color code conductors to designate neutral, phase, and ground as follows;

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Description</th>
<th>ID Label</th>
<th>120/208 V</th>
<th>277/480V 480V &amp; Above</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 3-Phase</td>
<td>Phase A</td>
<td>A</td>
<td>Black</td>
<td>Brown</td>
</tr>
<tr>
<td></td>
<td>Phase B</td>
<td>B</td>
<td>Red</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td>Phase C</td>
<td>C</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>Neutral</td>
<td>White</td>
<td>Gray</td>
</tr>
<tr>
<td></td>
<td>Ground</td>
<td></td>
<td>Green or Bare</td>
<td>Green or Bare</td>
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<tr>
<td>AC 1-Phase</td>
<td>Line 1</td>
<td>L1</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Line 2</td>
<td>L2</td>
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<td></td>
<td>Neutral</td>
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<td>White</td>
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</tr>
<tr>
<td></td>
<td>Ground</td>
<td></td>
<td>Green or Bare</td>
<td></td>
</tr>
</tbody>
</table>

Exception to above color code: Where there is an existing and defined color code in a building, new work in that building will use the existing color code.

1. Motor control conductors shall be red for the “STOP” or No. 1 wire, yellow for the “SEAL-IN” or No. 2 wire, and blue for the “START” or No. 3 wire.
2. Wires shall be factory color coded by integral pigmentation. Colored plastic tape permitted on No. 6 AWG and larger where integral pigmentation impractical. Apply tape in spiral half-lap over exposed portions in manholes, boxes, panels, switchboards, and other enclosures.
3. All circuit conductors shall be identified at all terminals, intermediate outlets, disconnect switches, circuit breakers, and motor control centers, etc. Both ends of a given conductor shall be identified alike.

I. DO NOT install wires of different voltage systems in the same raceway, box, gutter, or other enclosure.

J. In no instance shall cable be bent to a radius smaller than that specified by the manufacturer. Where manufacturer's minimum bending radius data is not available, the following shall apply:
   1. Minimum bending radius shall be as recommended by the Insulated Cable Engineers Association (ICEA) for permanent training during installation and as required by the NEC.
   2. The limits specified herein shall not apply to duct or conduit bends, sheaves, or other curved surfaces around which power cables may be pulled, under tension, while being installed. Such conditions require bends of larger radius.
   3. The minimum radii specified above refer to the inner surface of the cable and not to the axis of the cable.

K. Tag feeder circuits in each enclosure with wrap around circuit designation labels where more than one feeder passes through or terminates in the enclosure.
L. Motor Lead Connections: Bolt the lug of the motor lead back-to-back with the connector lug with proper size machine screws using flat washers. Wrap with friction tape with sufficient number of wraps so splice is equal to the wire insulation voltage rating.

M. Special or high voltage splicing techniques (methods) shall be as specified on the drawings.

N. Splices on wire size 1/0 and larger, except for high voltage, shall be with vinyl tape or rubber tape covered with vinyl tape. There shall be a sufficient number of wraps of tape so the splice is equal to the wire insulation voltage rating.

O. Provide drip pans under all fluid conducting piping which runs over exposed conductors as noted elsewhere in these Specifications.

3.02 ACCEPTANCE TESTING

A. Low voltage and medium voltage cables shall be inspected and tested as specified by the InterNational Electrical Testing Association, Inc. to determine the suitability for energization.
   1. Representative of the Owner shall be present to witness all phases of the tests.
   2. Notify the Owner at least 7 days before the testing is to be performed.
   3. Upon completion of the tests, a written record of all tests shall be furnished to the Owner within 30 days.

END OF SECTION
SECTION 26 05 26

GROUNDING AND BONDING

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Equipment grounding conductors.
B. Bonding.

1.02 REFERENCES

   ATS Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

B. National Fire Protection Association (NFPA).
   NFPA 70 National Electrical Code
   NFPA 99 Health Care Facilities

1.03 GROUNDING SYSTEM DESCRIPTION

A. Concrete encased electrode.

1.04 PERFORMANCE REQUIREMENTS

A. Grounding System Resistance: 10 ohms, unless lesser value noted.

1.05 SUBMITTALS

A. Product Data: Provide for grounding electrodes and connections.
B. Test Reports: Indicate overall resistance to earth to ground and resistance of each electrode.
C. Manufacturer’s Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
D. Operation and maintenance data.
E. Project Record Documents: Record actual locations of components and grounding electrodes.
F. Certificate of Compliance: Indicate approval of installation by authority having jurisdiction.
1.06 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum of three years experience.

1.07 REGULATORY REQUIREMENTS
A. Conform to requirements of NFPA 70.
B. Products: Listed and classified by Underwriters Laboratories, Inc., or testing firm acceptable to the authority having jurisdiction, as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.01 WIRE
A. Material: Stranded copper.
B. Foundation Electrodes: 2/0 AWG, minimum.
C. Grounding Electrode Conductor: Size to meet NEC requirements, minimum. Provide larger conductor as shown.
D. Bonding Conductor: Copper conductor, bare or insulated.

2.02 MECHANICAL CONNECTORS
A. Material: Bronze.

PART 3 - EXECUTION

3.01 EXAMINATION
A. Verify existing conditions prior to beginning of Work.
B. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.02 INSTALLATION
A. Install in accordance with manufacturer's instructions.
B. Install rod electrodes at locations indicated. Install additional rod electrodes as required to achieve specified resistance to ground.
C. Provide grounding well pipe with cover at each rod location, where indicated. Install well pipe top flush with finished grade.
D. Install bare copper wire in foundation footing where indicated.

E. Provide grounding electrode conductor and connect to reinforcing steel in foundation footing where indicated or perimeter ground system. Bond steel together.

F. Provide bonding to meet Regulatory Requirements.

G. Bond together metal siding not attached to grounded structure; bond to ground.

H. Bond together reinforcing steel and metal accessories in pool and fountain structures.

I. Bond structural steel to perimeter grounding system structures.

J. Bond lightning down conductors to perimeter grounding system.

K. Install transient suppression plate where indicated.

L. Install ground grid under access floors where indicated. Construct grid of 2 AWG bare copper wire installed on 24 inch (600 mm) centers both ways. Bond each access floor pedestal to grid.

M. Bond together each metallic raceway, pipe, duct and other metal object entering space under access floors. Bond to underfloor ground grid. Use 2 AWG bare copper conductor.

N. Provide isolated grounding conductor for circuits supplying electronic cash registers, personal computers, and the like.

O. Provide grounding and bonding in patient care areas to meet requirements of NFPA 99 and NFPA 70.

P. Equipment Grounding Conductor: Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.

Q. Interface with site grounding system installed.

R. Interface with lightning protection system installed.

3.03 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.13.

END OF SECTION
SECTION 26 05 29
SUPPORTING DEVICES

PART 1 - GENERAL

1.01 WORK INCLUDED
A. Inserts.
B. Conduit hangers and supports.
C. Anchors.
D. Sleeves.
E. Flashing and seals.
F. Firestop foam.

1.02 REFERENCES
B. ASTM E 84 Surface Burning Characteristics of Building Materials
C. Federal Specifications (FS).
D. FS FF-S-325 Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
E. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS).
F. MSS-SP-58 Pipe Hangers and Supports – Materials, Design and Manufacture
G. MSS-SP-69 Pipe Hangers and Supports – Selection and Application
H. MSS-SP-89 Pipe Hangers and Supports – Fabrication and Installation Practices
I. National Fire Protection Association (NFPA).
J. NFPA 70 National Electrical Code (NEC)
PART 2 - PRODUCTS

NOTE: Unless otherwise noted, all references to types of devices refer to MSS-SP-69.

2.01 INSERTS

A. Galvanized malleable iron shell and expander plug for connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms, Type 18.

B. Size inserts to suit threaded hanger rods.

2.02 CONDUIT HANGERS AND SUPPORTS

A. Hangers, Single Runs: Adjustable galvanized wrought steel clevis, Type 1. Steel rod hangers.

B. Hanger, Multiple runs: Trapeze hangers. Trapeze shall be cold-formed, U-shaped cross section, slipped channels, not less than 1-1/2 inch x 1-1/2 inch (40 mm x 40 mm) No. 12 gauge, designed to accept special spring held, hardened steel nuts for securing hanger rods or other attachments. System shall be zinc or cadmium plated. Steel rod hangers. Hanger rods shall be one size larger than size specified herein for largest conduit on trapeze. Where trapeze length exceeds 42 inches (1050 mm), additional hanger rods shall be installed equidistant, a maximum of 42 inches (1050 mm) apart. Each multiple hanger shall be designed to support a load equal to the sum of the weights of the conduits and contents, the weight of the hanger itself, and 200 pounds. Two or more channels may be welded together to form horizontal members of greater strength than single channels.


D. Wall Support, Conduit to 1-1/2 Inch (40 mm): Light steel bracket, Type 31, attached to wall surface. Galvanized conduit straps.

E. Wall Support, Conduit 2 Inches (50 mm) and Larger: Galvanized welded steel bracket, Type 32 or 33. With galvanized iron one-hole conduit clamp.

F. Vertical Support, at Floor Penetration: Galvanized steel riser clamp, Type 8.

G. Provide steel hanger rods, continuous threaded, except rods, threaded both ends or threaded one end shall be provided for exposed work in kitchens, laboratories, and DOE nuclear production areas. Hanger rods shall be connected to beam clamps, concrete inserts or expansion anchors, “C” clamps shall not be allowed. Eccentric loading by hangers is not permitted.
2.03 ANCHORS

A. Hollow Masonry: Toggle bolts or spider type expansion anchors.
B. Solid Masonry: Preset inserts, or expansion shields.
C. Metal Surfaces: Machine screws, bolts, welded studs.

2.04 SLEEVES

A. Conduit through floors, beams, walls, fireproofing, footings, potentially wet floor, form with Schedule 40 steel pipe.
B. Size large enough to provide movement due to expansion.
C. Firestops shall be provided through sleeves.

2.05 FLASHING AND SEALS

A. Waterproof Seal: Modular mechanical type, interlocking synthetic rubber links, sized to fill annulus between conduit and wall opening or sleeve as required. Rubber links expanded to form watertight seal with zinc-coated bolts.
B. Conduit Seal: Threaded conduit sealing fitting. Fill with Alumina-Silica based packing fiber and conduit sealing cement.
C. Steel Flashing: 26 gauge galvanized steel, to match roof contour.
D. Flexible Neoprene Flashing; Sheet Pipe and Conduit Flashing: One piece, hat-shaped, seamless, molded, 0.060 inch thick uncured neoprene; water absorption by weight maximum one percent; tensile strength of 1800 psi; elasticity of 300 percent with full recover without set; black color.

2.06 FIRESTOPS

A. Fire resistant silicone foam sealant.
B. Does not require heating to expand.
C. Meets requirements of NFPA NEC Article 300-21.
D. UL listed as a “wall opening protective device. Non-toxic, non-allergenic before and after cure.”
E. Char thickness increase rate not to exceed 1 inch (25 mm) per hour.
F. Flame spread 25, Fuel Contributed 25, ASTM E 84 shall not be exceeded.
G. Seals watertight.
2.07 Expansion Shields
   A. Shall conform to FF-S-325, Group III and VIII (except self-drilling may be used for one-quarter load listed).

2.08 Wall, Floor and Ceiling Escutcheons
   A. Material and Type: Chrome-plated brass or chrome-plated steel, one piece type with set screw for fastening to pipe, or sleeve. Use escutcheons that fit tight around conduit, cover openings around conduit and cover the entire sleeve projection.
   B. Thickness: Not less than 3/32 inch for floor escutcheons. For wall and ceiling escutcheons, not less than 0.025 for up to 3 inch conduit, 0.035 for larger conduit.

PART 3 - EXECUTION

3.01 Inserts and Expansion Shields
   A. Use inserts for new concrete work, expansion shields for existing.
   B. Use inserts or expansion shields for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams as necessary.
   C. Set inserts in position in advance of concrete work.
   D. Where concrete slabs form finished ceiling, finish inserts, flush with slab surface.
   E. Powder actuated explosive inserts not allowed.
   F. Inserts shall conform to MSS-SP-58 and MSS-SP-69.

3.02 Conduit Hangers and Supports
   A. Support horizontal conduit runs as follows:

<table>
<thead>
<tr>
<th>Conduit Sizes</th>
<th>Spacing</th>
<th>Hanger Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td>½”, ¾”, 1”, 1-1/4”</td>
<td>5’0”</td>
<td>3/8”</td>
</tr>
<tr>
<td>1-½&quot;, 2”</td>
<td>6’-0”</td>
<td>3/8”</td>
</tr>
<tr>
<td>2-½”, 3”</td>
<td>10’-0”</td>
<td>½”</td>
</tr>
<tr>
<td>3-½” thru 6”</td>
<td>12’-0”</td>
<td>¾”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5/8”</td>
</tr>
</tbody>
</table>

   B. Install hangers to provide minimum ½ inch (15 mm) clear space between adjacent work.
   C. Place a hanger within 1 foot (300 mm) of each horizontal elbow, and any concentrated load.
   D. Use hangers which are vertically adjustable 1-½ inch minimum after conduit is erected.
E. Support vertical conduit at every floor.

F. Where several conduits can be installed in parallel and at same elevation, provide trapeze hangers.

G. Where practical, support riser conduit independently of connected horizontal conduit.

H. Support conduit on each side of wall penetration. Do not use wall for support.

I. Hangers and supports shall be seismically restrained.

J. All hangers shall conform to MSS-SP-58 and MSS-SP-69, unless otherwise specified herein.

3.03 FLASHING AND SEALS

A. Waterproof Seal: Install and tighten seal as recommended by manufacturer.

B. Conduit Seal: Install as recommended by manufacturer.

3.04 SLEEVES

A. Install per drawing details. Holes for sleeves in floors and in concrete walls shall be core drilled in existing work or formed in new work.

B. Where conduit passes through floor, ceiling or wall, close off space between conduit and construction. Seal watertight with silicone sealant and firestop foam. Provide tight fitting metal caps on both sides and caulk.

C. Where sleeves are placed in exterior walls below grade, the space between the conduit and the sleeves shall be made completely waterproof.

D. Check floor and wall construction finishes to determine proper length of sleeves for various locations; make actual lengths to suit the following:
   1. Terminate sleeves flush with walls, partitions, and ceiling except as noted.
   2. In areas where conduits are concealed, as in chases, terminate sleeves flush with floor.
   3. In dry areas where conduits are exposed, extend sleeves 2 inches (50 mm) above finished floor.
   4. Extend sleeves through potentially wet floors 4 inches (100 mm) above finished floor level. Caulk sleeves full depth.

E. Fasten sleeves securely in floors and walls, so that they will not become displaced. Take precautions to prevent concrete, plaster, or other materials from being forced into the space between pipe and sleeve during construction.
3.05 ESCUTCHEONS

A. Install escutcheons at all wall, ceiling, and floor conduit penetrations to finished areas, including but not limited to offices, laboratories, cafeterias, etc.

B. Do not install at penetrations to mechanical and electrical rooms, or other unfinished areas.

3.06 INSTALLATION

A. Lay out to maintain headroom, neat mechanical appearance, and to support equipment loads required.

B. Exact location and spacing between supports per manufacturer’s recommendations and NEC requirements as minimum.

C. Conduit shall be installed in such a manner as to prevent the collection of trapped condensation. All runs of conduit shall be arranged so as to be devoid of traps wherever possible.

D. Conduit risers exposed in wire shafts shall be supported at each floor level by means of approved U-clamp hangers.

END OF SECTION
SECTION 26 05 33

CONDUIT

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Conduit

B. Fittings.

1.02 REFERENCES

A. Underwriter's Laboratories Inc. (UL).

B. American National Standards Institute (ANSI).
   ANSI C80.1  Rigid Steel Conduit – Zinc Coated
   ANSI C80.3  Electrical Metallic Tubing – Zinc Coated
   ANSI C80.5  Rigid Aluminum Conduit

C. National Electrical Manufacturers Association (NEMA).
   NEMA FB 1  Fittings, Cast Metal Boxes and Conduit Bodies for Conduit and Cable Assemblies
   NEMA RN 1  Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
   NEMA TC-2  Electrical Polyvinyl Chloride (PVC) Tubing (EPT) and Conduit (EPC-40 and EPC-80)
   NEMA TC-3  PVC Fittings for Use with Rigid PVC Conduit and Tubing
   NEMA TC-6  PVC and ABS Plastic Utilities Duct for Underground Installation
   NEMA TC-9  Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation

D. National Fire Protection Association (NFPA).
   NFPA 70  National Electrical Code (NEC)

PART 2 - PRODUCTS

2.01 MATERIALS AND COMPONENTS

A. Conduit.
   1. Galvanized rigid threaded conduit, ANSI C80.1.
   2. Intermediate metal conduit.
   3. Electrical metallic tubing, ANSI C80.3.
   4. Rigid aluminum threaded conduit, ANSI C80.5.
B. Underground Conduit Exterior to Building.
   1. Galvanized rigid steel threaded conduit: 20 mil (0.05 mm) PVC coating, ¾ inches (21 mm) minimum, NEMA RN-1.
   2. Fittings and Conduit Bodies: PVC coated same thickness as conduit, NEMA FB-1.

C. Fittings.
   1. General: Watertight, concretetight for conduit located in or under concrete.
   2. Galvanized Rigid Steel Conduit (GRC) and Intermediate Metal Conduit (IMC): Threaded (pressure type not allowed). Bushings with factory insulated throat.
   3. Electrical Metallic Tubing (EMT): Gland ring compression type only, steel or malleable iron, concretetight or watertight, insulated throats. Sizes 2-1/2 inch (63 mm) and larger may be steel set screw type (4 screws for couplings and 2 screws for connectors). Die-cast zinc alloy fittings not allowed.

D. Flexible Conduit: Steel armor, flexible liquidtight metallic conduit plastic jacketed type with liquidtight connectors. Continuous copper ground in core; watertight fittings.

E. Expansion Joints: Offset or sliding type with bonding straps and clamps. Approved for purpose.

F. Concrete Wall Seals: Modular mechanical type, interlocking synthetic rubber link sized to fill annulus between conduit and steel sleeve. Rubber links exposed to form watertight seal with zinc coated bolts (“Link Seal”).

G. Right Angle Turns: Cast metal fittings or symmetrical bends.

PART 3 - EXECUTION

3.01 CONDUIT

A. Provide threaded rigid galvanized steel or threaded rigid aluminum conduit in all cases except as outlined below:
   1. Provide flexible metal conduit for equipment connections and where installation, operation, or maintenance require flexibility.
   2. Electrical metallic tubing or intermediate metal conduit may be used for interior work where not subject to physical damage; and shall not be used in concrete slabs.
   3. Aluminum conduit shall not be used in or in contact with concrete or with bare copper conductors.
   4. When otherwise noted.

B. For underground conduit outside of buildings, provide conduit as described herein with watertight fittings.
C. Provide connections to motors and equipment with flexible metal conduit. Minimum size \( \frac{3}{4} \) inch (16 mm) for motor connections. Provide sufficient length flexible conduit to avoid transmission of vibration. Sizes not noted on the drawings shall be as required by the NEC, but not smaller than \( \frac{3}{4} \) inch (16 mm).

3.02 INSTALLATION

A. Comply with NECA “Standard of Installation.”

B. Conceal conduit in all areas except as listed below:
   1. Mechanical and electrical equipment rooms.
   2. Connections to motors and equipment.
   3. Connections to surface mounted electrical cabinets, panels, or enclosures.
   4. When new raceways are routed parallel and adjacent to existing exposed utilities such as raceways, ductwork, or piping, overhead clearance shall not be reduced. The bottom of such new raceways and the bottom of associated raceway supports shall not be lower than the bottom of existing exposed utilities.
   5. As otherwise noted.

C. Prime and paint exposed raceway systems to match color of adjacent surfaces.

D. Support conduit in accordance with specification Section SUPPORTING DEVICES.

E. Coordinate installation of conduit in concrete and masonry work.

F. Provide conduit in concrete slab with minimum 2 inch (53 mm) cover. DO NOT install conduit larger than 1 inch (27 mm) nominal size in concrete slabs unless specifically shown or approved. Do not install aluminum conduit in or in contact with concrete.

G. Do not interfere with placement of concrete reinforcing bars. Place conduit between upper and lower layers. Space conduit not less than 8 inches (200 mm) on center, and as wide as possible where converging at panels, etc. Adequately secure conduit boxes, inserts, etc., by mechanical means or suitable adhesive prior to placing concrete.

H. Crushed or damaged conduit shall not be used. Plug ends to prevent entry of dirt or moisture. The use of a pipe tee or a vise for bending conduit will not be permitted.

I. Clean interior of conduit before installation of conductor.

J. Alter conduit routing to avoid structural obstruction, minimizing crossovers. Bends and offsets shall be avoided where possible, but when necessary shall be made with an approved conduit-bending device or machine.

K. Provide UL approved expansion fittings complete with grounding jumpers where conduits cross building expansion joints and for long runs where conduit expansion may be excessive. Provide bends or offsets in conduit adjacent to building expansion joints where conduit is installed above suspended ceilings.

CONDUIT
26 05 33 - 3
L. Route all conduits parallel or perpendicular to building lines.

M. Provide minimum of 6 inches (150 mm) clearance at flues, steam pipes, and other heat sources. Do not run conduit near or in the slab beneath heating units.

N. Provide concrete wall seals for all exterior underground, and fire wall penetrations as noted.

O. Vertical Runs: Straight and plumb.

P. Conduit Running in Groups: Run at same relative elevation, properly spaced and supported as noted elsewhere in these specifications.

Q. Dissimilar Metals: Avoid contact with pipe runs of other systems.

R. Underground Conduit (Exterior to Building): Watertight, including fittings, sloped 3 inches (78 mm) per 100 feet (30 m) downward away from building. Seal exterior junction boxes or provide drainage.

S. Provide underground marking tape. Install in accordance with specification Section DUCTBANKS AND MANHOLES.

T. Lengths and Bends: Maximum number of bends in any run shall be the equivalent of four quarter bends (360 degrees total). Maximum length of any run shall be 300 feet (90 m), less 50 feet (15 m) for each equivalent quarter bend. Junction and pull boxes shall be provided to maintain these limits.

U. Provide permanent identification for all conduits as noted elsewhere in these specifications.

V. Provide drip pans under all fluid conducting piping which runs over equipment, conduits such as cable trays and other conduits with exposed conductors.

W. Internal Sealing: Conduit sealing fittings shall be provided to prevent internal passage of solids, liquids, and gases through electrical conduits:
   1. From one area to another area, through fire rated walls and partitions, and as noted where contamination isolation is required.
   2. From a building interior to exterior.
   3. Located on the most potentially contaminated side of the building penetration or on the interior side for below grade penetrations.

X. Provide steel pull wire in spare and unused conduit.

Y. Provide rigid steel factory elbows for bends with approved adaptors for nonmetallic conduit runs.
3.03 UNDERGROUND DUCT BANK INSTALLATION

A. Provide top of duct bank minimum 30 inches (760 mm) below finished grade unless other dimension shown.

B. Provide conduit with minimum grade of 4 inches (103 mm) per 100 feet (30 mm).

C. Terminate conduit in end bell at manhole entries.

D. Stagger conduit joints in trench by 6 inches (155 mm) minimum.

E. Provide suitable separators and chairs installed not greater than 4 feet (1200 mm) on centers. Band conduit together with suitable banding services. Securely anchor conduit to prevent movement during concrete placement.

F. Provide concrete cover at bottom, top, and sides of duct bank minimum 2 inches (50 mm) and as shown.

G. Provide two No. 15 Bar (No. 5) steel reinforcing bars, ASTM A 615 (ASTM A 615M), Grade 300, in the top of bank under the paved areas.

END OF SECTION
SECTION 26 05 34

PULL, JUNCTION, AND OUTLET BOXES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Outlet boxes.
B. Pull and junction boxes.

1.02 REFERENCES

A. American National Standards Institute (ANSI).
   ANSI C73 Series Dimensions of Attachment Plugs and Receptacles
B. Institute of Electrical and Electronics Engineers (IEEE).
   IEEE C2 National Electrical Safety Code
C. National Fire Protection Association (NFPA).
   NFPA 70 National Electrical Code (NEC)
D. Underwriters’ Laboratories Inc. (UL).
   UL 50 Cabinets and Boxes
   UL 514 Outlet Boxes and Fittings

PART 2 - PRODUCTS

2.01 MATERIALS

A. Standard Outlet Box: Zinc-coated or cadmium-plated galvanized steel. In general, 4 inches square by 1-1/2 inches (100 mm x 40 mm) for switch and receptacle outlets. Single gang box may be used for single switch or receptacle at end of run. Special sizes as required. Box cover as required to suit wall materials and devices.

B. Outlet Boxes in Exposed Work: Cast steel or iron alloy fitted with appropriate covers.

C. Outdoor, Damp Location Outlet Box: Gasketed cast metal with threaded hubs.

D. Outlet Box Plate Covers:
   1. Flush Mounting Plates: Beveled type with smooth rolled outer edge, Type 302 stainless steel. To match device installed.
   2. Surface Box Plates: Beveled, steel, pressure formed for smooth edge to fit box, complete with 4 mounted screws.
   3. Weatherproof Plates: Cast metal, gasketed; for switches and receptacles, provide spring-loaded gasketed doors.
4. Where two-gang boxes are required for single gang devices, provide special plates with device opening in one gage and second gang blank.

E. Pullboxes and Junction Boxes: Sheet metal (indoors) or cast metal (exterior or damp locations) construction, conforming to National Electrical Code, with screw-on or hinged cover.

F. Flush Mounted Pullboxes: Provide overlapping covers with flush-head cover retaining screws, finished in light gray enamel.

G. Box volumes shall meet NEC for size and number of entering conduits.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Locate outlet boxes flush in areas other than mechanical rooms, electrical rooms, and above removable ceilings.

B. For boxes mounted in exterior walls make sure that there is insulation behind outlet boxes to prevent condensation in boxes.

C. Coordinate location and mounting heights with built-in units. Adjust outlet mounting height to agree with required location for equipment served.

D. Locate pullboxes and junction boxes above removable ceilings or in electrical rooms, utility rooms, or storage areas.

E. Support: Secure boxes independent of entering conduits, by attaching directly to structure with bar hanger, blocking or flat side bracket.

F. Identify each junction and pull box with system description including branch circuit number of enclosed circuits.

G. Conduit shall be securely fastened to all sheet metal outlet, junction, and pullboxes with two galvanized locknuts, one interior and one exterior to the box, and with one insulating bushing installed in accordance with standard practice. The full number of threads shall project through to permit the bushing to be drawn tight against the end of the conduit, after which the locknuts shall be made up sufficiently tight to draw each into firm electrical contact with the box.

H. Conduits shall be fastened to enclosures and boxes exposed to outdoor conditions with liquidtight threaded hubs.

END OF SECTION
SECTION 26 05 35
CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.01 WORK INCLUDED
A. Cabinets and enclosures.
B. Terminal blocks and accessories

1.02 REFERENCES
A. National Electrical Manufacturer’s Association (NEMA).
   NEMA 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)
B. National Fire Protection Association (NFPA).
   NFPA 70 National Electrical Code (NEC)
C. Underwriter’s Laboratories, Inc. (UL).
   UL 50 Cabinets and Boxes

PART 2 - PRODUCTS

2.01 MATERIALS
A. Cabinets and Enclosures: Metal construction, conforming to National Electrical Code, finish painted, equipped with back panel, locking door, concealed flush hinges, flush lock and catch assembly.
B. Terminal Blocks and Accessories.
   1. Below 50 volts: Screw terminal type.
   2. Above 50 volts: Rated for circuit voltages to be terminated, 300 Volts, minimum, screw terminal type with barriers between each set of terminals and individual terminal points for each conductor.
   3. Power terminal blocks: Unit construction, closed back type, rated 600 volts.
C. Back Panels.
   1. Factory installed, interior mounted at back of enclosure.
   2. Removable.
   3. 14 gauge, minimum, steel unless wood panel noted. Wood panels shall be ¾ inch plywood.
   4. Finish painted matte white.
D. Identification: Identify terminal strips with permanent numbers. Identify conductors terminating on terminal strips with permanent labels attached to the conductor at the terminal strip.

E. Wiring Diagrams: Provide wiring diagram on inside of each cabinet door showing units and conductors connected to cabinet.

F. Provide barriers in cabinets to separate conductors of different systems.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Conduit shall be securely fastened to all cabinets with two galvanized locknuts, one interior and one exterior to the box, and with one insulating bushing installed in accordance with standard practice.

B. Terminate wiring on terminal blocks or strips mounted on interior panel.

C. Vacuum clean cabinet on completion of installation.

D. Mount cabinets with top 6 feet (2 m) above finished floor except as otherwise shown.

E. Mount cabinets flush with finished surface in finished areas, except as otherwise shown.

F. Conduits shall be fastened to cabinets and enclosures exposed to outdoor conditions or damp or wet locations with liquid-tight threaded hubs.

G. Provide NEMA Type 12 unless otherwise noted. Devices provided in and penetrations into enclosure shall be so installed as to maintain the enclosure NEMA type rating.

H. Provide accessory feet for free standing equipment enclosures.

END OF SECTION
SECTION 26 05 43

DUCT BANKS AND MANHOLES

PART 1  GENERAL

1.01  WORK INCLUDED

A.  Metal conduit.
B.  Duct.
C.  Manholes.

1.02  UNIT PRICE – MEASUREMENT AND PAYMENT

A.  Duct Bank:
   1.  Basis of Measurement: By the lineal foot, for each configuration.
   2.  Basis of Payment: Includes purchase, delivery, and installation of duct, fittings, supports, and accessories, and for trenching, concrete encasement, and backfill.

B.  Manhole:
   2.  Basis of Payment: Includes purchase, delivery, and installation of manhole.

1.03  REFERENCES

A.  ANSI C80.1 – Rigid Steel Conduit, Zinc-Coated.
B.  ASTM A 48 – Gray Iron Castings
D.  ASTM C 858 – Underground Precast Concrete Utility Structures
E.  ASTM C 891 – Installation of Underground Precast Utility Structures
F.  ASTM C 1037 – Inspection of Underground Precast Utility Structures
H.  NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
I.  NEMA TC 2 – Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
J.  NEMA TC 3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
K.  NEMA TC 6 – PVC and ABS Plastic Utilities Duct for Underground Installation
L. NEMA TC 9 – Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation
M. NEMA TC 10 – PVC and ABS Plastic Communications Duct and Fittings for Underground installation
N. NEMA TC 14 – Filament-Wound Reinforced Thermosetting Resin Conduit and Fittings
O. NFPA 70 – National Electrical Code
P. UL 651A – Type EB and A PVC Conduit and HDPE Conduit

1.04 SUBMITTALS
A. Product Data: Provide for metallic conduit, nonmetallic conduit, manhole accessories.
B. Shop Drawings: Indicate dimensions, reinforcement, size and locations of openings and accessory locations for precast manholes.

1.05 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum of three years documented experience and with service facilities within 100 (160 km) miles of Project.

1.06 REGULATORY REQUIREMENTS
A. Conform to requirements of NFPA 70, IEEE C2.
B. Products: Listed and classified by Underwriters Laboratories, Inc. or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.07 FIELD SAMPLES AND MEASUREMENTS
A. Provide field sample of plastic duct, two each at 2 feet (610 mm) long.
B. Verify that field measurements are as indicated.
C. Verify routing and termination locations of duct bank prior to excavation for rough-in.
D. Verify locations of manholes prior to excavating for installation.
E. Duct bank routing is shown in approximate locations unless dimensions are indicated. Route as required to complete duct systems.
F. Manhole locations are shown in approximate locations unless dimensions are indicated. Locate as required to complete duct bank system.
PART 2  PRODUCTS

2.01  RIGID STEEL CONDUIT

A. Rigid Steel Conduit: ANSI C80.1.
B. Fittings: NEMA FB 1, steel.

2.02  PLASTIC CONDUIT

A. Rigid Plastic Conduit: NEMA TC 2, Schedule 40, 80 PVC, with fittings and conduit bodies to NEMA TC 3.
B. Rigid Plastic Underground Conduit: UL 651A, Type A PVC; UL 651A, Type EB PVC; High-density polyethylene, Schedule 40; Fiberglass-reinforced epoxy.

2.03  PLASTIC DUCT

A. Plastic Utilities Duct: NEMA TC 6: PVC; ABS Type EB; DB.
C. Plastic Communications Duct Fittings: NEMA TC 10, Type EB; DB.

2.04  REINFORCED RESIN CONDUIT

A. Conduit and Fittings: NEMA TC 14, Type SW; HW.

2.05  PRECAST CONCRETE MANHOLES

A. Description: Precast manhole designed in accordance with ASTM C 858, Comprising modular, interlocking sections complete with accessories.
B. Loading: ASTM C 857, Class A-16; A-12; A-8; A-0.3.
C. Shape: Square; Rectangular with truncated corners; As indicated.
D. Base Section: include 3 inch x 14 inch (75 mm x 350 mm) round sump with cast sleeve, and two 1 inch (25 mm) ground rod openings.
E. Top Section: Include 39 inch (1000 mm) diameter grooved opening for frame and cover.
F. Riser Casting: 6, 12 inch (150, 300 mm), with manhole step cast into frame.
G. Frames and Covers: ASTM A48; Class 30B gray cast iron, 20, 30 inch (686, 762 mm) size, machine finished with flat bearing surfaces. Provide cover marked ELECTRIC, TELEPHONE to indicate utility.


I. Duct Entry Locations: As Indicated.

J. Duct Entry Size: 4, 6 inch (100, 150 mm)

K. Cable Pulling Irons: Use galvanized rod and hardware. Locate opposite each duct entry. Provide watertight seal.

L. Cable Rack Inserts: Minimum load rating of 800 pounds (365 kg).

M. Cable Rack Mounting Channel: 1-1/2 x ¾ inch (38 x 19 mm) steel channel, 48 inch (1.2 mm) length. Provide cable rack arm mounting slots on 1-1/2 inch (38 mm) centers.

N. Cable Racks: Steel channel, 1-1/2 x ¾ x 14 inches (38 x 19 x 350 mm), with fastener to match mounting channel.

O. Cable Supports: Porcelain, Maple clamps and saddles.

P. Manhole Steps: Polypropylene plastic manhole step with ⅛ inch (13 mm) steel reinforcement. Cast steps at 12 inches (300 mm) inches on center vertically.

Q. Ladder: Aluminum, length as required, with top hook to engage manhole step in riser casting. Provide one ladder for each manhole.

R. Sump Covers: ASTM A48; Class 30B gray cast iron.

S. Source Quality Control: Inspect manholes in accordance with ASTM C 1037.

2.06 ACCESSORIES

A. Underground Warning Tape: 4 inch (100 mm) wide plastic tape, detectable type, colored red, yellow with suitable warning legend describing buried electrical lines.

2.07 CAST-IN-PLACE MANHOLE ACCESSORIES

A. Frames and covers: ASTM A 48; Class 30B gray cast iron, 27 inch (686 mm), 30 inch (762 mm) size, machine-finished with flat bearing surfaces. Provide cover marked ELECTRIC, TELEPHONE to indicate utility.

B. Cable Pulling Irons: Use galvanized rod and hardware.

C. Cable Rack Inserts: Minimum load rating of 800 pounds (365 kg).
D. Cable Rack Mounting Channel: 1-1/2 x 3/4 inch (38 x 19 mm) steel channel, 48 inch (1.2 mm) length. Provide cable rack arm mounting slots on 1-1/2 inch (38 mm) centers.

E. Cable Racks: Steel channel, 1-1/2 x 3/4 x 14 inches (38 x 19 x 350 mm), with fastener to match mounting channel.

F. Cable Supports: Porcelain, Maple clamps and saddles.

G. Ladder: length as required with top hook to engage manhole step in riser casting. Provide one ladder for each manhole.

H. Sump Covers: ASTM A48; Class 30B gray cast iron.

PART 3 EXECUTION

3.01 DUCT BANK INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Install duct to locate top of duct bank at depths as indicated on drawings.

C. Install power, communications duct to locate top of duct bank minimum 24 inches below finished grade.

D. Install duct with minimum slope of 4 inches per 100 feet (100 mm per 25.4 m) (0.33 percent). Slope duct away from building entrances.

E. Cut duct square using saw or pipe cutter; de-burr cut ends.

F. Insert duct to shoulder of fittings; fasten securely.

G. Join nonmetallic duct using adhesive as recommended by manufacturer.

H. Wipe nonmetallic duct dry and clean before joining. Apply full even coat of adhesive to ensure area inserted in fitting. Allow joint to cure for 20 minutes, minimum.

I. Install no more than equivalent of three 90-degree bends between pull points.

J. Provide suitable fittings to accommodate expansion and deflection where required.

K. Terminate duct at manhole entries using end bell.

L. Stagger duct joints vertically in concrete encasement 6 inches (150 mm) minimum.

M. Use suitable separators and chairs installed not greater than 4 feet (1200 mm) on centers.

N. Band ducts together before backfilling, placing concrete.
O. Securely anchor duct to prevent movement during concrete placement.

P. Use mineral pigment to color concrete red.

Q. Provide minimum 3-inch (75-mm) concrete cover at bottom, top, and sides of duct bank.

R. Provide two No. 14 steel reinforcing bars in top of bank under paved areas.

S. Connect to existing concrete encasement using dowels.

T. Connect to manhole wall using dowels.

U. Provide suitable pull string in each empty duct except sleeves and nipples.

V. Swab duct. Use suitable caps to protect installed duct against entrance of dire and moisture.

W. Backfill trenches under provisions of Division 2.

X. Interface installation of underground warning tape with backfilling specified in Division 2 specifications. Install tape 6 inches (150 mm) below finished surface.

3.02 PRECAST MANHOLE INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Excavate for manhole installation under provisions of Division 2.

C. Install and seal precast sections in accordance with ASTM C 891.

D. Install manholes plumb.

E. Use precast neck and shaft sections to bring manhole cover to finished elevation.

F. Attach cable racks to inserts after manhole installation is complete.

G. Install drains in manholes and connect to site drainage system, 4 inch (DN100) pipe terminating in 1/3 cu yd (1/4 cu m) crushed gravel bed.

H. Dampproof exterior surfaces, joints, and interruptions of manholes after concrete has cured 28 days.

I. Backfill manhole excavation.

3.03 CAST-IN-PLACE MANHOLE INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Excavate for manhole installation under provisions of Division 2.
C. Formwork: Form inside and outside manhole surfaces.

D. Reinforcing: Install reinforcing.

E. Concrete: Provide air-entrained, 2000 psi (20 mPa) compressive strength at 28 days.

F. Shape: Square. Rectangular. As indicated.

G. Base: Include 14 inch (350 mm) drain opening and two 1 inch (25 mm) ground rod openings. Slope to drain at 0.25 inch per foot (6.35 mm per m) (2 percent).

H. Top: Include 39 inch (1000-mm) diameter opening; cast ½ inch (13 mm) rod in opening to accept ladder hook.

I. Duct Entry: Cast duct openings in walls as indicated.

J. Cable Pulling Irons: Locate opposite each duct entry.

K. Cable Rack Inserts: locate as required

L. Construct brick collar with 30 inch (760 mm) clear opening to bring cover to proper elevation.

M. Install ladder in each manhole.

N. Attach cable racks to inserts after manhole construction is complete.

O. Install drains in manholes and connect to site drainage system, 4 inch pipe terminating in 1/3 cu yd (0.25 cu m) crushed gravel bed.

P. Dampproof exterior surfaces, joints, and interruptions of manholes after concrete has cured 28 days.

Q. Backfill manhole excavation.

END OF SECTION
SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Permanent identification of all electrical system components.

1.01 APPLICABLE REGULATIONS

A. National Fire Protection Association (NFPA).

Identification shall conform to Article 110-22, as a minimum requirement.
NFPA 70 National Electrical Code (NEC)

PART 2 - PRODUCTS

2.01 MATERIALS

A. Laminated Plastic Nameplates.
   1. Three-layer, semi-matte black front and back with white core. Laminated phenolic resin sheet 1.5 mm thick.
   2. Engraved through outer layer to show white characters on black background.
   3. Beveled edges, square corners.
   4. All lettering shall be normal gothic.
   6. Other colors specified.

B. Plastic Embossing Tape: ½ inch wide minimum, ¼ inch minimum embossed characters embossed using the proper lettering machine for the tape used.

C. Brass Tags: 1-1/4 inch minimum dimension. Letters, 3/16 inch high machine stamped, hand stamped using dies, machine engraved, or etched, so the identification is embedded into the surface of the tag.

D. Panelboard Directory Card: Fiberboard neatly typed for newly installed panels. Circuit changes to existing panels shall be noted on the directory card by hand printing. When more than five changes have been made on the directory card, a new card shall be typed.

E. Stenciling and Silk Screening: Neatly lettered with enamel or lacquer paints. Legends contracting with the background on which applied.

F. Shrink Tube: Hot stamped, white, with letters, numbers clearly visible.
PART 3 - EXECUTION

3.01 ITEMS TO BE IDENTIFIED

A. Motor control centers, power panels, lighting panels, and the disconnecting devices contained therein.

B. Disconnecting devices that are not part of the items listed above.

C. Control panels, starters, pushbutton stations, pilot lights and other control devices.

D. All raceway systems at the point of origin and the point of destination and where raceways go through walls, floors, and ceilings. Identification shall also be made where multi-conductors enter pullboxes, junction boxes, and terminal boxes.

E. Receptacles and light switches.

F. Transformers.

G. Remote control devices.

H. Conductors at both device and terminal strip terminations for control and instrumentation cables and conductors.

I. Other items as specified or noted.

3.02 USE OF NAMEPLATES AND TAGS

A. Panel designations, as described above, and disconnecting devices in motor control centers shall be identified by either stenciling, using white or black paint, or by nameplates that are engraved, etched, or silk screened. Nameplates that are engraved, etched or silk screened shall have a black background with white letters. Letters for panel designations shall be a minimum of ½ inch high and letters for disconnect devices, mentioned in this paragraph, shall be smaller than the panel designation but have a minimum height of 3/8 inch. Unless otherwise indicated on the drawings, spacing between lines shall be ½ the letter height.

B. Disconnecting devices in lighting panels and power panels shall be identified on the panelboard directory card.

C. Control panels and other devices as called out above shall be identified by either stenciling or using nameplates that are engraved, etched or silk screened. The colors and sizes shall be as called out on drawings or in specifications. In cases where drawings and specifications are not available, the color and sizes shall be field determined and based on the color of the equipment being identified and the physical space available for the nameplate.

D. Raceway systems shall be identified using brass tags.

E. Light switches and receptacles shall be identified using plastic embossing tape.
3.03 APPLYING NAMEPLATES AND TAGS

A. Stenciled letters shall be applied by brush or by spraying.

B. Nameplates that are engraved, etched or silk screened, shall be attached with screws. On nameplates larger than 4 inches x 1-1/4 inches, four black finished round head self-threading screws located ¼ inch from each edge shall be used.

C. Brass tags shall be attached to the raceways with #14 gauge copper wire minimum.

D. Plastic embossing tape shall be attached to the device plates for light switches and receptacles. The sticky back of the tape shall not be relied upon entirely for attachment. Additional adhesive shall be used to ensure that the tape will not work loose.

E. Panelboard directory cards shall be placed in holders, provided for this purpose, located inside the panel doors.

F. Shrink tube conductor labels encircling the conductor shall be placed immediately adjacent to the screw or other termination. Place labels at both ends of conductor.

3.04 IDENTIFICATION OF NAMEPLATES AND TAGS

A. Nameplates for designating switchgear, bus ducts, panels, and motor control centers shall follow the system shown on the plans:

1st Entry: 
- “MDS” – 277/480V Switchboard
- “DPH” – 277/480V (over 400A) Distribution Panel
- “LPH” - 277/480V (0-400A)
- “LP” – 120/208V (0-400A)

2nd Entry: “1” indicates floor number

3rd Entry: “A” indicates sequential panel in series of panels (A, B, C, D, E...).

B. The voltage designation shall also be shown on the nameplate.

C. Nameplates for disconnecting devices contained in panels and motor control centers shall show the equipment name and location by floor and column number. Voltage designation shall not be included when the voltage is the same as for the panel or motor control center.

D. Nameplates on control panels, starters, and the like, shall have the equipment name; the individual switches and lights shall have the function, such as START, STOP, ON/OFF, and the like.

E. Panelboard directory cards shall list the circuit numbers and show the equipment name and location supplied by the circuits. Equipment locations shall be shown by floor and column numbers or by room numbers.
F. Nameplates on disconnect devices located in the area but not part of a panel or motor control center shall have the equipment name, power source identification, and voltage designation. Nameplates for disconnect devices located remotely from the equipment shall also show the equipment location by floor and column number.

G. Tags on raceways for power and lighting systems shall show the panel or motor control center designation, the circuit number and voltage designation (for voltages higher than 120 volts).

H. Tags on raceways for other systems shall have the system function (such as alarm, control, ADP, etc.). Other numbers used in the system to identify circuits, panels, devices, and raceways shall also be shown. Where panel and device numbers are used, the location (by floor and column number) of the panel or device shall be included.

I. Plastic embossing tape for light switches and receptacles shall show the panel number and circuit number. Tape shall be attached to the back of the coverplate.

J. Shrink tube conductor labels shall be indicative of device and function (e.g., "Compressor Run," "Pump Stop," "Control"). Provide label "Spare" on unused conductors in multipair cables.

END OF SECTION
SECTION 26 05 73

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.01 SUMMARY

A. Prepare and submit Short Circuit and Protective Device Coordination Study Report, also referred to herein as Study Report, encompassing the electrical distribution system as shown on Contract Drawing titled, "Electrical One-Line Diagram". The Study Report shall include:
   1. The distribution system components, feeders and circuits, and overcurrent protective devices starting at the high voltage terminals of the campus service transformer through and including breakers in the Main Distribution Switchboard (MDS), distribution panelboards, and main circuit breakers (MCBs) or main lug only (MLO) terminals of all panelboards shown on the Contract Drawing referenced above.
   2. As clarification, the Study Report shall include the normal power, emergency power, legally-required standby power, and optionally-required standby power systems shown on Contract Drawing titled, "Electrical One-Line Diagram".

B. Short circuit and protective device coordination Study Report will be included with the Deferred Submittals provided to the Authority Housing Jurisdiction (AHJ) per IBC Section 106.1.1.1.

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers:
   1. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).

B. National Fire Protection Association:
   1. NFPA 70 - National Electrical Code.
   2. NFPA 70E – Electrical Safety in the Workplace

C. International Electrical Testing Association (NETA)
   1. Acceptance Testing Specifications (ATS)

1.03 DESIGN REQUIREMENTS

A. Provide a complete Short Circuit and Protective Device Coordination Study Report to meet requirements of NFPA 70 and as specified herein.

B. Data Collection: Collect and document in the Study Report, data and information required for preparing the Study Report, including the following, minimum:
   1. Utility Data: Coordinate with and obtain from the campus utility services department the maximum and minimum utility short-circuit capacity and X/R
ratio for both three-phase fault and a single-line-to ground fault at the high voltage terminals of the campus service transformer.

2. Determination of Existing Facts: For existing distribution system equipment and protective devices, determine by on-site observation all information required for performing analysis and preparing the Study Report. Provide all labor, material, tools, test equipment, safety equipment, etc. to perform the on-site data collection.
   
   a. For existing protective devices, determine nameplate data, the time-current characteristics, kiloampere interrupting capacity (kAIC), features, and nameplate data.
   
   b. For existing equipment, determine all nameplate data including full-load rating, short-circuit current rating (SCCR) of the equipment items (e.g., transformers, motors, switchgear, switchboards, panelboards, bus ducts, raceway types, cables, lengths, etc.) Transformer impedances used in the analysis shall be the smaller of existing transformer impedances or the ANSI standard impedance values for the corresponding transformer kVA ratings. Document both values of impedances and clarify which values are used in the analysis.

3. Determination of New Facts: For new protective devices and equipment, electrical characteristics used in the Study Report shall be those characteristics of the proposed new protective devices and proposed new equipment.

C. Report Preparation:

1. Prepare study prior to ordering distribution equipment to verify equipment ratings required.

2. Perform study with aid of computer software program.

3. Calculate short circuit interrupting and, when applicable, momentary duties for assumed 3-phase bolted fault short circuit current and phase-to-ground fault short circuit current at each of the following:
   
   a. Service transformer primary terminals
   
   b. Service transformer secondary terminals
   
   c. Automatic transfer switches.
   
   
   e. Engine generators.
   
   f. Switchboards.
   
   g. Motor control centers.
   
   h. Distribution panelboards.
   
   i. Branch circuit panelboards.
   
   j. Busway.
   
   k. Each other significant equipment location throughout system.
D. Report shall include the following:

1. The narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

2. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristic curves and protective device ratings and settings.

3. Assumptions and calculation methods and calculations performed for the analyses, including computer analysis programs utilized. Provide the name of the software package, developer, and version number. Include computer printout showing results of fault current calculations. Include definition of terms and guide for interpretation of computer printout.

4. Base per unit value selected.

5. One-line diagram. Show the electrical system buses, devices, voltage transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with calculated available fault data on the source side of each device and the device interrupting rating.

6. Source impedance data including power company system available power and characteristics.

7. Typical calculations.
   a. Fault impedance.
   b. X to R ratios.
   c. Asymmetry factors.
   d. Motor fault contribution.
   e. Short circuit kVA.
   f. Symmetrical and asymmetrical phase-to-phase and phase-to-ground fault currents.
   g. Tabulations of calculation quantities and results.

8. State conclusions and recommendations.

E. Time-current device coordination curves graphically indicating coordination proposed for system, on conventional, log-log plot. Plots printed full-size on 8-1/2x11 inch paper preferred. Include with each time-current curve sheet a complete title and a partial one-line diagram with legend identifying specific portion of system covered by that particular time-current curve sheet.

F. Descriptive and technical data for existing protective devices and new protective devices proposed. The data device shall include manufacturers' published data, nameplate data, and definition of the fixed and adjustable features of the existing and new protective devices.
G. Tabulation of circuit breakers, fuses, and other protective device ratings and recommended device available adjustment settings (e.g., long-time pickup [LTPU], long-time delay [LTD], short-time pickup [STPU], short-time delay [STD], instantaneous [INST], ground-fault pickup [GFP], ground-fault delay [GFD]; tap, time dial, pickup, instantaneous, and time delay settings. Include in tabulations calculated short-circuit values at position applied, and commentary regarding device short-circuit rating adequacy.

H. Plotted device characteristic curves at point indicating maximum symmetrical fault current to which device is exposed. Include on curve sheets the following:
   1. Equipment circuit breaker trip device characteristics.
   2. Equipment fuse characteristics.
   3. Cable damage point characteristics.
   4. Pertinent transformer characteristics including:
      a. Transformer full load current.
      b. Transformer magnetizing inrush.
      c. ANSI transformer withstand parameters.
      d. Significant symmetrical fault current.
   5. Pertinent motor characteristics.
   6. Generator characteristics including:
      a. Phase and ground coordination of generator protective devices.
      b. Decrement curve and damage curve.
      c. Operating characteristic of protective devices.
      d. Actual impedance value.
      e. Time constants.
      f. Current boost data.
      g. Do not use typical values for generator.
   7. Transfer switch characteristics.
   8. Other system load protective device characteristics.

1.04 SUBMITTALS

A. Software: Submit for review, information on software proposed to be used in performing study.

B. Short Circuit and Protective Device Coordination Study Report: The Study Report shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The Study Report shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus; the rationale used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Provide recommendations to improve or enhance system
reliability, and detail where such changes would involve additions or modifications to the contract and cost changes (increase or decrease).

C. Project Computer Software Files
   1. Submit for Owner’s future use, computer electronic files specific to this project developed when completing the Short Circuit and Protective Device Coordination Study. Include all applicable input data files, data block files, output data files, output reports and listings, etc. to enable Owner personnel to use software program for future analyses.
   2. Provide User name and User Password for all files which are password protected.
   3. Submit two (2) copies of computer electronic files on two separate non-volatile recording media.

D. Submit copies of final report. Make additions or changes required by review comments.

1.05 OPERATIONS AND MAINTENANCE MANUALS

A. Include completed, corrected Study Report in each copy of Operations and Maintenance (O&M) Manuals described elsewhere in these specifications.

1.06 QUALITY ASSURANCE

A. Use commercially available software, designed specifically for short circuit and protective device coordination studies with minimum of 5 years documented availability.

B. Perform study in accordance with IEEE 242.

1.07 QUALIFICATIONS

A. Study Preparer: Company specializing in performing work of this section with minimum 3 years documented experience and having completed 5 projects of similar size and complexity within the past 5 years.

B. Demonstrate company performing study has capability and experience to provide assistance during system start up.

1.08 SEQUENCING

A. Complete and submit Study Report and deliver within 30 working days after pre-construction meeting.

B. Allow 10 working days for review of completed submitted Study Report by Architect/Engineer.

C. Submit short circuit and protective device coordination Study Report prior to receiving final approval of distribution equipment shop drawings and prior to releasing equipment for manufacturing.
D. When formal completion of Study Report will cause delay in equipment manufacturing, obtain approval for preliminary submittal of study data sufficient in scope to ensure selection of device ratings and characteristics will be satisfactory.

1.09 SCHEDULING

A. Schedule work to expedite collection of data to ensure completion of study for final approval of distribution equipment shop drawings prior to release of equipment for manufacturing.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL

A. Provide assistance to electrical distribution system equipment manufacturer during start up of electrical system and equipment.

B. Select each primary protective device for delta-wye connected transformer so device’s characteristic or operating band is within transformer characteristics, including point equal to 58 percent of ANSI withstand point to provide secondary line-to-ground fault protection.

C. Separate transformer primary protective device characteristic curves from associated secondary device characteristics by 16 percent current margin to provide proper coordination and protection in event of secondary line-to-line faults.

3.02 FIELD ADJUSTING AND TESTING

A. Perform field adjusting and testing of protective devices and modifications to equipment to place equipment in final operating condition.

B. Adjust settings in accordance with approved short circuit and protective device coordination Study Report.

C. Perform field adjusting and testing. Notify the Owner 10 calendar days prior to start of field adjusting and tests.

1. Perform in accordance with InterNational Electrical Testing Association, Inc. (NETA) Acceptance Testing Specifications (ATS). Tests performed shall include NETA “Visual and Mechanical Inspections” and NETA “Electrical Tests.”

2. Perform tests for circuit breakers, protective relays, ground-fault protection systems, minimum.

D. Furnish all materials, labor, and equipment necessary to conduct field adjusting and testing.
E. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the Owner.

F. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number, calibration dates, and name of test equipment, and test results. Add the written record information to Study Report by supplementing text of Study Report or by addition of appendix to Study Report.

3.03 SAFETY

A. Provide and use safety equipment as required by Contractor’s Safety plan and by applicable regulations.

B. Provide protective barriers, and danger signs to protect and warn personnel in the vicinity of the Work.

C. Replace any devices or equipment which are damaged due to improper adjustment and test procedures or handling.

END OF SECTION
SECTION 26 08 00

ELECTRICAL SYSTEMS COMMISSIONING

PART 1 GENERAL

1.01 DESCRIPTION

A. The purpose of this section is to specify the Contractor’s responsibilities and participation in the commissioning process.

B. Commissioning testing shall be performed by the Contractor under the direction of the Commissioning Authority (CxA). Commissioning is primarily the responsibility of the CxA, with start-up, testing and support for commissioning the responsibility of the Contractors. The commissioning process does not relieve the Contractor from participation in the process or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.

C. Work of Division 26 includes:
   1. Testing and start-up of the electrical equipment.
   2. Providing qualified personnel to perform commissioning/functional tests, including seasonal testing required after the initial commissioning to verify equipment/system performance.
   3. Completion and endorsement of Pre-functional Tests Checklists provided by the CxA to assure that Division 26 equipment and systems are fully operational and ready for functional testing.
   4. Providing equipment, materials and labor necessary to correct deficiencies found during the commissioning process which fulfill contract and warranty requirements.
   5. Providing operation and maintenance information and as-built drawings to the CxA for review verification and organization prior to distribution.
   6. Providing assistance to the CxA to develop, edit and document system operation descriptions.
   7. Providing training for the systems specified in this Division.

1.02 RELATED WORK

A. All installation, testing and start-up procedures and documentation requirements specified within Division 26 and related portions of this project.

B. Section 01 91 00 – Commissioning

C. Commissioning Functional Test Procedures that required participation of the Division 26 Contractors.
D. Cooperate with the CxA in the following manner:
   1. Provide all testing and start-up procedures and documentation requirements specified within Division 1 and Division 26 and related portions of this project.
   2. Allow sufficient time before final completion dates so electrical systems start-up, test and balance, and commissioning can be accomplished.
   3. Provide labor and material to make required connections, circuitry and delay.
   4. Put all electrical equipment into full operation and continue operation of the same during each waking day of the testing, balancing and commissioning.
   5. For specified electrical systems and component testing by a third-party testing Contractor, coordinate with the CxA the scope and schedule of that testing for observation by the CxA during the actual testing.

PART 2   PRODUCTS

2.01 TEST EQUIPMENT

A. Standard test equipment for commissioning will be provided by the CxA.

B. Division 26 Contractor shall provide standard and specialized test equipment as necessary to test and start up the electrical systems.

C. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment through the installing contractor. Manufacturer shall provide the test equipment, demonstrate its use and assist the CxA in the commissioning process.

D. The Contractor shall provide all equipment, software and all test programming support as necessary to start up, calibrate, debug and verify proper function of the control/facility management system. This equipment and software shall be provided for use by both the test and balance contractor and the CxA.

PART 3   EXECUTION

3.01 WORK PRIOR TO COMMISSIONING

A. Complete all phases of work so the systems can be energized, started, tested and otherwise commissioned. Division 26 has primary start-up responsibilities with obligations to complete systems, including all sub-systems, so they are functional. This includes the complete installation of all equipment materials, raceways, wire, terminations, controls, etc., per the Contract Documents and related directives, clarifications, change orders, etc.
B. A Commissioning Plan will be developed by the CxA. Upon request of the CxA, the Contractor shall provide assistance and consultation. The Commissioning Plan will be developed prior to completion of the installation. The Contractor is obligated to assist the CxA in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation. If Contractor-initiated system changes have been made that alter the commissioning process, the CxA will notify the Architect and the Contractor may be obligated to compensate the CxA to test the revised product or confirm the suitability/unsuitability of the substitution or revision.

C. Specific pre-commissioning responsibilities of Division 26 are as follows:
   1. Normal start-up services required bringing each system into a fully operational state. This includes motor rotational check cleaning, lug tightening, control sequences of operation, etc. The CxA will not begin the commissioning process until each system is complete, including normal contractor start-up and debugging.
   2. The Contractor shall perform pre-functional tests on the systems to be commissioned to verify that all aspects of the work are complete in compliance with the plans and Specifications. Contractor start-up forms may be substituted for the pre-functional test forms with prior approval by the CxA.
   3. Factory start-up services will be provided for key equipment and systems specified in Division 26. Factory start-up activities to be documented and submitted. The Contractor shall coordinate this work with the manufacturer and the CxA.
   4. Notify Construction Manager and CxA when systems are ready for functional testing.

D. Commissioning is intended to begin upon completion of a system. Commissioning may proceed prior to the completion of systems and/or sub-systems, if expediting this work is in the best interests of the Owner. Commissioning activities and schedule will be coordinated with the Contractor. Start of commissioning before system completion will not relieve the Contractor from completing those systems as per the schedule.

3.02 PARTICIPATION IN COMMISSIONING

A. Commissioning testing shall be performed by the Contractor under the direction of the Commissioning Authority (CxA). Provide skilled technicians to start up and debug all systems within this division of work. These same technicians shall be made available to assist the CxA 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 by the CxA and coordinated by the Contractor. Contractor will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments and/or problem resolutions.
B. System problems and discrepancies may require additional technician time, CxA time, redesign and/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 CxA reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system and/or sub-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 CxA to get the job done. A liaison or intermediary between the CxA and qualified factory representatives does not constitute the availability of a qualified technician for purpose of this work.

3.03 WORK TO RESOLVE DEFICIENCIES

A. In some systems, maladjustments, misapplied equipment, and/or deficient performance under varying loads will result in a system that does not meet the original design intent. Correction of work will be completed under direction of the Architect, with input from the Contractor, equipment supplier and CxA. Whereas all members will have input and the opportunity to discuss, debate and work out problems, the Architect/Engineer of Record will have final jurisdiction on the necessary work to be done to achieve performance.

3.04 ADDITIONAL COMMISSIONING

A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers and CxA shall include a reasonable reserve to complete this work as part of their standard contractual obligations.

B. The cost of compensation of the CxA for repeat testing or troubleshooting due to systems that do not meet specified performance shall be borne by the Contractor.

C. Corrective work shall be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the CxA deems the experimentation work to be ineffective or untimely to the commissioning process, the CxA will notify the Architect/Engineer of Record indicating the nature of the problem, expected steps to be taken and the deadline for completion of activities. If the deadline passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor’s responsibility.
3.05 SYSTEMS TO BE COMMISSIONED

A. Systems to be commissioned include:
   1. Emergency power systems
   2. Lighting and lighting control systems
   3. Fire alarm systems (with functional testing of all devices, including 10% of detectors with smoke.)

3.06 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

A. Seasonal commissioning pertains to testing under full-load conditions during peak heating and peak cooling seasons, as well as part-load conditions in the spring and fall. Initial commissioning will be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. All equipment and systems will be tested and commissioned in a peak season to observe full-load performance. Heating equipment will be tested during winter design extremes. Cooling equipment will be tested during summer design extremes, with a fully occupied building. Each Contractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required to demonstrate performance.

C. Subsequent commissioning may be required under conditions of minimum and/or maximum occupancy or use. All equipment and systems affected by occupancy variations will be tested and commissioned at the minimum and peak loads to observe system performance. Each Contractor and supplier will be responsible to participate in the occupancy sensitive testing of systems to provide verification of adequate performance.

3.07 POST-OCCUPANCY REVIEW

A. Subsequent commissioning will be required approximately 10 months after substantial completion of the project. The facility operation will be reviewed using BAS trend data, limited functional testing and interviews with the O&M staff and occupants. The Contractor will assist the post-occupancy review by assisting with functional testing as needed. The commissioning activities may identify items for correction by the contractor. To be included with enhanced LEED commissioning.
3.08 TRAINING

A. This Contractor will be required to participate in the training of the Owner’s engineering and maintenance staff for each electrical system and the related components. Training may be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids, or in the field with the specific equipment. The type of training will be per the Owner’s option.

B. The Contractor will be responsible for the generic training as well as instructing the Owner’s staff on the system peculiarities specific to this project.

3.09 SYSTEMS DOCUMENTATION

A. In addition to the requirements of Division 1, update Contract Documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be red-lined on two (2) sets. Division 26 as-built drawings shall include updated architectural floor plans and the individual electrical systems in relation to actual building layout.

B. Maintain as-built red-lines on the job site as required in Division 1. Given the size and complexity of this project, red-lining of the drawings at completion of construction based on memory of key personnel is not satisfactory. Continuous and regular red-lining and/or posting of drawings is considered essential and mandatory.

C. In addition to the stated requirements for operation and maintenance data, provide one (1) copy of equipment technical literature, operation and maintenance literature and shop drawings to the CxA as soon as they are available. This requirement is for review of these documents prior to distribution of multiple copies for the Owner’s final use.

END OF SECTION
SECTION 26 09 13
ELECTRICAL POWER MONITORING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes the following for monitoring of electrical power system:
   1. PC-based workstation(s) and software.

B. Related Sections:
   1. Division 26 Section "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.

1.03 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

C. HTML: Hypertext markup language.

D. I/O: Input/output.

E. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.

F. LAN: Local area network; sometimes plural as "LANs."

G. LCD: Liquid crystal display.

H. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

I. Modbus TCP/IP: An open protocol for exchange of process data.
J. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

K. PC: Personal computer; sometimes plural as "PCs."

L. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.


O. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

P. THD: Total harmonic distortion.

Q. UPS: Uninterruptible power supply; used both in singular and plural context.

R. WAN: Wide area network.

1.04 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.

B. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.
   1. Outline Drawings: Indicate arrangement of components and clearance and access requirements.
   2. 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.
   3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
   5. UPS sizing calculations for workstation.
   6. Surge suppressors: Data for each device used and where applied.
C. Software and Firmware Operational Documentation:
   1. Self-study guide describing the process for setting equipment's network address; setting Owner's options; procedures to ensure data access from any PC on the network, using a standard Web browser; and recommended firewall setup.
   2. Software operating and upgrade manuals.
   3. Software Backup: On a magnetic media or compact disc, complete with Owner-selected options.
   4. Device address list and the set point of each device and operator option, as set in applications software.
   5. Graphic file and printout of graphic screens and related icons, with legend.

D. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or power monitoring and control revisions.

E. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.

F. Qualification Data: For qualified manufacturer.

G. Field quality-control reports.

H. Operation and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Operating and applications software documentation.
   2. Software licenses.
   3. Software service agreement.
   4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
   5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.

I. Other Informational Submittals:
   1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Manufacturer Qualifications: A firm experienced in manufacturing power monitoring and control equipment similar to that indicated for this Project and with a record of successful in-service performance.
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.

1.06 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

1.07 SOFTWARE SERVICE AGREEMENT

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

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include the operating systems. Upgrade shall include new or revised licenses for use of software.
   1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.08 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
   2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers:
   2. General Electric Company; GE Consumer & Industrial.
   3. Landis+Gyr Inc.
   5. Schneider Electric - Power Management Operation.
2.02 FUNCTIONAL DESCRIPTION

A. Instrumentation and Recording Devices: Monitor and record load profiles and chart energy consumption patterns.
1. Calculate and Record the Following:
   a. Load factor.
   b. Peak demand periods.
2. Measure and Record Metering Data for the Following:
   a. Electricity.

B. Software: Calculate allocation of utility costs.
1. Automatically Import Energy Usage Records to Allocate Energy Costs for the Following:
   a. At least 15 buildings.

C. Power Quality Monitoring: Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters:
1. Voltage regulation and unbalance.
2. Continuous three-phase rms voltage.
3. Periodic max./min./avg. voltage samples.
4. Harmonics.
5. Voltage excursions.

2.03 SYSTEM REQUIREMENTS

A. Monitoring and Control System: Include PC-based workstation with graphics capability and Web access, with its operating system and application software, connected to data transmission network.

B. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

C. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

D. BAS Interface: Provide factory-installed hardware and software to enable the BAS to monitor, display, and record data for use in processing reports.
1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), power factor.
2. Industry-accepted, open-protocol communication interface with the BAS shall enable the BAS operator to remotely monitor meter information from a BAS operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the BAS.

2.04 OPERATING SYSTEM

A. Software: Configured to run on a portable laptop computer, a single PC, or a palm computer, with capability for accessing a single meter at a time. System is not connected to a LAN. Modbus TCP/IP, RS-232, and RS-485 digital communications.


D. Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be Web enabled. Workstations and portable computers shall not require any software except for an Internet browser to provide connectivity and full functionality. Include a firewall recommended by manufacturer. 100 Base-T Ethernet, Modbus TCP/IP RS-232, and RS-485 digital communications.

E. Operating System Software: Based on 32-bit, Microsoft Windows workstation operating system. Software shall have the following features:
   1. Multiuser and multitasking to allow independent activities and monitoring to occur simultaneously at different workstations.
   2. Graphical user interface to show pull-down menus and a menu tree format.
   3. Capability for future additions within the indicated system size limits.

F. Peer Computer Control Software: Shall detect a failure of workstation and shall cause other workstation to assume control of all system functions without interruption of operation. Drivers shall be provided in both central computers to support this mode of operation.

2.05 APPLICATIONS SOFTWARE

A. Basic Requirements:
   1. Fully compatible with and based on the approved operating system.
   2. Password-protected operator login and access; three levels, minimum.
   5. Capability of creating, deleting, and copying files; and automatically maintaining a directory of all files, including size and location of each sequential and random-ordered record.
   6. Capability for importing custom icons into graphic views to represent alarms and I/O devices.
7. Automatic and encrypted backups for database and history; automatically stored at selected workstation and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.

8. Operator audit trail for recording and reporting all changes made to user-defined system options.

B. Workstation Server Functions:
1. Support other client PCs on the LAN
2. Maintain recorded data in databases accessible from other PCs on the LAN.

C. Data Formats:
1. User-programmable export and import of data to and from commonly used Microsoft Windows spreadsheet, database, billing, and other applications; using dynamic data exchange technology.
2. Option to convert reports and graphics to HTML format.
3. Interactive graphics.
4. Option to send preprogrammed or operator designed e-mail reports.

D. Metered Data: Display metered values in real time.

E. Remote Control:
1. Display circuit-breaker status and allow breaker control.
2. User defined with load-shedding automatically initiated and executed schemes responding to programmed time schedules, set points of metered demands, utility contracted load shedding, or combinations of these.

F. Equipment Documentation: Database for recording of equipment ratings and characteristics; with capability for graphic display on monitors.

G. Graphics: Interactive color-graphics platform with pull-down menus and mouse-driven generation of power system graphics, in formats widely used for such drafting; to include the following:
1. Site plan.
2. Floor plans.
3. Equipment elevations.

H. User-Defined Monitoring and Control Events: Display and record with date and time stamps accurate to 0.1 second, and including the following:
1. Operator log on/off.
2. Attempted operator log on/off.
3. All alarms.
4. Equipment operation counters.
5. Out-of-limit, pickup, trip, and no-response events.
I. Trending Reports: Display data acquired in real-time from different meters or devices, in historical format over user-defined time; unlimited as to interval, duration, or quantity of trends.
   1. Spreadsheet functions of sum, delta, percent, average, mean, standard deviation, and related functions applied to recorded data.
   2. Charting, statistical, and display functions of standard Windows-based spreadsheet.

J. Alarms: Display and record alarm messages from discrete input and controls outputs, according to user programmable protocol.
   1. Functions requiring user acknowledgment shall run in background during computer use for other applications and override other presentations when they occur.

K. Waveform Data: Display and record waveforms on demand or automatically on an alarm or programmed event. Include the graphic displays of the following, based on user-specified criteria:
   1. Phase voltages, phase currents, and residual current.
   2. Overlay of three-phase currents, and overlay each phase voltage and current.
   3. Waveforms ranging in length from 2 cycles to 5 minutes.
   4. Disturbance and steady-state waveforms up to 512 points per cycle.
   5. Transient waveforms up to 83,333 points per cycle on 60-Hz base.
   6. Calculated waveform, based on recorded data, on a minimum of four cycles of data of the following:
      a. THD.
      b. rms magnitudes.
      c. Peak values.
      d. Crest factors.
      e. Magnitude of individual harmonics.

L. Data Sharing: Allow export of recorded displays and tabular data to third-party applications software.
   1. Tabular data shall be in the comma-separated values.

M. Activity Billing Software:
   1. Automatically compute and prepare activity demand and energy-use statements based on metering of energy use and peak demand integrated over user-defined interval.
   2. Intervals shall be same as used by electric utilities, including current vendor.
   3. Import metered data from saved records that were generated by metering and monitoring software.
   4. Maintain separate directory for each activity's historical billing information.
   5. Prepare summary reports in user-defined formats and time intervals.
N. Reporting: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in the system or a log of past events.
1. Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.
2. Sort and report by device name and by function.
3. Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.
4. Differentiate alarm signals from other indications.
5. When system is reset, report reset event with same information concerning device, location, date, and time.

O. Display Monitor:
1. Backlighted LCD to display metered data with touch-screen selecting device.
2. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
3. Display four values on one screen at same time.

2.06 COMMUNICATION COMPONENTS AND NETWORKS
A. Network Configuration: High-speed, multi-access, open nonproprietary, industry standard communication protocol; LANs complying with EIA 485, 100 Base-T Ethernet, and Modbus TCP/IP.

2.07 POWER MONITORS
A. Separately mounted, permanently installed instrument for power monitoring and control, complying with UL 1244.
1. Enclosure: NEMA 250, Type 1

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Indoor installation in spaces that have environmental controls to maintain 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.

C. rms Real-Time Measurements:
1. Current: Each phase, neutral, average of three phases, percent unbalance.
2. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to-neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.
3. Power: Per phase and three-phase total.
4. Reactive Power: Per phase and three-phase total.
5. Apparent Power: Per phase and three-phase total.
6. Power Factor: Per phase and three-phase total.
7. Displacement Power Factor: Per phase and three-phase total.
8. Frequency.
9. THD: Current and voltage.
10. Accumulated Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
11. Incremental Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
12. Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

D. Demand Current Calculations, per Phase, Three-Phase Average and Neutral:
   1. Present.
   2. Running average.
   3. Last completed interval.
   4. Peak.

E. Demand Real Power Calculations, Three-Phase Total:
   1. Present.
   2. Running average.
   3. Last completed interval.
   4. Predicted.
   5. Peak.
   6. Coincident with peak kVA demand.
   7. Coincident with kVAR demand.

F. Demand Reactive Power Calculations, Three-Phase Total:
   1. Present.
   2. Running average.
   3. Last completed interval.
   4. Predicted.
   5. Peak.
   6. Coincident with peak kVA demand.
   7. Coincident with kVAR demand.

G. Demand Apparent Power Calculations, Three-Phase Total:
   1. Present.
   2. Running average.
   3. Last completed interval.
   4. Predicted.
   5. Peak.
   6. Coincident with peak kVA demand.
   7. Coincident with kVAR demand.

H. Average Power Factor Calculations, Demand Coincident, Three-Phase Total:
   1. Last completed interval.
   2. Coincident with kW peak.
   3. Coincident with kVAR peak.
   4. Coincident with kVA peak.
I. Power Analysis Values:
   1. THD, Voltage and Current: Per phase, three phase, and neutral.
   2. Displacement Power Factor: Per phase, three phase.
   3. Fundamental Voltage, Magnitude and Angle: Per phase.
   5. Fundamental Real Power: Per phase, three phase.
   8. Phase rotation.
   10. Harmonic Magnitudes and Angles for Current and Voltages: Per phase, up to 63rd harmonic.

J. Power Demand Calculations: According to one of the following calculation methods, selectable by the user:
   1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
   2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
      a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
      b. Fixed block that calculates demand at end of the interval.
      c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
   3. Demand Calculation Initiated by a Synchronization Signal:
      a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
      b. Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
      c. Demand can be synchronized with clock in the power meter.

K. Sampling:
   1. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.
   2. Power monitor shall provide continuous sampling at a rate of 128 samples per cycle on all voltage and current channels in the meter.

L. Minimum and Maximum Values: Record monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:
   1. Line-to-line voltage.
   2. Line-to-neutral voltage.
3. Current per phase.
4. Line-to-line voltage unbalance.
5. Line-to-neutral voltage unbalance.
6. Power factor.
7. Displacement power factor.
8. Total power.
9. Total reactive power.
10. Total apparent power.
11. THD voltage L-L.
12. THD voltage L-N.
13. THD current.

M. Harmonic Calculation: Display and record the following:
1. Harmonic magnitudes and angles for each phase voltage and current 63rd harmonic. Calculate for all three phases, current and voltage, and residual current. Current and voltage information for all phases shall be obtained simultaneously from same cycle.
2. Harmonic magnitude reported as a percentage of the fundamental or as a percentage of rms values, as selected by user.

N. Current and Voltage Ratings:
1. Designed for use with current inputs from standard instrument current transformers with 5-A secondary and shall have a metering range of 0-10 A.
2. Withstand ratings shall not be less than 15 A, continuous; 50 A, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.
3. Designed for use with voltage inputs from standard instrument potential transformers with a 120-V secondary.

O. Accuracy:
1. Comply with ANSI C12.20, Class 0.5; and IEC 60687, Class 0.5 for revenue meters. Accuracy from Light to Full Rating shall meet the following criteria:
   a. Power: Accurate to 0.25 percent of reading, plus 0.025 percent of full scale.
   b. Voltage and Current: Accurate to 0.075 percent of reading, plus 0.025 percent of full scale.
   c. Power Factor: Plus or minus 0.002, from 0.5 leading to 0.5 lagging.
   d. Frequency: Plus or minus 0.01 Hz at 45 to 67 Hz.
2. For meters that are circuit-breaker accessories, metering accuracy at full-scale shall not be less than the following:
   a. Current: Plus or minus 2.5 percent.
   b. Voltage: Plus or minus 1.5 percent.
   c. Energy, Demand, and Power: Plus or minus 4.0 percent.
   d. Frequency: Plus or minus 1 Hz.
P. **Waveform Capture:**
   1. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 128 data points for each cycle, allowing resolution of harmonics to 63rd harmonic of basic 60 Hz.
   2. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.

Q. **Input:** One digital input signal(s).
   1. Normal mode for on/off signal.
   2. Demand interval synchronization pulse, accepting a demand synchronization pulse from a utility demand meter.
   3. Conditional energy signal to control conditional energy accumulation.

R. **Outputs:**
   1. Operated either by user command sent via communication link, or set to operate in response to user-defined alarm or event.
   2. Closed in either a momentary or latched mode as defined by user.
   3. Each output relay used in a momentary contact mode shall have an independent timer that can be set by user.
   4. One digital KY pulse to a user-definable increment of energy measurement. Output ratings shall be up to 120-V ac, 300-V dc, 50 mA, and provide 3500-V rms isolation.
   5. One relay output module(s), providing a load voltage range from 20- to 240-V ac or from 20- to 30-V dc, supporting a load current of 2 A.
   6. **Output Relay Control:**
      a. Relay outputs shall operate either by user command sent via communication link or in response to user-defined alarm or event.
      b. Normally open and normally closed contacts, field configured to operate as follows:
         1) Normal contact closure where contacts change state for as long as signal exists.
         2) Latched mode when contacts change state on receipt of a pickup signal; changed state is held until a dropout signal is received.
         3) Timed mode when contacts change state on receipt of a pickup signal; changed state is held for a preprogrammed duration.
         4) End of power demand interval when relay operates as synchronization pulse for other devices.
         5) Energy Pulse Output: Relay pulses quantities used for absolute kWh, absolute kVARh, kVAh, kWh In, kVARh In, kWh Out, and kVARh Out.
         6) Output controlled by multiple alarms using Boolean-type logic.
S. Onboard Data Logging:
   1. Store logged data, alarms, events, and waveforms in 800 KB of onboard nonvolatile memory.
   2. Stored Data:
      a. Billing Log: User configurable; data shall be recorded every 15 minutes, identified by month, day, and 15-minute interval. Accumulate 24 months of monthly data, 32 days of daily data, and between 2 and 52 days of 15-minute interval data, depending on number of quantities selected.
      b. Custom Data Logs: Three user-defined log(s) holding up to 96 parameters. Date and time stamp each entry to the second and include the following user definitions:
         1) Schedule interval.
         2) Event definition.
         3) Configured as "fill-and-hold" or "circular, first-in first-out."
      c. Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.
      d. Waveform Log: Store captured waveforms configured as "fill-and-hold" or "circular, first-in first-out."
   3. Default values for all logs shall be initially set at factory, with logging to begin on device power up.

T. Alarms.
   1. User Options:
      a. Define pickup, dropout, and delay.
      b. Assign one of four severity levels to make it easier for user to respond to the most important events first.
      c. Allow for combining up to four alarms using Boolean-type logic statements for outputting a single alarm.
   2. Alarm Events:
      a. Over/undercurrent.
      b. Over/undervoltage.
      c. Current imbalance.
      d. Phase loss, current.
      e. Phase loss, voltage.
      f. Voltage imbalance.
      g. Over kW demand.
      h. Phase reversal.
      i. Digital input off/on.
      j. End of incremental energy interval.
      k. End of demand interval.

U. Control Power: 90- to 457-V ac or 100- to 300-V dc.
V. Communications:
1. Power monitor shall be permanently connected to communicate via Modbus TCP via a 100 Base-T Ethernet.
2. Local plug-in connections shall be for RS-232 and 100 Base-T Ethernet.

W. Display Monitor:
1. Backlighted LCD to display metered data with touch-screen selecting device.
2. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
3. Display four values on one screen at same time.
   a. Current, per phase rms, three-phase average and neutral.
   b. Voltage, phase to phase, phase to neutral, and three-phase averages of phase to phase and phase to neutral.
   c. Real power, per phase and three-phase total.
   d. Reactive power, per phase and three-phase total.
   e. Apparent power, per phase and three-phase total.
   f. Power factor, per phase and three-phase total.
   g. Frequency.
   h. Demand current, per phase and three-phase average.
   i. Demand real power, three-phase total.
   j. Demand apparent power, three-phase total.
   k. Accumulated energy (MWh and MVARh).
   l. THD, current and voltage, per phase.
4. Reset: Allow reset of the following parameters at the display:
   a. Peak demand current.
   b. Peak demand power (kW) and peak demand apparent power (kVA).
   c. Energy (MWh) and reactive energy (MVARh).

2.08 STANDALONE, WEB-ENABLED MONITORING AND CONTROL INSTRUMENT

A. Separately mounted, permanently installed instrument for power monitoring and control.
   1. Enclosure: NEMA 250, Type 1

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability.
   1. Indoor installation in spaces that have environmental controls to maintain 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.

C. Power-Distribution Equipment Monitor: Web enabled, with integral network port and embedded Web server with factory-configured firmware and HTML-formatted Web pages for viewing of power monitoring and equipment status information from connected devices equipped with digital communication ports.
D. **LAN Connectivity**: Multipoint, RS-485 Modbus serial communication network, interconnecting all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network connected to Ethernet server that functions as a gateway and server, providing data access via 100 Base-T LAN.

E. **Communication Devices within the Equipment**: Addressed at factory and tested to verify reliable communication with network server.

F. **Server Configuration**:
   1. Initial network parameters set using a standard Web browser. Connect via a local operator interface, or an RJ-45 port accessible from front of equipment.
   2. Network server shall be factory programmed with embedded HTML-formatted Web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of RS-485 network; with internal memory management information pages for viewing using a standard Web browser.
   3. Login: Password protected; password administration accessible from the LAN using a standard Web browser.
   4. Operating Software: Suitable for local access; firewall protected.

G. **Data Access**:
   1. Network server shall include embedded HTML pages providing real-time information from devices connected to RS-485 network ports via a standard Web browser.

H. **Equipment Monitoring Options**: Login shall be followed by a main menu for selecting summary Web pages that follow.

I. **Summary Web pages** shall be factory configured to display the following information for each communicating device within the power equipment lineup:
   1. **User-Configured Custom Home Page**: Provide for the lineup, showing status-at-a-glance of key operating values.
   2. **Circuit Summary Page**: Circuit name, three-phase average rms current, power (kW), power factor, and breaker status.
   3. **Load Current Summary Page**: Circuit name, Phase A, B, and C rms current values.
   4. **Demand Current Summary Page**: Circuit name, Phase A, B, and C average demand current values.
   5. **Power Summary Page**: Circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
   6. **Energy Summary Page**: Circuit name, energy (kWh), reactive energy (kVARh), and time/date of last reset.
   7. **Transformer Status Page**: Transformer tag, coil temperatures, and cooling fan status.
   8. **Motor-Control Center Status Page**: Circuit name, three-phase average rms current, thermal capacity (percentage), and drive output frequency (Hz) contactor status.
9. Specific Device Pages: Each individual communicating device shall display detailed, real-time information, as appropriate for device type.
   a. Display historical energy data that shall be logged automatically for each device, as appropriate for device type.
   b. Display historical data logged from each device in graphical time-trend plots. Value to be displayed on time-trend plot shall be user selectable. Time interval to be displayed on scale shall be for previous day or week.
10. Export historical energy data to a PC or workstation through network using FTP (File Transfer Protocol). Format exported data in a CSV (Comma Separated Variable) file format for importing into spreadsheet applications.

J. Communications:
   1. Power monitor: Permanently connected to communicate via Modbus TCP via a 100 Base-T Ethernet.
   2. Local Plug-in Connections: RS-232 and 100 Base-T Ethernet.

2.09 WORKSTATION HARDWARE

A. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of 36 to 122 deg F (2 to 50 deg C dry bulb and 20 to 90 percent relative humidity, noncondensing.

B. Computer: Standard unmodified PC of modular design, designed for the latest version of Windows operating system.
   1. Memory: 500 GB of usable installed memory.
   2. Real-Time Clock. Automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.
   3. Ports: Two RS-232-F serial ports for general use; one parallel port; four USB ports
   4. Replaceable graphics board.
   5. LAN Adapter Card.
   7. Color Monitor: WXGA TFT, not less than 22 inches LCD type.
   11. Magnetic Tape System: 4-mm cartridge magnetic tape system with minimum 20GB formatted capacity per tape. Provide 10 tapes, each in a rigid cartridge with spring-loaded cover and operator-selectable write-protect feature.

13. CD-RW/DVD-ROM Drive.

C. Redundant Central Computer: Connected in a hot standby, peer configuration; automatically maintains copies of system software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant computer in near real-time. If central computer fails, redundant computer shall assume control immediately and automatically.

2.10 RS-232 ASCII INTERFACE

A. ASCII interface shall allow RS-232 connections to be made between a meter or circuit monitor operating as the host PC and any equipment that will accept RS-232 ASCII command strings, such as local display panels, dial-up modems and alarm transmitters.

B. Pager System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.
   1. RS-232 output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to paging system. This interface shall support both numeric and alphanumeric pagers.

C. Alarm System Interface:
   1. RS-232 output shall be capable of transmitting alarms from other monitoring and alarm systems to workstation software.

D. Cables:
   1. PVC-Jacketed, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
      a. NFPA 70, Type CM.
      b. Flame Resistance: UL 1581, Vertical Tray.

   2. Plenum-Type, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
      a. NFPA 70, Type CMP.
2.11 LAN CABLES

A. Comply with Division 27 Section "Communications Horizontal Cabling."

B. RS-485 Cable:
   1. PVC-Jacketed, RS-485 Cable: Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
   2. Plenum-Type, RS-485 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket, and NFPA 70, Type CMP.

C. Unshielded Twisted Pair Cables: Category 5e as specified for horizontal cable for data service in Division 27 Section "Communications Horizontal Cabling."

2.12 LOW-VOLTAGE WIRING

A. Comply with Division 26 Section "Control-Voltage Electrical Power Cables."

B. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
   1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
   2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
   3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

PART 3 - EXECUTION

3.01 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.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CABLING

A. Comply with NECA 1.

B. Install cables and wiring according to requirements in Division 27 Section "Communications Horizontal Cabling."

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
D. 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 air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

E. Install LAN cables using techniques, practices, and methods that are consistent with specified category rating of components and that ensure specified category performance of completed and linked signal paths, end to end.

F. Install cables without damaging conductors, shield, or jacket.

3.03 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

B. Label each power monitoring and control module with a unique designation.

3.04 GROUNDING

A. Comply with IEEE 1100, "Recommended Practice for Powering and Grounding Electronic Equipment."

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. 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.

D. Tests and Inspections:
   1. Electrical Tests: Use caution when testing devices containing solid-state components.
   2. Continuity tests of circuits.
Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by manufacturer. Submit sequences for approval. Note response to each test command and operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.

a. Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled.

b. Test LANs according to requirements in Division 27 Section "Communications Horizontal Cabling."

c. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of calculated battery operating time.

d. Verify accuracy of graphic screens and icons.

e. Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.

f. Record metered values, control settings, operations, cues, time intervals, and functional observations and submit test reports printed by workstation printer.

E. Power monitoring and control equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

H. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

I. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

J. Remove and replace malfunctioning devices and circuits and retest as specified above.
3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain systems. See Division 01 Section "Demonstration and Training."

1. Train Owner’s management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 12 hours' training.

2. Training Aid: Use approved final versions of software and maintenance manuals as training aids.

3.07 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION
PART 1 GENERAL

1.01 WORK INCLUDED

A. Transformers with windings rated 600 volts and below, including brackets, mounts, hardware, and other accessories for a complete installation.

B. Special requirements for power, voltage regulating isolation transformers.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

C57.12.90 General Requirements for Dry-Type Distribution and Power Transformers

B. Institute of Electrical and Electronics Engineers (IEEE).

IEEE 259

C. National Electrical Manufacturers Association (NEMA).

NEMA ST-20 Dry Type Transformers for General Application

D. National Fire Protection Association (NFPA).

NFPA 70 National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL).

UL 506 Safety Standards for Specialty Transformers

1.03 SUBMITTALS

A. Submit product data.

B. Submit drawing showing:
   1. Dimensions.
   2. Wiring diagram.
   3. Insulation.
   4. Decibel rating.
   5. Percent impedance.
   6. Temperature rise.
   7. Losses: No load and total.
C. Voltage Regulating Isolation Transformers: Submit test reports on electrically duplicate units with Shop Drawings, certifying that the following additional tests have been performed on the first rating of any design of voltage regulating high isolation transformers. Transformers provided shall exhibit test values as listed.
   2. Transverse mode noise attenuation.
   3. Capacitive coupling.
   4. Harmonic output.

1.04 FACTORY TESTING

A. Factory testing for isolation and noise isolation transformers shall include the following:
   1. Applied voltage test; one minute.
      a. 600 Volt class: 4 kV.
      b. Induced voltage test: 2 times normal for 7200 cycles.
      c. Ratio and phase relation test.

PART 2 PRODUCTS

2.01 TRANSFORMER GENERAL REQUIREMENTS

A. Dry type, distribution.
B. 60 Hertz.
C. KVA, phases, primary and secondary ratings as indicated on drawings or noted herein.

2.02 TAPS

A. Thru 10 kVA: No primary taps required.
B. 15 thru 25 kVA: Two each 5% full capacity taps below normal rated primary voltage.
C. 30 kVA and Larger: Two each 2-1/2% full capacity taps above and two each 2-1/2% full capacity taps below primary voltage.
D. Not required for voltage regulating transformers.
E. Other taps shall be required as noted.

2.03 INSULATION

A. Design: Continuous operation at rated kVA, 24 hours/day, 365 days/year, with maximum ambient temperature of 40 degrees C and 24 hour average ambient temperature of 30 degrees C.
C. Minimum 4.5% impedance.

DRY-TYPE TRANSFORMERS
26 12 00 - 2
D. Continuous Overload Capacity: 10% minimum at nominal voltage.

E. Insulation System:
   1. Encapsulated and nonventilated types shall use 180 or 185 degrees C insulation system with temperature rise of 115 degrees C average and 145 degrees C maximum hot spot in a 40 degrees C maximum ambient.
   2. Ventilated types shall use 220 degrees C insulation system with 150 degrees C average and 180 degrees C maximum hot spot temperature in a 40 degree C maximum ambient and a 30 degree C average ambient.

2.04 COILS
   A. Impregnation: Vacuum with nonhygroscopic thermosetting varnish.
   B. End Fillers or Tie Downs: Provide maximum mechanical strength. Splicing not acceptable.
   C. Materials incorporated must have at least one year minimum field usage. Accelerated lab tests not acceptable in lieu of field usage.

2.05 CORES
   A. Material: High grade, nonaging, silicon steel with high magnetic permeabilities, low hysteresis and eddy current losses.
   B. Magnetic Flux Densities: Well below saturation to allow for 10% minimum overvoltaje excitation.

2.06 TRANSFORMER CORE AND COIL
   A. Encapsulated or contained in a nonventilated enclosure for manufacturers design for lower kVA ratings, and contained in a ventilated enclosure for manufacturer’s design for higher kVA ratings.

2.07 MOUNTS
   A. Core and coil in ventilated enclosures shall be completely isolated from enclosure by means of vibration absorbing mounts. There shall be no metal-to-metal contact between core and coil and enclosure.

2.08 ENCLOSURES
   A. Ventilated enclosure transformers shall be designed with openings to prevent unauthorized access to electrically live parts.
   B. Mounting:
      1. 10 kVA and below: Suitable for wall mounting.
      2. 15 thru 75 kVA: Interchangeable mounting for floor, wall, or ceiling as shown.
3. Other special mounting requirements where shown.
4. All indoor mountings shall be vibration isolation type with minimum ¾ inch neoprene pad type loaded to 50 psi or as specified in specification Section Vibration Isolation of these specifications.

C. Construction: Self-bracing, rodent-proof.

D. Outdoor Enclosures: Weatherproof and tamperproof, and as additionally required for the location installed.

2.09 GROUNDING

A. Ground core and coils to frame of transformer cubicle with flexible grounding strap of Code size.

2.10 SOUND LEVELS

A. Sound levels shall not exceed standard levels for locations where installed, according to kVA ratings which have been established by NEMA and ANSI.

2.11 IDENTIFICATION

A. A metal nameplate shall be affixed to transformer case listing the following minimum:
   1. Manufacturer's name.
   2. Primary and secondary voltage.
   3. kVA.
   4. Serial number.
   5. Type.
   6. Catalog number.
   7. Impedance.
   8. Wiring diagram.

2.12 SPECIAL REQUIREMENTS

A. Voltage regulating isolation transformers shall be of the ferroresonant isolator/regulator type, and shall meet or exceed the following parameters:
   1. Output voltage regulation +/-2% at +/-15% input regulation.
   2. Sinusoidal filtered output with less than 3% harmonic distortion.
   3. Common mode noise rejection: 120 dB.
   4. Transverse mode noise rejection: 60 dB.
   5. Capacitive coupling: Less than 2.5 pfd.
   6. No loss of output for up to 3 milliseconds outage.

B. Three-phase units shall be three-wire delta primary to four-wire grounded wye secondary, unless otherwise shown.
PART 3   EXECUTION

3.01   INSTALLATION

A.  Provide dry-type transformers of types and ratings shown and as required in accordance with NEC and manufacturer’s instructions.

B.  The isolated ground for computer components shall be originated in the voltage regulating, isolation transformer cabinet.

3.02   VIBRATION CONTROL

A.  Primary and Secondary Conduit Connection: Liquidtight flexible metal conduit with ground conductor, 24 inch minimum length.

B.  Mounting: Mount transformers on vibration isolators, neoprene pad type.

END OF SECTION
SECTION 26 23 00

SWITCHBOARDS

PART 1 - GENERAL

1.01 SCOPE

A. Provide free-standing, dead-front type distribution switchboards, utilizing group mounted circuit protective devices as specified herein, and as shown.

1.02 REFERENCES

A. The low voltage distribution switchboards and all components shall be designed, manufactured and tested in accordance with the latest applicable following standards:
   1. NEMA PB-2
   2. UL Standard 891.

B. National Fire Protection Association (NFPA)
   NFPA 70 National Electrical Code (NEC)
   NFPA 70E Standard for Electrical Safety in the Workplace

1.03 SITE CONDITIONS

A. Switchboards will be installed in a heated and ventilated building, and will be subject to the following conditions:
   1. Indoor temperature: +50 degrees F to +104 degrees F (+10 degrees C to +40 degrees C)
   2. Relative Humidity: Maximum 95% noncondensing
   3. Altitude: 4,695 feet above sea level

1.04 SUBMITTALS

A. Submit the following general information:
   1. Master drawing index.
   2. Front view elevation.
   3. Floor plan.
   4. Top view.
   5. Single line diagram.
   7. Nameplate schedule.
   8. Component list.
   9. Conduit entry and exit locations.
   10. Assembly ratings including:
       a. Short-circuit rating.
       b. Voltage.
       c. Continuous current.
11. Major component ratings including:
   a. Voltage.
   b. Continuous current.
   c. Interrupting ratings.

12. Conductor terminal sizes.
13. Equipment anchorage details

B. Where applicable, include the following additional information:
   1. Busway connection
   2. Connection details between close-coupled assemblies
   3. Locations of shipping splits and dimensions of sub-assemblies for assemblies provided with shipping splits.
   4. Composite floor plan of close-coupled assemblies
   5. Key interlock scheme drawing and sequence of operations.

C. Submit the final (as-built) drawings which, as a minimum, shall include the same drawings as the original construction drawings and shall incorporate all changes made during the manufacturing process.

D. Operations and Maintenance Manuals: Include all items listed above in SUBMITTALS and the following information:
   1. Final as-built wiring diagrams
   2. Certified production test reports
   3. Installation instruction books
   4. Seismic certification.
   5. Field Test Report.
   6. Ground-Fault Protection System Performance Test Report for switchboards with ground-fault detection or ground-fault protection systems.

1.05 SYSTEM STARTING AND SYSTEM DEMONSTRATIONS

A. The system starting and system demonstration procedure shall be as recommended by the equipment manufacturer and as additionally noted elsewhere in these specifications.

B. Performance Test Report: Provide Ground-Fault Protection System Performance Test Report per NEC 230.95(c) as a Deferred Submittal per 2006 IBC Section 106.3.4.

1.06 QUALIFICATIONS

A. The manufacturer of the switchboard assembly shall be the manufacturer of the circuit protective devices within the assembly, unless otherwise noted or shown.

B. Equipment manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of 5 years.
D. Comply with the following minimum mounting and installation guidelines, unless specifically modified by the above referenced standards.

1. Provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

2. The equipment manufacturer shall certify that the equipment can withstand, and thus provide full rated operation and function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.07 REGULATORY REQUIREMENTS

A. Provide switchboards complete with UL label.

B. Provide switchboards listed and labeled as Suitable for Use as Service Equipment in accordance with UL requirements for switchboards applied in service entrance applications.

1.08 DELIVERY, STORAGE AND HANDLING

A. Handle and store equipment in accordance with manufacturer’s instructions. Include 1 copy of these instructions with the equipment at time of shipment.

1.09 Operation and Maintenance Manuals

A. Provide equipment operation and maintenance manuals with each assembly shipped including instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

B. Include all items listed in Paragraph SUBMITTALS.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Cutler-Hammer.

B. Square D Company.

C. Siemens

D. Approved equal.
E. The listing of specific manufacturers shall not imply acceptance of products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from compliance with these specifications, including Paragraph SUBMITTALS, in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer 10 days prior to bid date.

2.02 RATINGS

A. Provide switchboard assemblies with short circuit current rating of 65,000 amperes RMS symmetrical, minimum, and greater short circuit current rating as shown.

B. Voltage rating shall be as indicated.

2.03 CONSTRUCTION

A. Switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.

B. All sections of the switchboard shall be rear aligned with depth not greater than shown. Group mount all protective devices. Devices shall be front removable and load connections shall be front accessible enabling switchboard to be mounted against a wall. Access for complete operation and maintenance shall be required from front only.

C. Provide assembly with adequate lifting means and means to roll equipment into place using pipe rollers.

2.04 BUS

A. Provide each phase and neutral bus of silver-plated copper with flame-retardant anti-tracking insulation, unless otherwise noted or shown. Mount main horizontal bus bars with all three phases arranged in the same vertical plane. Base the size and rating of the bus on NEMA standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).

B. Provide a full capacity neutral bus when a neutral bus is indicated (minimum 1/4 x 2 inch), firmly secured using insulating supports to each vertical section structure and extending the entire length of the switchboard.

C. Provide a copper ground bus firmly secured to each vertical section structure and extending the entire length of the switchboard. Rating: 50% of phase bus rating and greater as shown, but not less than minimum of ¼-inch x 2-inch cross-sectional area.

D. All hardware used on conductors shall be high-tensile strength and zinc-plated. Provide all bus joints, including bus joint splices, with conical spring-type washers.
2.05 WIRING AND TERMINATIONS

A. Provide all required small wiring, fuse blocks and terminal blocks within the switchboard. Suitably mark control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., with identification corresponding to appropriate designations on manufacturer’s wiring diagrams.

B. Provide mechanical-type terminals for all line and load terminations suitable for both copper and aluminum conductors rated for 75 degrees C of the sizes and quantities as indicated and required.

C. Provide lugs in the incoming line section for connection of the main grounding conductor. Provide additional lugs for connection of other grounding conductors as required.

D. Provide all control wire, type SIS, bundled and secured with nylon ties; and insulated locking spade terminals for all control connections, except where saddle type terminals are provided integral to a device. Connect all current transformer secondary leads to conveniently accessible circuit-shorting terminal blocks before connecting to any other device. Provide all groups of control wires leaving the switchboard with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

E. Identify each wire by a machine printed heat shrink wire marker showing the wire number at each end. Wire numbers shall match the terminal block numbers.

F. Provide wiring between compartments and hinged doors bundled and with adequate slack length to protect the wiring from any damage due to opening and closing the door through a 120 degree angle.

G. Provide control and secondary wiring in one continuous length from terminal to terminal. Splicing is not permitted.

H. Wire all auxiliary spare and customer use dry contacts to accessible terminal blocks for Owner’s connections. Provide a minimum of 20 percent spare terminals on terminal blocks.

I. Provide current transformer circuits with dual compression type terminal blocks having screw-type short-circuiting provisions. Current transformer secondary circuit wiring shall be provided with non-insulated ring-type lugs.

J. Mark circuits to be disconnected at a shipping split both on the wiring and on the associated terminal blocks to ensure correct reconnection at the job site.
2.06 CIRCUIT BREAKERS

A. Provide circuit breakers that are operable by a toggle-type handle and which have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be nonwelding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes.

B. Circuit breakers shall have a minimum symmetrical ampere interrupting capacity equal to short circuit current rating specified for switchboard in Paragraph RATINGS.

C. Circuit breakers 250-ampere frame and below are permitted to use thermal-magnetic trip units with inverse time-current and instantaneous tripping characteristics, minimum. Provide additional functions as shown.

D. Circuit breakers 400-ampere through 1200-ampere frame shall use microprocessor-based RMS-sensing trip units as described in Paragraph TRIP UNITS. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

E. For solidly-grounded-wye systems with line-to-ground voltages greater than 150 volts, provide integral, adjustable ground-fault sensing and protection for each breaker rated 1000-ampere frame and larger, and as required on plans. For emergency circuits and feeders with these characteristics, provide only ground fault indication at the location as directed and do not provide automatic disconnecting or tripping.

F. Where indicated, provide circuit breakers UL listed for applications at 100% of their continuous ampere rating in their intended enclosure.

G. Where indicated, provide current-limiting circuit breakers.

H. Breakers which rely on series application ratings to afford the required interrupting capacity shall not be permitted, unless specifically shown to be permitted.

2.07 TRIP UNITS

A. Each molded case circuit breaker microprocessor-based tripping system shall consist of three (3) current sensors, a trip unit and a flux-transfer shunt trip. The trip unit shall use microprocessor-based technology to provide adjustable time-current protection functions. True RMS sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors, and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time-delay settings are reached.
B. An adjustable trip setting dial mounted on the front of the trip unit, or interchangeable ratings plugs shall establish the continuous trip ratings of each circuit breaker. Rating plugs shall be fixed or adjustable as indicated. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.

C. Provide the following microprocessor-based time-current curve shaping adjustments for each trip unit:
   1. Adjustable long-time pickup (LTPU) setting.
   2. Adjustable long-time delay (LTD) setting.
   3. Adjustable short-time pickup (STPU) setting.
   4. Adjustable short-time delay (STD) setting with selective curve shaping.
   5. Adjustable instantaneous (INST) pickup setting.
   6. Ground-Fault: For breakers indicated to have ground-fault sensing and protection, include adjustable ground-fault pickup setting and adjustable ground fault delay setting with three, minimum, time settings. Provide local indication of ground-fault alarm in lieu of ground fault tripping as indicated.

D. The microprocessor-based trip units shall have both powered and unpowered thermal memory to provide protection against cumulative overheating should a number of overload conditions occur in quick succession

E. When the adjustable instantaneous setting is shown to be omitted, provide trip unit with an instantaneous override.

F. Where internal ground fault protection is specified, adjustable settings shall not exceed 1200 amperes. Provide neutral ground fault sensor for four-wire loads.

G. Breakers shall have built-in test points for testing, by means of a test set, each of the tripping functions and delay functions (e.g., LTPU, LTD, STPU, etc) included with each breaker.

2.08 CIRCUIT BREAKER TEST SET

A. Provide one test set capable of testing all functions of breakers contained within the switchboard which have sensing trip units as specified in Paragraph TRIP UNITS.

2.09 ACCESSORIES

A. Provide means for locking or adding a lock to each disconnecting means which shall remain in place with or without the lock installed.

B. Provide shunt trips, bell alarms, and auxiliary switches, monitoring and metering devices as noted and shown.

C. Provide metering devices and switching devices to display voltages in real-time each phase-to-phase voltage (Phase A-to-B, Phase B-to-C, Phase C-to-A) and each phase-to-neutral voltage (Phase A-to-Neutral, Phase B-to-Neutral, and Phase C-to-Neutral).
D. Provide metering devices and selector switch means to display amperes in real-time for each phase current (Phase A, Phase B, and Phase C.)

2.10 SWITCHBOARD METERING

A. For each switchboard used for normal power distribution provide a customer metering system with front hinged compartment door and include the following:
   1. Current transformers for each Phase A, Phase B, and Phase C for each meter. Provide current transformers wiring and shorting-type terminal blocks.
   2. Potential transformers including primary and secondary fuses with disconnecting means.
   3. Metering devices and switching devices to display voltages in real-time each phase-to-phase voltage (Phase A-to-B, Phase B-to-C, Phase C-to A) and each phase-to-neutral voltage (Phase A-to-Neutral, Phase B-to-Neutral, and Phase C-to-Neutral).
   4. Metering devices and selector switch means to display amperes in real-time for each phase current (Phase A, Phase B, and Phase C.)

2.11 UTILITY METERING

A. Where indicated, furnish a separate barriered-off utility metering compartment complete with hinged sealable door. Bus work shall include provisions for mounting utility company current transformers and potential transformers or potential taps as required by the utility company. Provide service entrance label and provide necessary applicable service entrance features per NEC and local code requirements.

2.12 ENCLOSURES

A. Interior Installations: NEMA 1 enclosure, unless otherwise noted or shown.

B. Exterior Installations: Provide enclosure with features as follows:
   1. Outdoor enclosure, non-walk-in, complying with applicable NEMA 3R enclosure UL requirements.
   2. Enclosure roof with roof sloping downward toward rear.
   3. Outer sections shall be the same widths as indoor structures, except each end of the outdoor assembly shall have an end trim.
   4. Rear hinged doors for each section.
   5. Doors with provisions for padlocking.
   6. Ventilating openings complete with replaceable fiberglass air filters and rodent-proof screens.
   7. Space heaters, thermostatically-controlled, for each structure with adequate wattage to prevent the accumulation of moisture.
   8. Power for space heaters, lights and receptacles obtained from an included control power transformer within the switchboard. Control power transformer secondary voltage shall be 120 volts AC unless otherwise shown.
2.13 NAMEPLATES

A. Provide engraved nameplates, mounted on the face of the assembly for all main and feeder circuits as indicated. Provide master nameplate stating switchboard designation, voltage, number of phases (e.g., three-phase, single-phase), number of wires (e.g., 4-Wire, 3-Wire), ampere rating, short-circuit rating, manufacturer’s name, general order number, and item number.

B. Nameplates shall be laminated plastic, black characters on white background with characters 3/16-inch high, minimum. Nameplates shall state item designation and circuit number as well as switch or breaker frame ampere size and appropriate trip rating.

C. Suitably mark control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., with identification corresponding to appropriate designations on manufacturer’s wiring diagrams.

D. Provide nameplate on each compartment door and for each overcurrent protective device to identify the load supplied.

E. Provide nameplates with identification "SPARE" for spare devices and provide blank nameplates for space compartments.

F. Provide label on each vertical section to warn persons of possible arc-flash hazards. Locate the labels so as to be readily visible.

G. Provide phasing identification tape applied as follows:

<table>
<thead>
<tr>
<th>480V/277V</th>
<th>208V/120V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Phase A</td>
<td>Yellow</td>
</tr>
<tr>
<td>2. Phase B</td>
<td>Orange</td>
</tr>
<tr>
<td>3. Phase C</td>
<td>Brown</td>
</tr>
</tbody>
</table>

Provide phase identification for protective relays, control transformers, current transformers and potential transformers.

2.14 FINISH

A. Properly clean all exterior and interior steel surfaces of the switchboard with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 light gray, unless otherwise specified or shown.

2.15 SURGE PROTECTION DEVICES

A. Provide surge protection devices (SPD’s) as specified in Section SURGE PROTECTION DEVICES (SPD). Surge protective devices, and associated disconnecting devices, wiring, etc. shall be provided integral to switchboard enclosures.

B. Include overcurrent protective devices and disconnecting devices to disconnect SPDs assembly from switchboard bus.
PART 3 - EXECUTION

3.01 FACTORY TESTING

A. Perform the following standard factory tests on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

   1. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, test the complete switchboard for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for 1 minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for 1 minute between live parts and ground.

B. Provide 3 certified copies of factory test reports.

C. Factory tests as outlined above shall be witnessed by the Owner’s representative.

   1. Notify the Owner 2 weeks prior to the date the tests are to be performed.

3.02 MANUFACTURER’S CERTIFICATION

A. A certified test report of all standard production tests shall be available to the Engineer and shall be provided upon request at no additional cost.

3.03 TRAINING

A. Provide a training session for up to 5 Owner’s representatives on normal workdays at a location determined by the Owner. Training session shall be for duration as specified elsewhere in these specifications but not less than 4 full hours.

B. Conduct training by a manufacturer’s qualified representative. The training program shall consist of instruction on operation of the assembly, circuit breakers, fused switches, metering systems, surge protection systems, ground-fault detection and ground-fault protection systems, monitoring systems, and major components within the assembly.

3.04 INSTALLATION

A. Install all equipment per the manufacturer’s instructions, contract drawings and National Electrical Code.

B. Provide the assembly with adequate lifting means for moving into installation position and bolt directly to Contractor-supplied floor sills set level in concrete per manufacturer’s recommendations. Provide all necessary drilling, anchors, and hardware and secure the assembly in place.
C. Provide full ampacity bus splices between bars of adjacent section shipping splits.

D. Coordinate with other trades to preclude installation of piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation within the NEC Dedicated Electrical Spaces above switchboards. Provide protection (e.g., drip pans) under all fluid conducting foreign systems which route above the NEC Dedicated Electrical Spaces.

E. Install switchboards on 4 inch high concrete housekeeping pads which shall follow the contour of switchboards with 1 inch of overlap on all sides.

3.05 FIELD ADJUSTMENTS

A. Perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the Owner-approved short-circuit study and protective device evaluation study and protective device coordination study.

B. Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with the Owner-approved short circuit and protective device coordination study shall be performed by the Contractor at no additional cost to the Owner.

3.06 FIELD TESTING


END OF SECTION
SECTION 26 24 16

PANELBOARDS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Provide panelboards incorporating switching and protective devices of the number, rating and type specified herein, as required, and as shown.

1.02 REFERENCES

A. American National Standards Institute (ANSI).
   ANSI 67 Panelboards (UL 67)

B. Federal Specifications (FS).
   FS W-C-375B/GEN Circuit Breakers, Molded Case: Branch Circuit and Service (FSC 5925)
   FS W-C-375/1 thru 20 Circuit Breakers, Molded Case, Branch Circuit and Service (Combinations of types, poles, and amperages) (FSC 5925)
   FS W-F-879C(1) Fuseholder (For Plug and Enclosed Cartridge Fuses) (FSC 5920)
   FS W-P-115A(3) Panel, Power Distribution (FSC 6110)

C. Institute of Electrical and Electronics Engineers (IEEE).
   IEEE 141 Electric Power Distribution for Industrial Plants
   IEEE 241 Electric Systems for Commercial Buildings

D. National Electrical Manufacturers Association (NEMA).
   NEMA PB 1 Panelboards
   NEMA PB 1.1 General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less

E. Military Specifications (MS).
   MS MIL-P-29183 Panelboard, Power Distribution, Portable, Weatherproof (FSC 6110)
   MS MIL-P-24395 Panel, Ground Detector (FSC 6110)

F. US Defense Supply Agency
   Interim Federal Item—
   Identification Guide T122: Consoles, Switchboards, and Panels
1.03 APPLICABLE REGULATIONS

A. National Fire Protection Association (NFPA).
   NFPA 70 National Electrical Code (NEC)
   NFPA 70E Standard for Electrical Safety in the Workplace

1.04 SUBMITTALS

A. Submit product data only if required by specification Section SUBMITTALS.

B. Include outline and support dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement, and sizes.

1.05 RESTRICTIONS

A. Panelboards and panelboard components, which rely upon series-connected ratings: Not permitted, unless specifically shown.

PART 2 PRODUCTS

2.01 CONSTRUCTION

A. Box.
   2. Size: 20 inch minimum width; 4 inch minimum gutter space on all sides.
   4. Knockouts: Individual knockouts by manufacturer for NEMA 1 enclosures only or field-cut by Contractor. No concentric knockouts.
   5. Finish: Except for box, all exterior and interior steel surfaces properly cleaned and finished with industry standard gray baked enamel paint over a rust-inhibiting phosphatized primer coating approved by the paint manufacturer.

B. Bussing.
   1. Material: Copper.
   2. Bus Arrangement and Tap Connections: Maintain sequence phasing throughout; that is, adjacent poles shall be of unlike polarity and rotated in sequence.
   3. Short Circuit Bracing: 10,000 Amperes RMS Symmetrical, minimum for 208 VAC panels, and minimum 14,000 Amperes RMS Symmetrical for 480 VAC panels and larger ratings as noted.
   5. Neutral Bus: Full rating, minimum, and greater rating as noted. Suitable lug for each outgoing feeder and circuit requiring a neutral connection.
   6. Ground Bus: Full rating, unless otherwise noted. Suitable lug for each outgoing feeder and circuit.
   7. All bolts used to connect current-carrying parts together shall be accessible for tightening from the front of the panel.
8. Wiring Terminals: Compression or set screw type for conductor material type (e.g., copper or aluminum) terminated; bolted to bus.

C. Trim.
2. Flush Panelboards: ¾ inch minimum overlap all around.
3. Surface Panelboards: Same width and height as box.
4. Mountable by screwdriver, without need for special tools.
5. Tamper-proof: Trim shall not be removable with door closed. Adjustable indicating trim clamps shall be concealed inside door.
6. Doors:
   a. Door-in-hinged trim or Door-in-door arrangement with one door covering all device handles, except panelboards having individual metal clad externally operable deadfront units, and an additional hinged door or hinged trim which will expose the wiring gutter in the panelboard.
   b. Hinges: Concealed, steel.
   c. Over 48 inches in height: Shall have auxiliary fasteners at top and bottom of door in addition to flush latch (3-point).
   d. Latches:
      1) Flush, not protruding beyond front of door.
      2) Spring-loaded door pull.
   e. Locks: Equipment latches with flush, 5-pin cylinder-type locks keyed alike.

D. NEMA 1 enclosure unless otherwise noted or otherwise recommended or required by the NEC for location installed.

2.02 CIRCUIT BREAKERS

A. General: Circuit breakers shall have the following characteristics, minimum, unless otherwise noted:
1. Molded case, automatic air circuit breaker type.
2. Thermal and magnetic trip. Additionally, provide adjustable magnetic trip feature for motor load applications and as shown.
3. Trip free operation. Tripped position separate from either ON or OFF position.
5. Interrupting rating as noted for panelboard in which installed.

B. Main Breaker.
1. Individually mounted separate from branch breakers.
2. Covered by a metal plate, except for the operating handle.
3. Connection from the load side to the panelboard bus shall be bus bar. Insulated wire not permitted.

C. Branch Breakers.
1. Connection to bus: Bolt-on, except as otherwise noted.
D. Other requirements as noted elsewhere in these Specifications and in accordance with the NEC.

E. Ground-Fault Circuit-Interrupters (GFCI).
   1. Provided as shown.
   2. GFCI type as noted elsewhere in these Specifications.

2.03 120/208 OR 277/480 VOLT PANELBOARDS

A. Panelboards shall have the following characteristics, minimum, unless otherwise noted.
   1. 3 phase, 4-wire.
   2. Sequence style bussing.
   3. Full capacity solid neutral.
   4. Composed of an assembly of circuit breakers as noted above and with interrupting ratings as follows:
      a. 10,000 Amperes RMS Symmetrical, minimum, for 208 VAC.
      b. 14,000 Amperes RMS Symmetrical, minimum, for 480 VAC.
      c. Provide larger ratings as noted.

2.04 SURGE PROTECTION DEVICES

A. Provide surge protection devices (SPDs) for panelboards as specified in specification Section SURGE PROTECTION DEVICES. Provide SPDs integral to each panelboard unless otherwise noted or shown.

2.05 ADDITIONAL REQUIREMENTS

A. Provide 20 percent spare branch pole spaces on new panelboards, but not less than quantity of 4 spare branch pole spaces.
   1. Example: Panelboard with 42 branch circuit pole positions shall have 42 positions x 20% = 8 spare branch circuit pole positions.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide mounting brackets, bus bar drillings, and filler pieces for unused spaces.

B. Prepare and affix typed directory to inside cover of panelboard indicating loads controlled by each circuit as required elsewhere in these Specifications.

C. Provide panelboard flush in areas other than mechanical rooms, electrical rooms, and in unfinished areas which may have painted walls and ceilings consisting of the basic building structure.
D. Securely fasten conduit to all panelboards and sheet metal outlet, junction, and pull boxes with two galvanized locknuts, one interior and one exterior to the box, and with one insulating bushing installed in accordance with standard practice. The full number of threads shall project through to permit the bushing to be drawn tight against the end of the conduit, after which the locknut shall be made up sufficiently tight to draw each into firm electrical contact with the box.

E. Provide panelboards listed as Suitable for Use as Service Equipment for Panelboards applied in Service Entrance applications.

F. Keys: Collect all panelboard keys. Combine all keys on one key ring and submit at time of substantial completion.

G. Mount top of panel at 72 inches above finished floor, unless otherwise shown or otherwise required to coordinate with finishes and equipment at location installed.

3.02 LABELING

A. Identification: Prepare and securely attach panelboard label as specified in SECTION ELECTRICAL IDENTIFICATION.

B. Arc-Flash Hazard: Prepare and securely attach to each panelboard a clearly visible arc-flash hazard label to warn persons of possible arc-flash hazards.

3.03 COORDINATION

A. Coordinate with other trades to preclude installation of piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation in the NEC Dedicated Electrical Spaces above panelboards. Provide protection (e.g., drip pans) under all fluid conducting foreign systems which route above the NEC Dedicated Electrical Spaces.

END OF SECTION
PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the contract, including General and Supplementary Conditions and division 01 Specifications Sections, apply to this Section.

1.02 SUMMARY
A. Section includes equipment for electricity metering by Owner.

1.03 DEFINITIONS
A. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.
B. PC: Personal computer.

1.04 SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings: For electricity-metering equipment.
   1. Dimensioned plans and sections or elevation layouts.
   2. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.
C. Field quality-control reports.
D. Operation and Maintenance Data. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Application and operating software documentation
   2. Software licenses
   3. Software service agreement.
   4. Hard copies of manufacturer’s operating specifications, design user’s guides for software and hardware, and PDF files on CD ROM of the hard copy Submittal.

1.05 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
1.06 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center according to NECA 400.

1.07 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Owner no fewer than two days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Owner’s written permission.

1.08 COORDINATION

A. Electrical Service Connections: coordinate with utility companies and components they furnish as follows:
   1. Comply with requirements of utilities providing electrical power services.
   2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.09 SOFTWARE SERVICE AGREEMENT

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

B. Upgrade Service: Updae software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   1. Provide 30 days’ notice to Owner to allow scheduling and access to system and to allow Owner to upgrade his computer equipment if necessary.

PART 2 - PRODUCTS

2.01 EQUIPMENT FOR ELECTRICITY METERING BY OWNER

A. Manufacturers:
   1. E-Mon, a division of Hunt Power.
   2. Eaton Electrical Inc., Cutler-Hammer Business Unit.
   5. Square D; a brand of Schneider Electric.
B. General Requirements for Owner’s Meters:
1. Comply with UL 1244
2. Meters used for billing shall have an accuracy of 0.2 percent of reading, complying with requirements of ANSI C12.20.
3. Enclosure: NEMA 250, Type 1 minimum, with hasp for padlocking or sealing.
4. Identification: Comply with requirements in Division 26 Section “Identification for Electrical Systems.”
5. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
6. Sensors: Current sensing type, with current or voltage output selected for optimum range and accuracy for meters indicated for this application.
   a. Type: solid core.
7. Current Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
8. Building Automation System (BAS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to BAS input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.

C. Kilowatt-hour Meter: Electronic three-phase meters, measuring electricity used.
1. Voltage and Phase configurations: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours and current kilowatt load. Retain accumulated kilowatt-hour in a nonvolatile memory, until reset.
3. Display: Digital electromechanical counter, indicating accumulative kilowatt-hours.

D. Killowatt-hour/Demand Meter: Electronic three-phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute period with a one second sampling rate.
1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration for its application.
2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours, current time and date, current demand, and historic peak demand, and time and date of historic peak demand. Retain accumulated kilowatt-hour and historic peak demand in a nonvolatile memory, until reset.

E. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Division 26 Section "Control-Voltage Electrical Power Cables."
F. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation.

1. Utility cost Allocation: Automatically import energy usage records to allocate energy costs for the following:
   a. At least 15 buildings.

2. Tenant or Activity Billing software: Automatically import energy usage records to automatically compute and prepare activity demand and energy-use statements based on metering of energy use and peak demand. Maintain separate directory for each building’s historical billing information. Prepare summary reports in user-defined formats and time intervals.

PART 3 EXECUTION

3.01 INSTALLATION

A. Comply with equipment installation requirements in NECA a.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company’s written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.02 IDENTIFICATION

A. Comply with requirements for identification specified in Division 26 Section “Identification for Electrical Systems.”

1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.

2. Equipment Identification Labels: Adhesive film labels with clear protective overlay.

3.03 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. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.

2. Turn off circuits supplied by metered feeder and secure them in off condition.
3. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.

4. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.

C. Electricity metering will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports

END OF SECTION
PART 1 - GENERAL

1.01 WORK INCLUDED

A. Wall switches.
B. Receptacles.
C. Ground Fault Receptacles.

1.02 REFERENCE STANDARDS

A. American National Standards Institute (ANSI).
   ANSI C73
   Fittings for Rigid-Metal Conduit and Electrical Metallic Tubing

   FS W-C-596D
   Electrical Power Connector, Plug, Receptacle and Cable Outlet

C. National Electrical Manufacturer’s Association (NEMA).
   NEMA WD-1
   General Purpose Wiring Devices
   NEMA WD-2
   Wiring Device Configurations

D. National Fire Protection Association (NFPA).
   NFPA 70
   National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL)
   UL 20
   Standard for Snap Switches
   UL 467
   Grounding and Bonding Equipment
   UL 498
   Attachment Plugs and Receptacles

PART 2 - PRODUCTS

2.01 SWITCHES

A. 120-277 volt; current and modifiers as shown.
B. AC lifetime, quiet slow make, slow break design, toggle handle.
C. Totally enclosed case.
D. Rated 20 ampere minimum.

E. Heavy duty, specification grade.

F. Outdoor, Damp or Wet Locations: Approved for use.

G. Wiring: Side terminal screws and back wiring wells for up to No. 10 AWG copper wire.

H. Switch and Pilot Light: Push action type with red handle, integral long-life neon pilot light, rated at 15 ampere, 120 volts.

I. Provide matching two pole, 3-way and 4-way switches.

2.02 RECEPTACLES

A. Receptacles.
   1. Full gang size.
   2. Polarized.
   3. Duplex, unless otherwise shown.
   4. Parallel blade, U-grounding slot.
   5. Specification grade; heavy duty.
   6. 125 volts.
   7. Designed for split feed service.
   8. Rating as shown and per NEC 210-21; 15 amperes minimum.
   9. Terminal screws and wiring wells for up to No. 10 AWG copper wire.

B. Ground Fault Receptacles.
   1. Specification grade; heavy duty duplex receptacle.
   2. Integral ground fault circuit interrupter.
   3. Test and reset buttons.
   5. Additional requirements as noted herein for standard receptacles.

C. Outdoor, Damp, or Wet Locations: Approved for use.

D. Power Receptacles: Locking type, grounding, heavy duty, specification grade. Ratings as shown.

E. Computer Power Receptacles: Straight blade (15 and 20 amp), locking type (30 amp and larger), isolated ground type, heavy duty, premium specification grade, orange color. Ratings as shown.

2.03 COLOR

A. Provide ivory switches and receptacles in areas with light wall finish. Provide brown switches and receptacles in areas with wood or dark wall finish.
2.04 COVERPLATES

A. Finished Areas: Satin stainless steel, nominal 0.040” thickness. Match device.

B. Unfinished Areas: Raised galvanized plates where conduits run exposed with surface mounted boxes.

C. Surface Mounted Raceway: By raceway manufacturer, specifically for the purpose. Color to match raceway.

2.05 WEATHERPROOF COVERPLATES

A. Material: Stainless steel or cast aluminum.

B. Finish: Satin stainless steel or gray aluminum enamel.

C. Receptacle Configuration: Gasketed wall plate with individually hinged and gasketed cover lids over device openings.

D. Switch Configuration: Gasketed wall plate, external switch operator with weatherproof bushing.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide wiring devices of number, rating, and type shown.

B. Devices shall include appropriate outlet box, cover, wall plate and other necessary installation materials for a complete and satisfactory operating outlet.

C. Mount switches 42 inches above floor except as otherwise noted on drawings.

D. Coordinate switch mounting location with architectural detail. In kitchen, laboratory, and utility areas, coordinate receptacle height with benches and counters.

E. Mount receptacles vertically at 18 inches above finished floor with grounding pole at top, unless otherwise indicated. When mounting receptacles above counters or casework, mount horizontally with grounding pole at left 12 inches above top of counters or casework. Provide weatherproof coverplates for all receptacles within 8 feet of emergency eyewash stations.

F. Back wiring wells may be used for receptacles.

G. Grounding: Provide a separate green or bare wire between the receptacle strap grounding (green) screw and a screw into the outlet box. Self-grounding strap not approved as grounding means.
H. **Isolated Grounding Network**: Connect insulated isolated ground conductor to receptacle grounding slot. Do not bond to device box. Connect separate equipment grounding conductor to device box with screw into box.

I. **Nameplates**: Provide engraved or embossed plastic nameplate as described elsewhere in these specifications. For receptacles other than standard duplex receptacles, additionally indicate voltage, phases, amperes, circuit, and panel.

**END OF SECTION**
SECTION 26 28 19
CIRCUIT AND MOTOR DISCONNECTS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide and install motor disconnects as shown and as required by Codes.

B. Provide and install circuit disconnects as shown and as required by Codes.

C. Disconnects to include mounting stands, brackets, plates, supports, and required hardware and accessories for complete installation.

1.02 REFERENCES

A. National Electrical Manufacturers' Association (NEMA).
   NEMA ICS 6 Enclosures for Industrial Controls and Systems
   NEMA KS-1 Enclosed and Miscellaneous Distribution Equipment
   Switches

B. National Fire Protection Association (NFPA).
   NFPA 70 National Electrical Code (NEC)

C. Underwriters Laboratories, Inc. (UL)
   Annual Product Directories
   UL 98 Enclosed Switches

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Safety Switches.
   1. GE
   2. Siemens
   3. Square D
   4. Westinghouse
   5. Others, as specifically shown.

B. Fuses: All fuses, except control fuses, shall be of the time-delay type, Bussman Manufacturing Company’s “Fusetron” or Grould Shawmut Company’s “Tri-Onic”. All control fuses shall be Buss or Gould one-time nonrenewable fuses. A complete set of fuses shall be furnished for all fuse-holding devices.
2.02 COMPONENTS

A. Motor and circuit disconnects shall have an UL label.

B. Three-phase motor disconnect switches shall have the following characteristics minimum, unless otherwise noted:
   1. 3-pole heavy duty, quick-make, quick-break.
   2. 250 Volt or 600 Volt as required.
   3. Load interrupter, enclosed knife switch.
   4. Number of poles and ampacity as noted or required by Code.
   5. Nonfusible.
   6. Short circuit rating sufficient to withstand the available fault current or let-through current.

C. Compression or set-screw lugs approved for use with copper wire.

D. ON/OFF Operating Handle.
   1. Externally operable with “ON” and “OFF” positions clearly marked.
   2. Lockable in “OFF” position.

E. Cover Interlock.
   1. Prevents switch from being opened when “ON”.
   2. Prevents closing switch when cover is open.
   3. Defeater to permit authorized personnel to open door and inspect switch when “ON”, or operate with cover open.

F. Switches shall be horsepower rated for AC and/or DC, as indicated by the plans.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide motor and circuit disconnects as recommended by manufacturer and as required by Code and UL.

B. Maintain code clearances.

C. Provide a nameplate on each motor and circuit disconnect identifying the equipment item served.

D. Where two motor disconnects serve a common motor, i.e., a two-speed motor, the disconnects shall be mounted beside each other and clearly labeled as a dual source of power to one motor. A caution to open both switches in order to de-energize the motor shall be posted.
E. Enclosures.
   1. Disconnects shall be in NEMA 1 enclosures unless otherwise indicated. Penetrations into enclosure shall be so provided as to maintain the enclosure NEMA type rating.
   2. Knockouts provided by manufacturer not permitted except for NEMA 1 enclosures.

F. Where noted as fusible, provide switch complete with fuses.

END OF SECTION
SECTION 26 28 23

OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Fuses.
B. Circuit breakers.

1.02 REFERENCES

A. American National Standards Institute (ANSI).
   ANSI C97.1 Low Voltage Cartridge Fuses 600 Volts or Less

B. Federal Specifications (FS).
   FS W-C-375B/GEN Circuit Breakers, Molded Case; Branch Circuit and
   Service, Federal Supply Classification (FSC) 5925
   FS W-C-375(1-20) Circuit Breakers, Molded Case, Branch Circuit and
   Service, (FSC) 5925
   FS W-F-1814 Fuse Cartridge, High Interrupting Capacity, (FSC) 5920

C. National Electrical Manufacturer’s Association (NEMA).
   NEMA FU-1 Low Voltage Cartridge Fuses

D. National Fire Protection Association (NFPA).
   NFPA 70 National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL).
   UL 489 Molded Case Circuit Breakers and Circuit Breaker
   Enclosures
   UL 943 Class A Ground Fault Circuit Interrupters
   UL 198E Class R Fuses
   UL 198.2 High Interrupting Capacity Fuses, Current Limiting Type
PART 2 - PRODUCTS

2.01 FUSES

A. All control circuit fuses shall be buss one-time nonrenewable fuses sized for control circuit voltage and current requirements.

2.02 MOLDED CASE CIRCUIT BREAKERS

A. Branch Breakers.
1. Connection to Bus: Bolt-on unless otherwise noted.
2. Thermal-magnetic molded case, with inverse time current overload and instantaneous magnetic tripping unless otherwise shown.
3. Quick-make, quick-break, with tripped indication clearly shown by breaker handle taking a position between ON and OFF.
4. Multi-pole breakers shall have a common internal trip. No handle ties between single pole breakers.
5. Special service requirements.
   a. 15 and 20 ampere single-pole circuit breakers used on 120 volt and 277 volt AC fluorescent lighting loads shall be UL listed as SWD rated.
   b. All combination motor starters, MCC or local, shall utilize magnetic trip motor short-circuit protector (MCP) disconnect device with external operating handles lockable in the OFF position. MCP size and setting shall be per manufacturer’s recommendations for the actual full load current of the motor controlled.
6. Breakers feeding convenience outlets shall have sensitive instantaneous trip settings of not more than 10 times the breaker trip rating to prevent repeated arcing shorts resulting from frayed appliance cords.
7. Provide circuit breakers with minimum interrupting rating of 14,000 AIC RMS symmetrical at 240 or 120 Volt AC and 22,000 AIC RMS symmetrical at 480 Volts AC, and as otherwise noted or required by the NEC.
8. Ground fault circuit interrupter (GFCI) breakers shall be UL listed as Class A, Group 1 with sensitivity of 5 milliamperes or less of ground fault current and normal circuit protection with inverse time overload and instantaneous short circuit protection.
9. Adjustable ground fault protection shall be supplied as an integral part of the service entrance circuit breaker.
PART 3 - EXECUTION

3.01 FUSE INSTALLATION

A. Label each switch to indicate type and rating of fuse installed.

B. All fuses shall be selected to provide selective system coordination.

C. Provide 10% (3 minimum) spare fuses of each size and rating used.

3.02 CIRCUIT BREAKER INSTALLATION

A. Label each breaker located in switchboard or separate enclosure to indicate load served.

B. Adjust settings on breakers to operate properly under actual field conditions and to provide selective system coordination.

END OF SECTION
SECTION 26 29 13

MOTOR STARTERS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Motor starters for all electric motor driven equipment. All starters shall be of one manufacturer and shall match motor control centers except equipment packages with which motor starters are supplied with the equipment package.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA).
   
   NEMA ICS 1 Industrial Control and Systems: General Requirements
   NEMA ICS 2 Industrial Control and Systems: Controllers, Contactors and Overload Relays Rated 600 Volts
   NEMA ICS 6 Industrial Control and Systems: Enclosures

B. Underwriters Laboratories, Inc. (UL).
   
   UL 508 Industrial Control Equipment

C. Military Specifications (MS).
   
   MIL-S-12541C Starter, Motor, Across-the-Line and Reduced Voltage Types, A-C Induction, 3/4 to 100 HP, Manual and Electric

D. National Fire Protection Association (NFPA).
   
   NFPA 70 National Electrical Code (NEC) - Article 430, Motors, Motor Circuits, and Controllers
   NFPA 79 Electrical Standards for Industrial Machinery

1.03 APPLICABLE REGULATIONS

NFPA 70 National Electrical Code (NEC) - Article 430, Motors, Motor Circuits, and Controllers

1.04 SUBMITTALS

A. Manufacturer's literature: Required.

B. The submittals, shop drawings, product data, and samples procedure shall be as noted elsewhere in these specifications and as indicated below.
C. Submittal items required as follows:
   1. Manufacturer's component and installation instruction books.
   2. Circuit breaker ratings and curves. Overload heater curves and selection criteria.
   3. Factory shop drawings and unit schematic wiring diagrams. Shop drawings shall note and define all applicable options.
   4. Renewal parts books.

1.05 SYSTEM STARTING AND SYSTEM DEMONSTRATIONS

   A. The system starting and system demonstration procedure shall be as noted elsewhere in these specifications.

PART 2 - PRODUCTS

2.01 MANUAL MOTOR STARTERS

   A. For single phase motors, except as otherwise noted, provide toggle-operated switches with thermal overload sized for full load current of motor controlled. Provide complete with pilot light, green color unless otherwise noted or shown.

   B. Provide with pad-lockable NEMA type enclosure as required by NEC for location installed and as otherwise noted. Provide devices in enclosure and penetrations into enclosure in a manner to maintain the enclosure NEMA type rating.

2.02 MAGNETIC MOTOR STARTERS

   A. Provide magnetically-operated contactors with three pole overload relays and heaters.

   B. Provide 120 volt operating coils unless otherwise noted.

   C. Provide pilot lights per paragraph PILOT LIGHTS.

   D. Provide cover mounted reset button, and hand-off-auto (HOA) 3-position selector switch or start-stop 2-position selector switch, or start-stop pushbutton station as indicated on the drawings or required for the control scheme. Additionally, provide one pushbutton for each forward and reverse speed for manual operation when in the "hand" position of HOA switches or "start" mode of start-stop switches.

   E. Provide starters with a sufficient number of auxiliary contacts (Normally Open [N.O.] and Normally Closed [N.C.]) to afford the control and interlocking required in addition to standard auxiliary holding contacts supplied with each contactor, plus two field convertible spare auxiliary contacts.

   F. Provide control transformer, 120 volt secondary (unless otherwise noted) of sufficient capacity to handle operating coil and associated controls. Protect control transformers with fuses on primary and secondary sides of transformer as required by NEC.
G. Provide with pad-lockable NEMA type enclosures as required by NEC for the location installed and as otherwise noted. Provide devices in enclosure and penetrations into enclosure in a manner to maintain the enclosure NEMA type rating.

2.03 COMBINATION MOTOR STARTERS

A. Provide magnetic trip motor short-circuit protector (MCP) disconnect devices with operating handle pad-lockable in OFF position, unless otherwise noted. MCP size and setting shall be per MCP manufacturer’s recommendations for the full load current of the motor controlled.

B. Restrict opening of enclosure cover to the use of a defeater screw when disconnect device is in the ON position.

C. Provide magnetically-operated contactors with three pole overload relays and heaters.

D. Provide 120 volt operating coils unless otherwise noted.

E. Provide pilot lights per paragraph PILOT LIGHTS.

F. Provide cover mounted reset button, and hand-off-auto (HOA) 3-position selector switch, or start-stop 2-position selector switch, or start-stop pushbutton station as indicated on the drawings or required for the control scheme. Additionally, provide one pushbutton for each forward and reverse speed for manual operation when in the "hand" position of HOA switches or "start" mode of start-stop switches.

G. Provide starters with a sufficient number of auxiliary contacts (Normally Open [N.O.] and Normally Closed [N.C.]) to afford the control and interlocking required in addition to standard auxiliary holding contacts supplied with each contactor, plus two field convertible spare auxiliary contacts.

H. Provide control power transformer, 120 volt secondary (unless otherwise noted) of sufficient capacity to handle operating coil and associated controls. Protect control transformers with fuses on primary and secondary sides of transformer as required by NEC. Control power transformer shall be de-energized when combination motor starter disconnect device is in OFF position.

I. Provide with pad-lockable NEMA type enclosures as required by NEC for the location installed and as otherwise noted. Provide devices in enclosure and penetrations into enclosure in a manner to maintain the enclosure NEMA type rating.

2.04 MULTI-SPEED AND REVERSING MOTOR STARTERS

A. Provide multi-speed and reversing motor starters of the appropriate type and NEMA size for the motor controlled.

B. Provide magnetically-operated contactors with three pole overload relays and heaters for each speed.
C. Provide pilot lights per paragraph PILOT LIGHTS.

D. Provide accelerating and decelerating timing relays for multi-speed motors and anti-plugging timing relays for reversing applications with adjustable time delays of 0 to 60 seconds or longer as noted. Temperature ranges shall be suitable for environment where installed. Provide other relays and controls as noted or required.

E. Provide magnetically-operated contactors with mechanical interlocks of the nonjamming type to ensure only one operating coil is energized at once.

F. All other requirements for motor starters as described in paragraphs MAGNETIC MOTOR STARTERS, COMBINATION MOTOR STARTERS, and PILOT LIGHTS are applicable to multi-speed and reversing motor starters.

2.05 PILOT LIGHTS

A. Provide pilot lights in enclosure cover as follows, unless otherwise noted:
   1. Transformer type.
   2. One, green color, for OFF indication with legend plate lettering “OFF.”
   3. One, red color, for each forward and reverse speed with legend plate lettering indicating speed (e.g., FAST, SLOW, MEDIUM, REVERSE).
   4. Control each pilot light by individual auxiliary contacts.
   5. Other characteristics as noted.

B. Exception to above color code: Where there is an existing and defined color code in a building, new work in that building will use the existing color code.

2.06 SOLID-STATE REDUCED-VOLTAGE MOTOR CONTROLLER

A. Acceptable Manufacturers: Eaton Cutler-Hammer Intelligent Technologies Soft Starter, or approved equal.

B. Provide cover-mounted reset button, and Hand-Off-Auto (HOA) 3-position selector switch or start-stop 2-position selector switch, or start-stop pushbutton station as indicated on the drawings or required for the control scheme.

C. Provide 3-phase, solid-state reduced-voltage (SSRV) combination fused disconnect switch and motor starter as shown for each motor that otherwise would have full-voltage across-the-line starting kVA (skVA) that would exceed specified maximum skVA.

D. Provide SSRV complete with integral manufacturer’s required power supply, control power transformer (CPT) with fuse protection per NEC, metal oxide varistor (MOV) surge protection on all phases on both input and output.

E. Provide with pad-lockable NEMA 12, minimum, enclosure as additionally required by NEC for the location installed, and as shown. Provide devices in enclosure and penetrations into the enclosure in a manner to maintain the enclosure NEMA-type rating.
F. Maximum starting kVA (skVA): Equivalent to three times motor nameplate full-load current.

G. Provide SSRV with severe duty rating adequate for motor rating including motor nameplate service factor for motor provided at site ambient conditions and elevation, and rated for 6 starts per hour, minimum. Adjust SSRV accelerating starting period start ramp setting to limit starting inrush to specified maximum skVA.

PART 3 - EXECUTION

3.01 INSTALLATION

A. In finished areas, mount motor starters flush when depth permits and provide suitable coverplates. Unless otherwise shown, in unfinished areas, such as electrical rooms and mechanical rooms, provide surface mounted motor starters.

B. Provide heaters correlated with full load current of motors controlled at each motor speed.

C. Set overload devices to suit motors controlled.

D. Coordinate mounting position with other trades and building systems to maintain required NEC working spaces and NEC dedicated equipment spaces.

E. Unless otherwise shown on drawings, locate starters within sight of their associated motors.

F. Provide watertight hubs for motor starters located in damp and wet locations.

G. Provide horsepower-rated disconnecting device in sight of each noncombination magnetic motor starter.

H. Provide horsepower-rated disconnecting device in sight of each motor.

3.02 IDENTIFICATION AND LABELING

A. Nameplates: Provide identifying nameplate on front cover of each motor starter. Size, type, and identifying lettering as specified elsewhere in these specifications.

B. Provide label, separate from identifying nameplate, on each motor controller to warn persons of possible arc-flash hazards. Locate the labels so as to be readily visible.

END OF SECTION
SECTION 26 32 13

ENGINE GENERATOR

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Engine generator system.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. National Electrical Manufacturers Association (NEMA).
   - NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
   - NEMA AB 1 Molded Case Circuit Breakers
   - NEMA MG 1 Motors and Generators

C. National Fire Protection Association (NFPA).
   - NFPA 30 Flammable and Combustible Liquids
   - NFPA 37 Installation and Use of Stationary Combustion Engines and Gas Turbines
   - NFPA 70 National Electrical Code (NEC)
   - NFPA 99 Health Care Facilities
   - NFPA 110 Emergency and Standby Power Systems

D. Underwriters Laboratories, Inc. (UL),
   - UL142 Steel Aboveground Tanks for Flammable and Combustible Liquids
   - UL2200 Stationary Engine Generator Assemblies
   - UL 1236 Battery Chargers for Charging Engine-Starter Batteries
1.03 SYSTEM DESCRIPTION

A. Provide engine generator assemblies as described in specifications unless otherwise noted or shown on plans.

B. UL Listing: Engine generator assemblies listed in accordance with UL2200

C. Application: Engine generator system shall provide source of power in accordance with NFPA 110, for the Level, Class, and Type as follows:
   1. Level: 1
   2. Class: 8 (8 Hours)
   3. Type: 10

D. System rated output capacity: SEE PLANS (0.8 lagging power factor.)

E. Rated nominal output voltage: 277/480 V, 3-phase, 4-wire, 60 Hz.

F. Transient Response Characteristics.
   1. Maximum step load shall be comprised of the following individual loads which shall be energized simultaneously:
      a. Motors: One motor rated 100 hp, 460 V, 3-phase, NEMA Design B, kVA-code letter A (fire pump service).
      b. Lighting: 60 kVA, total; balanced among 3 each 277 V single-phase circuits of fluorescent lighting (emergency lighting service).
   2. Provide load pickup and load shedding per NEC 700.5. Order of priority shall be the following (from highest priority to lowest priority):
      a. E-ATS-A (NFPA 110 Level 1)
      b. S-ATS-A (NFPA 110 Level 2)
      c. OS-ATS-A
   3. Transient speed deviation shall not exceed plus or minus 5 percent of rated speed upon addition or removal of a block of load equal to the maximum step load.
   4. Time to return to within plus or minus 5 percent of the initial speed value shall not exceed 5 seconds upon addition or removal of a block of load equal to maximum step load.
   5. Transient voltage deviation shall not exceed plus or minus 8 percent of rated voltage upon addition or removal of a block of load equal to maximum step load.
   6. Time to return to within plus or minus 3 percent of the initial voltage value shall not exceed 10 seconds upon addition or removal of a block or load equal to maximum step load.

G. Site Conditions: Installed equipment shall provide the specified capacities and ratings when installed in the following environment:
   1. Ambient temperature: -33 degrees C to 40 degrees C (-20 degrees F to 104 degrees F).
   2. Elevation: 4956 feet above sea level.
   3. Humidity: Noncondensing to 90%.
   4. Wind loading: Wind Speed = 90 MPH, Exposure C, Wind Load Importance Factor, lw = 1.15
5. Snow loading: Ground Snow Load = 20 psf, Snow Load Importance Factor, Is = 1.1

H. Duty: Standby.

1.04 SUBMITTALS

A. Provide manufacturer's published warranty documents, certification of prototype testing, and installation instructions.

B. Provide on-site test reports indicating results of performance testing.

C. Provide manufacturer's operating and maintenance manuals, including instructions for routine maintenance items, service manual for engine and day tank, oil sampling and analysis for engine wear.

D. Provide product data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, and control panel, battery, battery rack, battery charger, exhaust silencer, vibration isolators, day tank, remote radiator, and remote annunciator.

E. Provide shop drawings including the following:
   1. Base-mounted equipment, complete with base and all attachments including anchor bolt template and recommended clearances for maintenance and operation.
   2. Electrical and mechanical connection requirements. Show plan and elevation views with overall and interconnection point dimensions.
   3. Starting system.
   4. Fuel system.
   5. Cooling system.
   6. Ventilation and combustion air requirements and exhaust system.
   7. Electric wiring of relays, breakers, and switches including single line and wiring diagrams.
   8. Lubrication system, including piping, pumps, strainers, filters, heat exchangers for lube oil and turbocharger cooling, electric heater, controls and wiring.
   9. Location, type, and description of isolation devices.
  10. The safety system, including wiring schematics.
  11. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and all instrumentation.
  12. Control and annunciator panel layouts.
  13. Mounting and support for each panel and major piece of electrical equipment.
  14. Engine generator rigging points and lifting instructions.

F. Provide as-built drawings which accurately depict the as-built configuration of the installation, upon acceptance of the engine generator installation.
G. Emissions: Provide exhaust gas emissions based on standard timing and use of specified fuel type at rated output in pounds per hour for each of the following:
1. Total suspended particulate/PM10.
2. Sulfur dioxide
3. Nitrogen oxide
4. NOX
5. Carbon monoxide
6. Volatile organic compounds

H. Test Reports: Indicate results of performance testing.

1.05 QUALIFICATIONS
A. Manufacturer: Company specializing in packaged engine generator system with minimum three years documented experience.

B. Supplier: Authorized distributor of engine generator manufacturer with service facilities within 150 miles of project site.

1.06 DELIVERY, STORAGE, AND HANDLING
A. Store and protect products and equipment from dirt and moisture by securely wrapping in heavy plastic.

1.07 SINGLE SUPPLIER
A. The supplier shall be the manufacturers authorized distributor, who shall provide initial start-up services, conduct field acceptance testing and warranty service.

B. The supplier shall provide all equipment including annunciators, remote annunciators, automatic transfer switches, and appurtenances for a complete and operable system, all provided within a single warranty as indicated elsewhere in this specifications.

1.08 WARRANTY
A. Provide one year warranty for all products against defects in materials and workmanship from the startup date per the manufacturer's Base Coverage Limited Warranty.

1.09 MAINTENANCE SERVICE
A. Furnish service and maintenance of packaged engine generator system for one year from Date of Substantial Completion.

1.10 EXTRA MATERIALS
A. Provide two of each additional fuel, oil, and air filter elements for the engine.
PART 2 - PRODUCTS

2.01 ENGINE GENERATORS

A. Provide engine generators with accessories, auxiliary equipment, and associated work, except as specified otherwise. Each engine generator shall consist of an engine direct-connected to a generator provided with brushless excitation system and accessories. Coordinate the engine generators to ensure an installed rating in the environment described in the paragraph entitled “Site Conditions.”

B. Construction:
1. Mount each engine generator on a structural steel sub-base sized to support the engine generator with the following together with the interconnecting piping and wiring for systems as standard from the manufacturer and as additionally required for this project:
   a. Engine.
   b. Generator.
   c. Silencer
   d. Lubricating oil filters
   e. Heat exchangers (radiators) and pumps
   f. Fuel oil filters and pumps
   g. Jacket coolant heat exchangers
   h. Auxiliaries.
2. The structural sub-base shall be designed to properly support the equipment and maintain proper alignment of the engine and generator. In addition, provide sub-base with both lifting rings and jacking pads properly located to facilitate shipping and installation of the unit.
3. The sub-base shall be designed to provide the necessary lateral support in the specified seismic zone. Provide a vibration isolation system between the engine and generator and the engine generator sub-base. The vibration isolation system shall meet or exceed the manufacturer's recommendations.
4. Engine and generator shall be factory-aligned on the sub-base.
5. Provide anchor bolts of type, size, quantity, and placement and mounting methods as recommended by engine generator manufacturer.

C. Critical Speeds: Each complete engine-generator unit shall be free of critical speeds of either a major or minor order that might endanger satisfactory operation, or cause undue vibration in any part of plant equipment or structure.

D. Design and Construction: Rotating or reciprocating parts, or other parts that present a potential hazard to operating personnel, shall be isolated or shielded to minimize danger. Design characteristics shall limit operating temperatures at critical points of maximum wear at full load operating conditions.
ENGINE

A. Type:
1. Water-cooled or air-cooled.
2. In-line or V-type.
3. Four stroke cycle or two stroke cycle.
4. Internal combustion engine.
5. Engine speed shall be 1800 rpm maximum.

B. Engine Safety Devices: Engine shutdown on high water temperature, low oil pressure, overspeed, and engine overcrank. Limits as selected by manufacturer.

C. Rating: Sufficient to operate at 10 percent overload for one hour at specified elevation and maximum ambient temperature limits.

D. Lubrication: Each engine shall be provided with a gear type oil pump, full flow cartridge type filter, dipstick for oil level indication, and an oil cooler as recommended by the engine manufacturer.

ENGINE FUEL SYSTEM

A. Use No. 2 diesel fuel oil.

B. Fuel Tank: Provide integral fuel tank constructed of materials allowed by NFPA 37 and with double wall construction. Each fuel tank shall be provided with connections for a fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and drain line. A fuel return cooler shall be provided as recommended by the engine generator manufacturer. The temperature returning to the fuel tank shall be below the flashpoint of the fuel. A temperature sensing device shall be installed in the fuel supply line to stop the engine generator should the temperature of the returning fuel be greater than the flashpoint of the fuel. The fuel tank shall be UL listed and shall have stub-up area for routing of utilities to engine generator from below.
1. Capacity: Tank shall provide sufficient fuel for the minimum number of hours specified by NFPA 110 Class to permit uninterrupted operation at 100 percent rated load without being refilled, plus any fuel which may be required for cooling the fuel manifold.
2. Drain Line: Each tank drain line shall be accessible and equipped with a shutoff valve. Self-supporting day tanks shall be arranged to allow drainage into a 305 mm (12 inch) tall bucket.
3. Local Fuel Fill: A fuel fill port on the day tank shall be provided with a lockable screw-on cap.
4. Fuel Level Controls: Each fuel tank shall have a float switch assembly to activate the "Low Fuel Level" alarm at 50 percent of the total tank volume.
5. Leak Detection: Provide leak detection system capable of continuous monitoring and recording with on-demand reporting to monitor each interstitial space of double-wall tanks.
6. Arrangement: Integral fuel tanks may allow gravity flow into the engine. Gravity flow tanks shall be provided with an integral or external valve located as near as possible to the shell of the tank. The valve shall close when the engine is not operating. Integral day tanks shall be provided with any necessary pumps to supply fuel to the engine as
recommended by the engine generator manufacturer. Each self-supporting day tank shall either be arranged so that the fuel level in the fuel tank remains above the suction port of the engine driven fuel pump, or be provided with a transfer pump to provide fuel to the engine driven pump. The overflow connection and fuel supply line shall be arranged so that the highest possible fuel level is below the fuel injectors. The fuel supply line from the fuel tank to the manufacturer’s standard engine connection shall be welded pipe.

2.04 ENGINE GOVERNOR

A. Provide droop governors to maintain the midpoint of the frequency bandwidth linearly for steady-state loads over the range of zero to 100 percent of rated output capacity, with 3 percent droop. Isochronous governors which provide equivalent bandwidth will be considered.

B. Droop Governor Bandwidths:
   1. Mechanical: Governors shall have centrifugal speed sensing and maintain a frequency bandwidth of plus or minus 0.60 percent (maximum).
   2. Mechanical-Hydraulic: Governors shall have centrifugal speed sensing and maintain a frequency bandwidth of plus or minus 0.40 percent (maximum).
   3. Electrical: Electrical governors shall have electrical speed sensing and maintain a frequency bandwidth of plus or minus 0.25 percent (maximum).

2.05 ENGINE EXHAUST SILENCER

A. Residential silencer, with muffler companion flanges and flexible stainless steel exhaust fitting, suitable for concealed or horizontal orientation, vertical exhaust pipe termination, sized in accordance with engine manufacturer’s instructions. Exhaust silencer shall be designed for 15 to 20 dBA resulting in an attenuated exhaust sound pressure level of 55 dBA at 50 feet. Provide rain cap if the exhaust pipe terminates in the vertical position.

2.06 STARTING SYSTEM

A. DC starting system with positive engagement, number and voltage of starter motors in accordance with manufacturer's instructions. Include both local and remote starting control circuits as specified in paragraph "Engine Generator Control Panel."
   1. Batteries: Provide integral starting battery system including the battery, battery rack, intercell connectors, all necessary cables and connectors and spacers. Critical system components (rack, protection, etc.) shall be sized to withstand the seismic acceleration forces of the zone specified. The battery shall be lead-acid type, with sufficient capacity to start the engine, at the minimum ambient temperature specified to provide the specified cranking periods. Match battery system voltage to the starting system voltage.
   2. Battery Tray: Plastic, plastic-coated metal, or wood treated for electrolyte resistance, constructed to contain spillage of electrolyte.
   3. Battery Charger: In accordance with NFPA 110 for Level specified. Provide current-limiting type designed to float at 2.17 V per cell and equalize at 2.33 V per cell, conforming to UL 1236, which shall automatically recharge the batteries. The charger shall be capable of an equalize charging rate for recharging fully depleted batteries within 24 hours and a float charge rate for maintaining the batteries in prime starting.
ENGINE GENERATOR

2.07 ENGINE COOLING

A. Engine mounted radiator, with engine driven blower (front discharge type) propeller fan, sized for 0.5 inches water gage external static pressure, minimum.

B. Selected and sized by engine manufacturer to maintain engine manufacturer's normal operating engine temperature when operated at temperature and altitude specified in paragraph Site Conditions. Provide initial fill of 50% ethylene glycol and demineralized water coolant solution.

2.08 ENGINE ACCESSORIES

A. Provide the following engine accessories:
   1. Fuel filter.
   2. Lube oil filter.
   3. Intake air filter.
   4. Lube oil cooler.
   5. Fuel transfer pump.
   7. Gear-driven water pump.
   8. Fuel pressure gage, coolant temperature gage, and lube oil pressure gage on engine generator control panel.

B. Engine Lubricating Oil Heaters: Provide thermostatically controlled electric heater mounted in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus 3 degrees of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. Power for the heaters shall be 120 VAC, single-phase.

C. Jacket-Coolant Heater:
   1. A thermostatically controlled electric heater shall be mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. The control temperature shall be the temperature recommended by the engine manufacturer to meet the starting time specified.
   2. Jacket coolant heater shall be suitable for operation on 120VAC, single-phase.

2.09 GENERATOR

A. Generator: NEMA MG 1; three-phase, four-pole, reconnectable brushless synchronous generator with brushless exciter.
B. Insulation: NEMA MG 1, Class F.

C. Temperature Rise:
   1. Continuous duty: 105 degrees C.
   2. Standby duty: 130 degree C.

D. Enclosure: NEMA MG 1; open drip-proof.

E. Voltage Regulator. Provide each generator with a solid-state voltage regulator. Regulator shall be configured for safe manual adjustment of the engine generator voltage output without special tools, during operation from 90 to 110 percent of the rated voltage.
   1. Steady State Performance: The voltage regulator shall have a maximum droop of 3 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.
   2. Regulator Bandwidth: Regulators shall have an operational bandwidth of plus or minus 2 percent of rated voltage.

2.10 ENGINE GENERATOR ENCLOSURE

A. Assembled engine generator shall include sound-attenuating, all-weather enclosure as provided by the engine generator manufacturer. The enclosure shall be constructed and provide the following:
   1. Reinforced steel frame rated for loading specified in paragraph Site conditions.
   2. Electrostatically applied zinc-coated sheet metal, baked enamel paint, stainless steel key locks and hinges or approved equal.
   3. All components and ventilation shall permit operation at rated load under secured conditions.
   4. Hinged, lockable doors for access to all controls, service points, and equipment requiring periodic maintenance or adjustment.
   5. Removable lockable panels for access to components requiring periodic replacement.
   6. Removable enclosure without disassembly of the engine generator or removal of components other than the exhaust system.
   7. Attenuated sound level shall not be greater than as specified for the attenuated exhaust system.
   8. Include louver and insect screens. All openings large enough to admit rodents shall be screened.

2.11 ENGINE GENERATOR ACCESSORIES

A. Line Circuit Breaker: NEMA AB 1 molded case circuit breaker on generator output with integral thermal and instantaneous magnetic trip in each pole, number and rating as indicated, sized in accordance with NFPA 70. Include battery-voltage operated shunt trip and connection to open circuit breaker on engine failure. Mount circuit breaker in enclosure to meet NEMA 250, Type 1 requirements, minimum, and as additionally required for location installed. Provide solid state trip circuit breaker with adjustable settings. Provide ground fault sensing with remote alarm.
B. Engine Generator Control Panel: NEMA Type 1 enclosure, minimum, and suitable for location installed. Provide control panel enclosure with engine and generator controls and indicators as required by NFPA 110 for an automatic control and safety panel in accordance with the Level specified. Include provision for padlock and the following equipment and features and functions:

1. Frequency Meter: 45-65 Hz range, 3-1/2 inch (89 mm) dial, 1% accuracy.
2. AC Output Voltmeter: 3-1/2 inch (89 mm) dial, 2% accuracy, with phase selector switch.
3. AC Output Ammeter: 3-1/2 inch (89 mm) dial, 2% accuracy, with phase selector switch.
4. Output voltage adjustment.
5. Lamp test function.
7. Engine running time meter.
8. Oil pressure gage.
10. Additional visual indicators and alarms as required by NFPA 110.
11. Auxiliary Relay: 3PDT, operates when engine runs, with contact terminals prewired to terminal strip.
12. Remote Alarm Contacts: Pre-wire SPDT contact to terminal strip for remote alarm functions required by NFPA 110.

C. Remote Control and Status Panels: Provide with NEMA rated enclosure suitable for location installed. Provide audible and visible indicators and alarms and silencing means required by NFPA 110 for Level specified and powered by storage battery. Provide two remote control and status panels per engine generator set. Locate one in the Engineer’s Control Center and one in the Fire Control Center. Provide control and status points as required by NFPA 110 for level 1 systems and as specified herein. Provide separate switch status points for each transfer switch.

1. Provide control and status points as follows:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Engine Generator Control &amp; Status Panel</th>
<th>Fire Control Center Remote Control &amp; Status Panel</th>
<th>Engineer’s Control Center Control &amp; Status Panel</th>
<th>Engine Shut Down</th>
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<tr>
<td>High Coolant Temperature</td>
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<td>Alarm</td>
<td>Yes</td>
</tr>
<tr>
<td>Approach to High Coolant Temperature</td>
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<td>Alarm</td>
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<tr>
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<td>Low Oil Pressure</td>
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<tr>
<td>Low Battery Voltage</td>
<td>Alarm</td>
<td>Alarm</td>
<td>Alarm</td>
<td>No</td>
</tr>
</tbody>
</table>

ENGINE GENERATOR
26 32 13 - 10
D. Generator electric-operated thermostatically-controlled strip heater for condensation control: 120 VAC, single-phase.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that surfaces are ready to receive work and field dimensions are as shown on Drawings.

B. Verify that required utilities are available in proper location and ready for use.

C. Beginning of installation means installer accepts existing conditions.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.
3.03 FIELD QUALITY CONTROL

A. Load Test: Provide under the direction of the engine generator manufacturer’s representative, full load test for four hours minimum. Provide fuel and portable test bank for test, and for repeat tests if initial test is unsuccessful. Simulate power failure including operation of transfer switch, automatic starting cycle, and automatic shutdown, and return to normal. Repeat tests until completely successful. Submit written test report. During test, record the following output values at 20 minute intervals:
1. Kilowatts.
2. Amperes, each of three phases.
3. Voltage, each of three line-to-line.
4. Coolant temperature.
5. Ambient temperature.
6. Frequency.
7. Oil pressure.

B. Test each pre-alarm, alarm, and shutdown circuit by simulating conditions. Verify and record proper operation of controls sequences and associated visual and audible indicators and alarms and shutdown systems.

C. Post Testing Replacements: Prior to scheduling tests, provide not less than two sets of spare fuses and lamps for each type, size, and rating of fuses and lamps used in the equipment. After successful completion of field testing, replace blown fuses and burned out lamps. Spare fuses and lamps not used during testing shall be turned over to the Owner. Replace all air, fuel, and lubricating oil filters. Examine fuel and lubricating oil filters for foreign matter.

3.04 ADJUSTING

A. Adjust generator output voltage and engine speed.

3.05 CLEANING

A. Clean all work.

B. Clean engine and generator surfaces. Replace oil and fuel filters.

3.06 DEMONSTRATION

A. Demonstrate the system.

B. Describe connected loads and restrictions for future load additions.

C. Simulate power outage by interrupting normal source, and demonstrate that system operates to provide specified power.

END OF SECTION

ENGINE GENERATOR
26 32 13 - 12
SECTION 26 33 53
STATIC UNINTERRUPTIBLE POWER SUPPLIES

PART 1 GENERAL

1.01 WORK INCLUDED
A. Static uninterruptible power supply.

1.02 REFERENCES
A. Institute of Electrical and Electronics Engineers:

B. National Electrical Manufacturers Association:
   1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
   2. NEMA PE 1 - Uninterruptible Power Systems.

C. International Electrical Testing Association:

1.03 SUBMITTALS
A. Section Submittal Procedures: Submittal procedures.

    B. Shop Drawings: Indicate electrical characteristics and connection requirements. Indicate battery rack dimensions; battery type, size, dimensions, and weight; detailed equipment outlines, weight, and dimensions; location of conduit entry and exit; single-line diagram indicating metering, control, and external wiring requirements; heat rejection and air flow requirements.

    C. Product Data: Submit catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.

    D. Manufacturer's Field Reports: Indicate inspections, findings, and recommendations.

1.04 CLOSEOUT SUBMITTALS
A. Section Execution Requirements: Closeout procedures.

    B. Operation and Maintenance Data: Submit description of operating procedures; servicing procedures; list of major components; recommended remedial and preventive maintenance procedures; and spare parts list.
1.05 QUALIFICATIONS
   A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience.

1.06 DELIVERY, STORAGE, AND HANDLING
   A. Protect equipment from extreme temperature and humidity by storing in conditioned space.
   B. Protect equipment from dust and debris by wrapping unit in dust tight cover and storing away from construction activity.
   C. Deliver batteries no sooner than 7 days before charging.

1.07 ENVIRONMENTAL REQUIREMENTS
   A. Do not store or install unless temperature is maintained between 32 degrees F (0 degrees C) and 104 degrees F (40 degrees C), at relative humidity less than 95 percent (non-condensing).

1.08 WARRANTY
   A. Section Execution Requirements: Product warranties and product bonds.
   B. Furnish one year manufacturer warranty.

1.09 MAINTENANCE SERVICE
   A. Section Execution Requirements: Maintenance service.
   B. Furnish service and maintenance of uninterruptible power supply for one year from Date of Substantial Completion.

1.10 MODES OF OPERATION
   A. The UPS system shall operate as an on-line reverse transfer system in the following modes:
      1. Normal: The output AC load is continuously powered by the UPS inverter(s). The rectifier/converter(s) derive power from the input AC source and supplies DC power to the inverter(s), while simultaneously float charging the battery.
      2. AC Source Failure: Upon failure or degradation of input AC power, the output AC load shall be powered by the inverter(s) which obtain power from the battery. There shall be no interruption of voltage, current, or power supplied to the output load upon failure, degradation, or restoration of the input AC source.
      3. Bypass: If the UPS system must be taken out of service for maintenance or repair, the bypass switch shall transfer the load to the bypass source upon receipt of a manual transfer command from the user interface. Upon detection
of an external fault or overload, or an internal failure, the bypass static switch shall automatically transfer the critical load to the bypass source. The transfer process shall cause no interruption in voltage, current or power supplied to the output load.

4. Off-Battery: If the battery only is taken out of service for maintenance, it shall be disconnected from the rectifier/converter(s) and inverter(s) by means of disconnect breakers. The UPS shall continue to function and meet all of the specified steady-state performance criteria, except for the power outage back-up capability.

PART 2 PRODUCTS

2.01 STATIC UNINTERRUPTIBLE POWER SUPPLY

A. Manufacturers:
   1. Chloride Power Protection.
   2. Liebert Corp.
   3. Mitsubishi.
   4. Toshiba.
   5. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered.

B. Product Description: Nonredundant uninterruptible power supply with reverse transfer.

C. System Ratings and Operating Characteristics:
   1. System Continuous Rating: As indicated on Drawings, but in no instance less than 20 kilovolt-amperes (kVA) over entire battery voltage range at specified power factor. Maintain output voltage within specified limits at load from full load to no-load.
   2. Battery Capacity: Capable of operating at full load for 2 hours.
   5. Input Voltage Operating Range: Plus or minus 10 percent.
   6. Input Frequency Operating Range: 60 Hz plus or minus 3 Hz.
   7. Input Current Limit: Adjustable to maximum of 125 percent required to operate at full load with battery bank on float charge.
   8. Current Walk-in: 25 to 100 percent in fifteen seconds.
   9. UPS Power Factor Over Full Range of Loads and Input Voltages: 74 to 100 percent, lagging.
   10. Harmonic Distortion of Input Current Wave Form: 5 percent maximum at full load.
   11. Output Voltage Regulation:
       a. Plus or minus 1 percent for balanced load, full range of DC input and no load to full load variations.
b. Plus or minus 3 percent for 50 percent unbalanced load, full range of DC input and no load to full load variations.

12. Output Voltage Adjustment: Plus or minus 5 percent.
13. Output Free Running Frequency: 60 Hz plus or minus 0.5 percent.
14. Frequency Adjustment: Plus or minus 2 Hz.
15. Output Harmonic Distortion: Maximum 5 percent rms total harmonic distortion (THD) and maximum 3 percent any single harmonic, at rated frequency and voltage, from 10 percent load to full load and over battery voltage range, measured into linear load.
16. Voltage Transient Response for Application of 0 to 50 Percent, 50 to 100 Percent, 100 to 50 Percent, and 50 to 0 Percent Step Loads, and Transfer To and From Bypass Line:
   a. Plus 8, minus 10 percent for maximum of 8.3 milliseconds.
   b. Plus or minus 5 percent for maximum of 25 milliseconds.
   c. Plus or minus 3 percent for maximum of 50 milliseconds.
   d. Recovery to steady state within 100 milliseconds after out-of-tolerance variation.

17. Phase Displacement:
   a. 120 plus or minus 1 degree for balanced loads.
   b. 120 plus or minus 4 degrees for 50 percent unbalanced loads.

18. Three-phase Overload Ratings:
   a. 150 percent for 20 seconds.
   b. 125 percent for 10 minutes.

20. Voltage Unbalance: 3 percent maximum line-line with 100 percent load unbalance.
21. Efficiency: 92 percent at full load, minimum. Measure efficiency of unit including battery and isolation transformer (when used) losses.

D. Design:
1. Inverter Type: Pulse-width modulated.
2. Designed for capacity expansion by addition of parallel modules in field with minimum downtime.
3. Rectifier/Charger Capacity: Sufficient to supply full load to inverter while recharging fully-discharged battery to 95 percent of full capacity in four hours or less; and within input current limits specified.
4. Furnish means for on-line testing of UPS, including test points to allow adjusting and servicing. Furnish means for testing static switch while load is bypassed to utility.
5. Mean Time Between Failures: 40,000 hours, minimum.
6. Cooling: Furnish forced air cooled unit with redundant cooling so failure of one cabinet cooling fan or fan circuit does not affect continued operation at full load and ambient temperature of 77 degrees F (25 degrees C) or lower.
7. Operate battery floating, isolated from UPS AC input and AC output.
8. Do not use continuous moving parts or electron tubes. Accomplish power switching using semiconductor devices.

9. Construct equipment so each power component capable of replacement without soldering iron or special tools.

10. Use front-panel removable plug-in control modules.

E. Controls:
1. AC input circuit breaker.
2. "Inverter operate" switch to initiate inverter operation.
3. "Inverter standby" switch to cause inverter to cease operation.
4. "Static switch transfer" switch to permit manual actuation of static transfer switch.
5. "Static switch lock-out" switch to inhibit automatic retransfer of load to inverter.
8. Controls for maintenance bypass switch.
   a. The UPS control panel shall have a local emergency power off (EPO) pushbutton with protective cover.
   b. Pressing the EPO pushbutton shall cause the opening of the input, output contactors, and battery breakers to open, completely isolating the UPS.
   c. Provisions shall be available for a remote emergency power off function, which completely removes power from the critical bus when activated.

F. Indicators:
1. "Inverter synchronized to utility."
2. "Load connected to utility."
3. "Static transfer switch inhibited."
4. "High/low DC voltage."
5. "Overtemperature."
6. "Inverter output overload."

G. Meters: Include 1 percent accuracy meters to indicate the following:
1. Rectifier/charger DC voltage and current.
2. Utility, inverter output, and load AC voltage.
3. Load AC current.
4. Inverter output and utility frequency.
5. UPS output watts.

H. Input Harmonic: Include manufacturer's standard or standard optional input harmonic filter which shall limit input total harmonic current distortion (THDi) to less than 7 percent during normal operation condition.

I. Fabrication:
1. Electroplate brackets and securing hardware with corrosion resistant material. Secure bolts, studs and nuts with lock washers.
2. Identify internal wiring at each end of conductor. Furnish cabinet grounding lug.
3. Conversion Equipment Enclosure: NEMA 250, Type 1 enclosure allowing access from front for servicing adjustments and connections. Access through hinged door equipped with tumbler lock and latch handle. Equip cabinet for fork truck lifting.
4. Equip air inlet with permanent type filters and pressurize cabinet, or use gaskets around door and panel openings to prevent entry of dirt.
5. Cabinet finish: Primed and painted inside and outside with suitable semi-gloss enamel.

2.02 BATTERY

A. Storage Battery: Lead calcium valve regulated heavy duty industrial battery, designed for auxiliary power service. Furnish battery with impact resistant cases. Furnish cells with explosion proof vents, clear containers, and ample space for plate growth without stressing container and cover.

B. Ampere-Hour Rating: Sized in accordance with IEEE 1184.

C. Battery Enclosure Racks: Steel construction, with plastic insulating rails at points of contact with battery case. Paint racks with acid resistant paint.

D. Spill Containment: Provide battery electrolyte spill containment basin and absorption pillows integral to cabinet.

2.03 STATIC TRANSFER SWITCH

A. A static transfer switch shall be an integral part of the UPS. The control unit shall contain an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions to provide an uninterrupted transfer of the load to the bypass source without exceeding the transient limits specified herein when a malfunction occurs in the UPS or an external overload condition occurs. The static transfer switch shall be a full electronic static type switch with the following capabilities and characteristics:

B. Maximum Transfer Time: Make before break.

C. Uninterrupted transfer initiated as follows:
   1. Inverter overload exceeds output ratings.
   2. Upon reaching rated battery discharge voltage.
   3. Inverter failure.

D. Automatic uninterrupted forward transfer as follows:
   1. After the equipment is turned on a forward transfer function shall result in the inverter system being on line.
   2. After an overload induced reverse transfer to the bypass AC circuit has occurred and the overload current subsides to less than the UPS full load rating the forward transfer shall occur.
3. Only after the UPS output automatically synchronizes with the AC bypass input line.

E. Manual Transfer: On/off momentary pushbutton initiated, make-before-break.

2.04 EXTERNAL MAINTENANCE BYPASS

A. Provide an external maintenance bypass and cabinet to allow the entire UPS system to be bypassed for service without requiring the power supply to the output load to be interrupted.

2.05 SOURCE QUALITY CONTROL

A. Furnish shop inspection and testing of components and completed UPS assembly.

B. Make completed UPS available for inspection at manufacturer’s factory prior to packaging for shipment. Notify Owner at least seven days before inspection is allowed.

C. Allow witnessing of factory inspections and tests at manufacturer’s test facility. Notify Owner at least seven days before inspections and tests are scheduled.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify HVAC Systems are operational to maintain specified environmental conditions.

3.02 FIELD QUALITY CONTROL

A. Section Quality Requirements, 01700 - Execution Requirements: Field inspecting, testing, adjusting, and balancing.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.22.

D. Verify specification performance criteria.

E. Measure battery discharge and recharge times.

F. Simulate fault in each system component and utility power.

G. Operate unit at 77 degrees F (25 degrees C) for eight hours.

H. Perform other tests as recommended by manufacturer.
3.03 MANUFACTURER’S FIELD SERVICES
   A. Section Quality Requirements: Manufacturer’s field services.
   B. Prepare and start up UPS.

3.04 ADJUSTING
   A. Section Execution Requirements: Testing, adjusting, and balancing.
   B. Adjust output voltage to within 1 percent of nominal.
   C. Adjust output frequency to within 0.6 percent of nominal.

3.05 DEMONSTRATION AND TRAINING
   A. Furnish 8 hours of instruction each for two persons, to be conducted at project site with manufacturer’s representative.

3.06 PROTECTION OF INSTALLED CONSTRUCTION
   A. Section Execution Requirements: Protecting installed construction.

END OF SECTION
SECTION 26 35 53

SURGE PROTECTIVE DEVICES (SPD)

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Surge Protective Devices.

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers:
   IEEE 1100   Recommended Practice for Powering and Grounding Electronic Equipment
   IEEE C62.41   Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
   IEEE C62.43   Guide for the Application of Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits
   IEEE C62.45   Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits

B. National Electrical Manufacturers Association:
   NEMA LS 1    Low Voltage Surge Protection Devices

C. National Fire Protection Association:
   NFPA 70   National Electrical Code
   NFPA 780   Standard for the Installation of Lightning Protection Systems

D. Underwriters Laboratories Inc.:
   UL 1283   Electromagnetic Interference Filters
   UL 1449   Surge Protection Devices (SPD)

1.03 SUBMITTALS

A. Section SUBMITTALS.

B. Product Data: Submit capacity, dimensions, weights, details, and wiring configuration.

C. Test Reports:
   1. Indicate Let-Through voltage test data.
   2. Submit spectrum analysis of electrically equivalent units.
   3. Submit test reports from nationally recognized independent testing laboratory verifying suppressors can survive published surge current rating.
D. Manufacturer’s Installation Instructions: Submit installation instructions and connection requirements.

E. Manufacturer’s Certificate: Certify Surge Protective Device complies with UL 1449 Surge Voltage Ratings.

F. Operation and Maintenance Data: Submit manufacturer’s descriptive literature, installation instructions, and maintenance and repair data.

1.04 QUALITY ASSURANCE

A. List individual units under UL 1449 and UL 1283.

1.05 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

1.06 WARRANTY

A. Furnish one year manufacturer’s warranty for surge protective devices part failure.

PART 2 - PRODUCTS

2.01 SURGE PROTECTIVE DEVICES (SPD)

A. Manufacturers:
   2. General Electric Company.
   5. Liebert.
   6. Or approved equal.

B. Product Description: Surge protective devices for protection of electrical circuits.

C. Types: Motor control centers, Power panelboards, Lighting panelboards, data, communications and signaling circuits.

D. Unit Operating Voltage: As indicated on Drawings or as required for the nominal system operating voltage at location which applied.

E. Maximum Continuous Operating Voltage: Greater than 115 percent of nominal system operating voltage.
F. Construction:
   2. Balanced Suppression Platform: Equally distribute surge current to Metal Oxide Varistor (MOV) components to ensure equal stressing and maximum performance. Furnish surge suppression platform with equal impedance paths to each matched MOV.
   3. Internal Connections: Hardwired with connections using low impedance conductors and compression fittings.
   4. Safety and Diagnostic Monitoring:
      a. Equipped with integral internal fused overcurrent protection rated 200 kAIC.
      b. Continuous monitoring of fusing system.
      c. Monitor individual MOV’s (including neutral to ground). Capable of identifying open circuit failures.
      d. Monitor for overheating in each mode due to thermal runaway.
      e. Provide green and red solid state indicator lights on each phase. Absence of green light and presence of red light shall indicate which phases have been damaged. Fault detection shall activate flashing trouble light. Units not capable of detecting open circuit damage, thermal conditions, and overcurrent will not be accepted.
   5. Labeling: Permanently affix UL 1449 (Second Edition) suppression voltage ratings to unit.

G. Rating:
   1. Electrical Noise Filter: Furnish each unit with high performance EMI/RFI noise rejection filter. Electric line noise attenuation shall be no less than 45 dB at 100 kHz using MIL-STD-220A insertion loss test method.

H. Accessories:
   1. Digital display transient event counter.
   2. Local audible alarm.
   3. Form C dry contacts one normally open (NO) and one normally closed (NC) for remote status monitoring.

I. Surge Current Capacity: Total surge current in kiloamperes (kA) (based on 8 x 20 microsecond waveform) which device is capable of surviving shall not be less than:

J. Integral SPD’s: Failure of SPD or SPD part shall not interrupt operation of panelboard, switchboard, MCC or other electrical equipment.
### SURGE PROTECTIVE DEVICES

#### 100% Construction Documents

**0850.00**

**20 July 2009**

<table>
<thead>
<tr>
<th>Application</th>
<th>Minimum Surge Current Per Phase</th>
<th>Minimum Surge Current Per Mode*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Entrance (Switchboards, Switchgear, MCC)</td>
<td>250 kA</td>
<td>125 kA</td>
</tr>
<tr>
<td>High Exposure Roof-top Locations</td>
<td>160 kA</td>
<td>80 kA</td>
</tr>
<tr>
<td>Distribution and branch locations (Panelboards, MCC, Bus Duct)</td>
<td>120 kA</td>
<td>60 kA</td>
</tr>
</tbody>
</table>

*K-G, L-N and N-G (WYE system); L-L, L-G (Delta system)*

**K.** Protection Modes: For Wye configured system, furnish device with directly connected suppression elements between each phase-to-neutral (L-N), each phase-to-ground (L-G), and neutral-to-ground (N-G). For Delta configured system, furnish device with suppression elements between each phase-to-phase (L-L) and each phase-to-ground (L-G).

**L.** ANSI/IEEE Category C1 Let-Through Voltage: Based on ANSI/IEEE C62.41 and C62.45 recommended procedures for Category C1 surges (6 kV, 3 kA) shall be less than:

<table>
<thead>
<tr>
<th>Modes</th>
<th>Nominal System Operating Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wye L-L</td>
<td>208Y/120 480Y/277</td>
</tr>
<tr>
<td>Wye L-N; L-G; N-G</td>
<td>680 V 1600 V</td>
</tr>
<tr>
<td>Delta L-L, L-G</td>
<td>450 V 900 V</td>
</tr>
<tr>
<td></td>
<td>800 V 1500 V</td>
</tr>
</tbody>
</table>
M. ANSI/IEEE Category C3 Let-Through Voltage: Based on ANSI/IEEE C62.41 and C62.45 recommended procedures for Category C3 surges (20 kV, 10kA) shall be less than:

<table>
<thead>
<tr>
<th>Modes</th>
<th>Nominal System Operating Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>208Y/120</td>
</tr>
<tr>
<td>Wye L-L</td>
<td>1000 V</td>
</tr>
<tr>
<td>Wye L-N; L-G; N-G</td>
<td>800 V</td>
</tr>
<tr>
<td>Delta L-L, L-G</td>
<td>1000 V</td>
</tr>
</tbody>
</table>

N. ANSI/IEEE Category B3 Let-Through Voltage: Based on ANSI/IEEE C62.41 and C62.45 recommended procedures for ANSI/IEEE Category B3 Ringwave (6 kV, 500 amps) shall be less than:

<table>
<thead>
<tr>
<th>Modes</th>
<th>Nominal System Operating Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>208Y/120</td>
</tr>
<tr>
<td>Wye L-L</td>
<td>800 V</td>
</tr>
<tr>
<td>Wye L-N; L-G; N-G</td>
<td>400 V</td>
</tr>
<tr>
<td>Delta L-L, L-G</td>
<td>800 V</td>
</tr>
</tbody>
</table>

2.02 SOURCE QUALITY CONTROL AND TESTS

A. Section Quality Requirements: Testing, inspection and analysis requirements.

B. Test units to specified surge ratings to ensure devices will achieve required life expectancy and reliability and to also verify internal construction quality of suppressors. Provide withstand testing for each mode and each phase basis.

C. Provide actual Let-through voltage test data in form of oscillograph results for ANSI/IEEE C62.41 Category C3 (20 kV, 10 kA), Category C1 (6 kV, 3 kA), and Category B3 (6 kV, 500 A at 100 kHz) tested in accordance with ANSI/IEEE C62.45.

D. Perform spectrum analysis of each unit based on MIL-STD-220A test procedures between 50 kHz and 200 kHz verifying device noise attenuation exceeds 45 dB at 100 kHz.

E. Perform test verifying suppressors can survive published surge current rating for each mode and each phase basis. Test wave based on ANSI/IEEE C62.41, 8x20 microsecond current wave.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide SPDs in accordance with IEEE 1100.

B. Provide SPDs service entrance suppressors integral to service entrance equipment, unless otherwise noted or shown. Examples: Service entrance switchboards, service entrance switchgear, service entrance motor control centers, service entrance panelboards.

C. Provide SPDs suppressors integral to distribution and branch panelboards.

D. Provide SPDs at additional locations as shown and as specified.

E. Provide SPDs using direct bus bar connection, unless otherwise shown.

F. Provide SPDs indicator lights and surge counter in face of motor control center or panelboard.

END OF SECTION
SECTION 26 36 00

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Automatic transfer switches.

1.02 REFERENCES


IEC 947-6-1 Low-Voltage Switchgear and Controlgear; Multifunction Equipment; Automatic Transfer Switching Equipment

B. Institute of Electrical and Electronic Engineers (IEEE).

IEEE Std. 446 IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications

C. National Electrical Manufacturers Association (NEMA).

NEMA ICS10-1993 AC Automatic Transfer Switches (formerly ICS2-447)

D. National Fire Protection Association (NFPA).

NFPA 70 National Electrical Code

NFPA 99 Essential Electrical Systems for Health Care Facilities

NFPA 110 Standard for Emergency and Standby Power Systems

E. Underwriters Laboratories (UL).

UL 508 Industrial Control Equipment

UL 1008 Standard for Automatic Transfer Switches

1.03 SUBMITTALS

A. Manufacturer’s specifications and product data cutsheets for the ATS, including manufacturer’s installation instructions for the automatic transfer switch.

B. Submit product data indicating dimensions, weights, ratings, interconnection points, internal wiring diagrams, and accessories.
C. Submit shop drawings showing plan and elevation views, including schematic and interconnection diagrams.

1.04 QUALITY ASSURANCE

A. The automatic transfer switch manufacturer shall be a company specializing in transfer switches and emergency power control systems with a minimum of 20 years experience.

B. The automatic transfer switch manufacturer shall maintain a local service center capable of emergency service or routine preventive maintenance and shall offer preventive maintenance contracts. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Contractor shall protect switches from moisture with appropriate coverings. Store in clean, dry, interior location.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Transfer switches shall comply with the requirements of NFPA 110 for emergency power supply systems (EPSS) as follows:
   1. Level 1.
   2. Type 10.
   3. Class 8 (8 Hours).

2.02 ACCEPTABLE MANUFACTURERS

A. Automatic transfer switches shall be as specified below. Any alternate shall be submitted for approval prior to bid. Alternate bids must list any deviations from this specification.

   1. Onan Cummins.

2.03 MECHANICAL HELD TRANSFER SWITCH

A. The transfer switch shall be electrically operated and mechanically held. Electrical operator shall be a momentarily energized, single-solenoid mechanism. Main operators which include overcurrent disconnect devices, linear motors or gears shall not be acceptable. The switch shall be mechanical interlocked to ensure only two possible positions, normal or emergency.

B. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.
C. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

D. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 600 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

E. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

F. Where neutral conductors must be switched as shown on the plans, the ATS shall be provided with fully rated overlapping neutral transfer contacts. The neutrals of the normal and emergency power sources shall be connected together only during the transfer and retransfer operation and to remain connected together until power source contacts close on the source to which the transfer is being made. The overlapping neutral contacts shall not overlap for a period greater than 100 milliseconds. Neutral switching contacts which do not overlap are not acceptable.

G. Where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated AL-CU pressure connector shall be provided.

2.04 MICROPROCESSOR CONTROLLER

A. The controller’s sensing and logic shall be provided by a single built-in microprocessor for maximum reliability, minimum maintenance, and the ability to communicate serially through an optional serial communication module.

B. Voltage sensing shall be true RMS type and shall be accurate to 1% of nominal voltage. Frequency sensing shall be accurate to 0.2%. The panel shall be capable of operating over a temperature range of –20 to 60 degrees C and storage from –55 to 85 degrees C.

C. Interfacing relays shall be industrial grade plug-in type with dust covers.

D. All field connections shall be wired to a common terminal block to simplify field wiring connections.

E. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:
   1. IEEE 472 (ANSI C37.90A) Ring Wave Test.
   2. ENC55011 1991 Class A Conducted and Radiated Emission.
   3. EN61000-4-2 Electrostatic Discharge Immunity, Direct Contact and Air Discharge.
   4. EN61000-4-3 Radiated Electromagnetic Field Immunity.
5. EN61000-4-4 Electrical Fast Transient Immunity.
6. EN61000-4-5 Surge Immunity.
7. ENV50141 HF Conducted Disturbances Immunity.

2.05 ENCLOSURE

A. The ATS shall be furnished in a NEMA Type 1 enclosure unless otherwise shown on the plans.

B. All standard and optional door-mounted switches and pilot lights shall be 16 mm industrial grade type or equivalent for easy viewing and replacement. Door controls shall be provided on a separate removable plate.

2.06 OPERATION

A. Controller Display And Keypad
1. A four-line 20 character LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the serial communications input port. The following parameters shall only be adjustable via DIP switches on the controller.
   a. Nominal line voltage and frequency.
   b. Single or three-phase sensing.
   c. Operating parameter protection.
   d. Transfer operating mode configuration (Open transition, Closed transition, Delayed transition) factory set for open transition.

2. All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

B. Voltage, Frequency And Phase Rotation Sensing
1. Continuously on each phase monitor both voltage and frequency on both the normal (N) and alternate (A) sources (as noted below) with the following pickup, dropout, and trip setting capabilities (values shown as % of nominal unless otherwise specified):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sources</th>
<th>Dropout/Trip</th>
<th>Pickup/Reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undervoltage</td>
<td>N+E, 3 phases</td>
<td>70 to 98%</td>
<td>85 to 100%</td>
</tr>
<tr>
<td>Overvoltage</td>
<td>N+E, 3 phases</td>
<td>102 to 115%</td>
<td>2% below trip</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>N+E</td>
<td>85 to 98%</td>
<td>90 to 100%</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>N+E</td>
<td>102 to 110%</td>
<td>2% below trip</td>
</tr>
<tr>
<td>Voltage unbalance</td>
<td>N+E</td>
<td>5 to 20%</td>
<td>1% below dropout</td>
</tr>
</tbody>
</table>

2. Repetitive accuracy of all settings shall be within +/- 2.0% over an operating temperature range of -20 degrees to 60 degrees C.
3. Voltage and frequency settings shall be field adjustable in 1% increment either locally with the display and keypad or remotely via serial communication port access.
4. The controller shall be capable (when activated by the keypad or through the serial port) of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable and thus transfer shall be inhibited if the phase rotation is not the preferred rotation selected (ABC or CBA).

5. Source status screens shall be provided for both normal and emergency to provide digital of voltage on all 3 phases, frequency, and phase rotation.

C. Time Delays.

1. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting. Capability shall be provided to extend this time delay to 60 minutes by providing an external 24 VDC power supply.

2. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.

3. Two time delay modes (which are independently adjustable) shall be provided on retransfer to normal. One time delay shall be for actual normal power failures and the other for the test mode function. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source of acceptable.

4. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.

5. All time delays shall be adjustable in 1 second increments.

6. All time delays shall be adjustable by using the LCD display and keypad or with a remote device connected to the serial communications port.

D. Additional Features:

1. Manual Operation. Provide capability for safety manually nonelectric transfer when the transfer switch electric transfer capability malfunctions.

2. A three-position momentary-type test switch shall be provided for test/automatic/reset modes. The test position will simulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal.

3. A set of DPDT gold-flashed contacts rated 10 amps, 32 VDC shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

4. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one contact closed, when the ATS is connected to the emergency source.

5. LED indicating lights (16 mm industrial grade, Type 12) shall be provided; one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red).

6. LED indicating lights (16 mm industrial grade, Type 12) shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal and emergency sources, as determined by the voltage sensing trip and reset settings for each source.
E. The following features shall be built into the controller, but capable of being activated through keypad programming or the serial port only when required by the user:

1. Provide the ability to select “commit/not commit to transfer” to determine whether the load should be transferred to the emergency generator if the normal source restores before the generator is ready to accept the load.

2. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or serial pad.

3. An in-phase monitor shall be provided in the controller. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The in-phase monitor shall be specifically designed for and be the product of the ATS manufacturer. The in-phase monitor shall be equal to ASCO Feature 27.

4. The controller shall be capable of accepting a normally open contact that will allow the transfer switch to function in a nonautomatic mode using an external control device.

5. Engine Exerciser: The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to seven different exercise routines. For each routine, the user shall be able to:
   a. Enable or disable the routine.
   b. Enable or disable transfer of the load during routine.
   c. Set the start time:
      1) Time of day.
      2) Day of week.
      3) Week of month (1st, 2nd, 3d, 4th, alternate or every).
   d. Set the duration of the run.

6. At the end of the specified duration the switch shall transfer the load back to normal and run the generator for the specified cool down period. A 10-year life battery that supplies power to the real time clock in the vent of a power loss will maintain all time and date information.

7. System Status: The controller LCD display shall include a “System Status” screen which shall be readily accessible from any point in the menu by depressing the “ESC” key a maximum of two times. This screen shall display a clear description of the active operating sequence and switch position. For example:

   Normal Failed
   Load on Normal
   TD Normal to Emerg
   2min15s

8. Self-Diagnostics: The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller which may be preventing load transfer commands from being completed.
9. Communications Interface: The controller shall be capable of interfacing, through an optional serial communication module, with a network of transfer switches, locally (up to 4000 ft) or remotely through modem serial communications. Standard software specific for transfer switch applications shall be available by the transfer switch manufacturer. This software shall allow for the monitoring, control and setup of parameters.

10. Data Logging: The controller shall have the ability to log data and to maintain the last 99 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a nonvolatile memory:
   a. Event Logging:
      1) Date and time and reason for transfer normal to emergency.
      2) Date and time and reason for transfer emergency to normal.
      3) Date and time and reason for engine start.
      4) Date and time engine stopped.
      5) Date and time emergency source available.
      6) Date and time emergency source not available.
   b. Statistical Data:
      1) Total number of transfers.
      2) Total number of transfers due to source failure.
      3) Total number of days controller is energized.
      4) Total number of hours both normal and emergency sources are available.

11. Communications Module: A full duplex RS485 interface shall be installed in the ATS controller to enable serial communications. The serial communications shall be capable of a direct connect or multi-drop configured network. This module shall allow for the seamless integration of existing or new communication transfer devices. The serial communication interface shall be equal to ASCO Accessory 72.

F. Withstand and Closing Ratings.
   1. The ATS shall be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS terminals with the type of overcurrent protection shown on the plans.
   2. The ATS shall be UL listed in accordance with UL 1008 and be labeled in accordance with 1-1/2 and 3 cycle, long-time ratings. ATSs which are not tested and labeled with 1-1/2 and 3 cycle (any breaker) ratings and have series, or breaker ratings only, are not acceptable.

G. Tests and Certifications.
   1. The complete ATS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.
   2. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards, and withstand and closing
ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.

3. The ATS manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation, and servicing in accordance with ISO 9001.

H. Service Representation.
   1. The ATS manufacturer shall maintain a service center that is located within 200 miles of the project location. The service center’s personnel must be factory trained and must be on call 24 hours a day, 365 days a year.
   2. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 10 years.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide automatic transfer switches where shown unless otherwise directed.

B. Provide all source and load power circuits connected as indicated on the drawings.

C. Provide all interconnecting control circuits which are associated with the engine generator unit.

D. Provide all interconnecting control and supervision circuits between automatic transfer switch and the Life Safety System

E. The ATS shall be supplied completely assembly in a NEMA type 1 enclosure as specified above. An exterior enclosure door shall be provided with a locking handle.

3.02 COORDINATION

A. Coordinate selection of any and all interfaces between equipment specified herein and the engine generator control and alarm panel specified elsewhere in these Specifications to provide a completely integrated emergency power supply system which complies fully with NFPA 110 and NFPA 70 (NEC).

3.03 TESTING AND CERTIFICATION

A. All production units shall be subjected to the following factory test:
   1. The complete ATS shall be tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.
   2. The switch shall be subjected to a dielectric strength test per NEMA Standard ICS 1-109.21.
3. Provide a notarized letter from the ATS manufacturer certifying compliance with all of the requirements of the specification including compliance with the above codes and standards, and withstand current ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the Specification, other than those stipulated at the time of submittal, shall be included in the certification.

END OF SECTION
SECTION 26 51 00

LIGHTING AND ACCESSORIES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Interior luminaires.
B. Exterior luminaires.
C. Lamps.
D. Ballasts.
E. Accessories.
F. Occupancy sensors.

1.02 REFERENCES

A. American National Standards Institute (ANSI).
   ANSI C78.41 Electric Lamps – Low Pressure Sodium Lamps
   ANSI C78.42 Electric Lamps – Guideline for High Pressure Sodium Lamps
   ANSI C78.1375 Electric Lamps – 400-Watt, M59 Single-Ended Metal-Halide Lamps
   ANSI C78.1376 Electrical Lamps – 1000-Watt, M47 Single-Ended Metal-Halide Lamps
   ANSI C78.1377 Electric Lamps – 175-Watt, M57 Single-Ended Metal-Halide Lamps
   ANSI C78.1378 Electric Lamps – 250-Watt, M58 Single-Ended Metal-Halide Lamps
   ANSI C78.1381 Electric Lamps – 70-Watt, M85 Metal-Halide Lamps
   ANSI C78.1382 Electric Lamps – 100-Watt, M90 Single-Ended Metal-Halide Lamps
   ANSI C78.1384 Electric Lamps – 150-Watt, M102 Single-Ended Metal-Halide Lamps
   ANSI C82.1 Electric Lamp Ballast – Line Frequency Fluorescent Lamp Ballast
   ANSI C82.2 Fluorescent Lamp Ballasts – Methods of Measurement
   ANSI C82.4 Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)
   ANSI C82.11 High-Frequency Fluorescent Lamp Ballasts

ASTM A 366  Commercial Steel, Sheet, Carbon, Cold-Rolled
ASTM A 580  Stainless Steel Wire
ASTM A 641  Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A 653  Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron-Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B 633  Electrodeposited Coatings of Zinc on Iron and Steel

C. Illuminating Engineering Society of North America (IESNA).

IESNA LHBK  Lighting Handbook

D. National Electrical Manufacturers Association (NEMA).

NEMA ICS 2  Industrial Control and Systems Controllers, Contactors and Overload Relays, Rated Not More than 2000 Volts AC or 750 Volts DC
NEMA ICS 6  Industrial Control and Systems Enclosures
NEMA LL 1  Procedures for Linear Fluorescent Lamp Sample Preparation and the TCLP

E. National Fire Protection Association (NFPA).

NFPA 70  National Electrical Code
NFPA 90A  Installation of Air Conditioning and Ventilating Systems
NFPA 101  Code for Safety to Life from Fire in Buildings and Structures

F. Underwriters Laboratories (UL).

UL 20  General-Use Snap Switches
UL 57  Electric Lighting Fixtures
UL 595  Marine-Type Electric Lighting Fixtures
UL 844  Electric Lighting Fixtures for Use in Hazardous (Classified) Locations
UL 924  Emergency Lighting and Power Equipment
UL 935  Fluorescent-Lamp Ballasts
UL 1029  High-Intensity-Discharge Lamp Ballasts
UL 1570  Fluorescent Lighting Fixtures
UL 1571  Incandescent Lighting Fixtures
UL 1572  High Intensity Discharge Lighting Fixtures

1.03 SUBMITTALS

A. Shop Drawings: Scaled and dimensioned plans and elevations indicating components for each luminaire not standard product of manufacturer.
B. Product Data: Manufacturer’s catalog data for each luminaire, including accessories, mounting hardware, spare parts lists, lamp quantity and type, photometric data, finishes, voltage, input watts, ballast type, and luminaire type/designation that matches electrical drawings. Cutsheet shall be annotated to clearly include which options the contractor is ordering.

C. Fluorescent Electronic Ballasts: Catalog data demonstrating requirements in the paragraph entitled “Fluorescent Lamp Electronic Ballasts.” As an option, submit the fluorescent fixture manufacturer’s electronic ballast specification information in lieu of the actual ballast manufacturer’s catalog data. This information shall include published specifications and sketches, which cover the information required by the paragraph entitled “Fluorescent Lamp Electronic Ballasts.” This information may be supplemented by catalog data if required, and shall contain a list of vendors with vendor part numbers. Data or specification submitted shall include ballast type, power factor, input voltage, input watts, and ballast factor.

D. Sufficient information clearly presented to determine compliance with drawings and specification.

E. Samples: Submit two color chips 3x3 inch (75x75 mm) in size illustrating luminaire finish color where indicated in luminaire schedule. When light fixture samples are called for manufacturer shall provide luminaire complete with ballast rated for 120 V operation and 6 foot pigtail with three-prong Edison plug.

F. Field Test Reports, including operating test results where indicated.

G. Seismic restraint calculation in jurisdictions requiring them.

H. Submittals must clearly indicate manufacturer’s name and/or name of local representative agency preparing the submittal.

1.04 DEFINITIONS

A. Average Life: Time after which 50 percent of the lamp will have failed and 50 percent will have survived under normal conditions.

B. Total Harmonic Distortion (THD): The root mean square (RMS) of all the harmonic components divided by the fundamental current.

C. Luminaires, light fixtures, and fixtures shall be synonymous with each other.

1.05 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
1.06 CERTIFICATION
A. Provide ballasts certified by Electrical Testing Labs, Inc. (ETL) and the Certified Ballasts Manufacturers Association (CBMA).

1.07 FIELD MEASUREMENTS
A. Verify field measurements prior to fabrication.

1.08 SPARE PARTS
A. Furnish two of each plastic lens type, and two of each acrylic lens type.
B. Furnish two replacement lamps for each lamp installed.
C. Furnish two ballasts for each ballast type installed.

PART 2 - PRODUCTS
2.01 FLUORESCENT LIGHTING FIXTURES
A. Fluorescent Lamp Electronic Ballasts: UL 1570. Fluorescent fixtures shall have electronic ballasts unless specifically indicated otherwise.

B. Acceptable Manufacturers:
1. Advance
2. General Electric
3. Magnetek
4. Or approved equal.

C. Electronic ballasts shall as a minimum meet the following characteristics:
1. Comply with UL 935, ANSI C82.11, and NFPA 70 unless specified otherwise. Ballast shall be designed for the wattage of the lamps used in the indicated application, and to operate on the voltage system to which they are connected.
2. Power factor shall be 0.95 (minimum).
3. Operate at a frequency of 20,000 Hertz (minimum), with no detectable lamp flicker.
4. Light regulation of +/-10 percent lumen output with a +/-10 percent input voltage regulation. Ballast shall have 10 percent flicker (maximum) using any compatible lamp.
5. UL listed Class P with a sound rating of "A".
6. Enclosure size shall conform to standards of electromagnetic ballasts. Circuit diagrams and lamp connections shall be displayed on ballast packages. Operate lamps in a parallel circuit configuration that permits the operation of remaining lamps if one or more lamps fail or are removed.
7. Operate in an instant start mode.
8. Full replacement warranty of 5 years from date of manufacture as specified in paragraph entitled “Electronic Ballast Warranty” herein.

9. Where installed in exterior or nonheated environments, ballasts shall be capable of starting at ambient temperatures down to a minimum of zero degrees F (minus 17 degrees C).

D. Fluorescent Lamp Electronic Dimming Ballast: The electronic ballast shall as a minimum meet the following characteristics:

1. Comply with UL 935, ANSI C62.11, and NFPA 70, unless specified otherwise. Ballast dimming capability range shall be from 100 to 20, 10 percent (minimum range) of light output, flicker free. Ballast shall start lamp at any preset light output setting. When power is applied, ballast shall not ramp at any preset light output setting. When power is applied, ballast shall not ramp up to full light output and then dim to preset level. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected.

2. Power factor shall be 0.95 (minimum) at full light output, and 0.90 (minimum) over the entire dimming range.

3. Operate at a frequency of 20,000 Hertz (minimum).

4. Ballast factor at full light output shall be between 0.85 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum).

5. UL listed Class P with a sound rating of “A”.

6. Circuit diagrams and lamp connections shall be displayed on the ballast package. Ballast shall operate lamps in a parallel circuit configuration that permits the operation of remaining lamps if one or more lamps fail or are removed.

7. Operate in rapid start mode.

8. Capable of starting and maintaining operation at a minimum of 50 degrees F (10 degrees C) for F32T8 lamps, unless otherwise indicated.

9. Total harmonic distortion (THD): 20 percent (maximum) over the entire dimming range.

10. Minimum of ten year operation life operation with a case temperature range of 50 degrees F to 167 degrees F 90% noncondensing relative humidity.

11. Designed and tested to withstand electrostatic discharges up to 15,000 V.

12. Inaudible in a 27 dBA ambient environment.

13. No visible change in light output with a variation of +/- 10% line voltage input.

E. Fluorescent Electromagnetic Ballasts: UL 935. High power factor type (0.9 minimum), unless indicated otherwise, designed to operate on the voltage system to which they are connected. Class P and sound rating of “A”.

1. Electromagnetic Energy-Saving Ballasts: ANSI C82.1. Provide energy-saving fluorescent ballasts of the CBM certified full light output type except where fixtures are provided with low temperature ballasts. Test in accordance with ANSI C82.2 methods.

2. Provide Electromagnetic Ballasts for Compact Fluorescent Lamps.

3. Electromagnetic Low Temperature Ballasts: Provide fluorescent ballasts having a minimum starting temperature of 0 degrees F (-17 degrees C) or –20 degrees F (-28 degrees C) for 800 milliampere, high output (HO) lamps in fixtures mounted in cold rooms, outdoors, unheated buildings, and as indicated.
4. Ballasts shall meet or exceed FCC Regulations Part 18 and NEMA standards for electromagnetic and radio frequency interference and shall not interfere with operation of other electrical equipment.

F. T-8 Lamp Ballast.
   1. Capable of starting and maintaining operation at a minimum of 50 degrees F (10 degrees C) for F32T8 lamps, unless otherwise indicated. When indicated, ballast shall be capable of starting and maintaining operation at a minimum of zero degrees F (minus 17 degrees C) for F32T8 lamps.
   2. Total harmonic distortion (THD): 10 percent (maximum).
   3. Provide two, three, and four lamp fixtures with two ballasts per fixture where multi-level switching is indicated. Where single level switching is indicated, provide single ballast for each fixture.
   4. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.
   5. T-8 Lamp Ballast Input Wattage, for indicated lamp quantity shall be:
      a. 35 watts (maximum) when operating one F32T8 lamp.
      b. 70 watts (maximum) when operating two F32T8 lamps.
      c. 104 watts (maximum) when operating three F32T8 lamps.

G. T-5 Lamp Ballast.
   1. Capable of starting and maintaining operation at a minimum of 50 degrees F (10 degrees C), unless otherwise indicated. When indicated, ballast shall be capable of starting and maintaining operation at a minimum of zero degrees F (minus 17 degrees C) .
   2. Total harmonic distortion (THD): 10 percent (maximum).
   3. Provide two, three, and four lamp fixtures with two ballasts per fixture where multi-level switching is indicated. Where single level switching is indicated, provide single ballast for each fixture.
   4. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.

H. Dimming Ballast Controls: Slide dimmer with ON/OFF control. Slide dimmer shall be compatible with ballast and control the ballast light output over the full dimming range.

I. Light Level Sensor: UL listed. Capable of detecting changes in ambient lighting levels, provide a dimming range of 20 percent to 100 percent, minimum, and designed for use with dimming ballast and voltage system to which they are connected. In addition:
   1. Capable of controlling 40 electronic dimming ballast, minimum.
   2. Adjustable sensor light level and a set level range from 10 to 100 foot-candles (100 to 1000 LUX), minimum.
   3. Bypass function to electrically override sensor control.
2.02 FLUORESCENT LAMPS

A. Acceptable Manufacturers.
   1. General Electric
   2. Phillips Electronic North America
   3. Osram/Sylvania
   4. Or approved equal.

B. T-8 Lamps.
   1. Rapid start lamps shall be rated minimum 2800 initial lumens (minimum), CRI of 80 (minimum), color temperature of 3500 K, and an average rated life of 24,000 hours.
   2. Rapid start lamp rated 17 watt (maximum), nominal length of 24 inches (610 mm), 1300 initial lumens, CRI of 75 (minimum), color temperature of 3500 K, and an average rated life of 20,000 hours.
   3. Instant start lamp, nominal length of 96 inches (2438 mm), minimum CRI of 75, 5800 initial lumens, color temperature of 3500 K, and average rated life of 15,000 hours.

C. T-5 Lamps.
   1. Rapid start lamps shall be rated minimum 2900 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and an average rated life of 24,000 hours.
   2. Rapid start lamp rated 17 watt (maximum), nominal length of 24 inches (610 mm), 1300 initial lumens, CRI of 80 (minimum), color temperature of 3500 K, and an average rated life of 20,000 hours.
   3. Instant start lamp, nominal length of 96 inches (2438 mm), minimum CRI of 75, 5800 initial lumens, color temperature of 3500 K, and average rated life of 15,000 hours.

D. Compact Fluorescent Lamps shall be 3500 K, 10,000 hours average rated life, and as follows:
   1. T-4 twin tube, rated 600 initial lumens (minimum), 13 watts, 825 initial lumens (minimum), as indicated.
   2. T-4 double twin tube, rated 900 initial lumens (minimum) 1200 initial lumens (minimum), and 1800 initial lumens (minimum) as indicated.

E. Compact Fluorescent Fixtures: Manufactured specifically for compact fluorescent lamps with ballasts integral to the fixture. Assemblies designed to retrofit incandescent fixtures is prohibited except when specifically indicated for renovation of existing fixtures. Fixtures shall use lamps as indicated.

F. Open-Tube Fluorescent Fixtures, with self-locking sockets or lamp retainers (two per lamp). Shatter-resistant coating, non-yellowing, nominal thickness of 15 mils (0.38 mm), and with 97 percent (minimum) light transmission. Clear polycarbonate protective sleeve with end caps, over lamp, with 95 percent (minimum) light transmission. The sleeve shall be rated to withstand the thermal profile of the lamp and ballast.
2.03 SUSPENDED FIXTURES

A. Hangers shall be capable of supporting twice the combined weight of fixtures supported by hangers. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangers shall be shock-absorbing type where indicated. Hangers shall allow fixtures to swing within an angle of 20 degrees. Brace pendants 4 feet (1219 mm) or longer provided in shops or hangers to limit swinging. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 0.18 inch (4.57 mm) diameter.

2.04 EXTERIOR FIXTURES

A. Sheet steel luminaire housings and iron and steel parts shall have a corrosion inhibiting phosphate treatment to assure positive paint adhesion. Luminaires without phosphate treatment shall be zinc or cadmium plates, or hot dip zinc galvanized after composition of all forming, welding, and drilling operations.

B. Exterior luminaires shall be designed and manufactured specifically for outdoor service. Components including nuts, bolts, rivets, springs, and similar parts, shall be corrosion resistant.

C. Exterior luminaires shall be suitable and effectively gasketed to prevent entrance of moisture into luminaire. Luminaires which are directly exposed to the elements shall be labeled for wet locations. Luminaires which are exposed to dampness shall be labeled for damp locations.

D. Metal parts of luminaires requiring painting shall be painted with suitable weather and moisture resisting paint equal to epoxy-based coatings.

E. Aluminum parts of exterior luminaires which are not specified as requiring a painted finish shall be anodized.

2.05 LIGHTING CONTACTOR

A. NEMA ICS 2, electrically, mechanically held contactor. Contacts shall be rated 120/208 volts, 20 amperes, and 1 poles. Coils shall be rated 600 volts. Rate contactor as indicated. Provide in NEMA 1 or 4 enclosure conforming to NEMA ICS 6. Contactor shall have silver alloy double-break contacts and coil clearing contacts for mechanically held contactor. Provide contactor with Hand-Off-Automatic ON/OFF selector switch.

2.06 TIME SWITCH

A. Astronomic dial type or electronic type, arranged to turn ON at sunset and turn OFF at predetermined time between 8:30 p.m. and 2:30 a.m. or sunrise, automatically changing the settings each day in accordance with seasonal changes of sunset and sunrise. Provide switch rated ___ volts, having automatically wound spring mechanism or capacitor, to
maintain accurate time for a minimum of 15 hours following power failure. Provide time switch with a manual ON/OFF bypass switch. Housing for the time switch shall be surface flush-mounted, NEMA 1 or 3 enclosure conforming to NEMA ICS 6.

2.07 OCCUPANCY SENSORS

A. UL listed. Sensor mounting type shall be ceiling surface.

B. Detector shall be ultrasonic.

C. LED positive detection indicator, adjustable delayed off-time range between 30 seconds and 15 minutes, minimum, and sensitivity adjustment.

D. Input rated for 120 or 277 volts ac, as required, 60 Hz.

E. Sensor shall have fail on function designed to keep lights on if the sensor fails.

F. Manual override switch at sensor, or wall mount near fixture.

2.08 PHOTOCCELL SWITCH

A. UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell rated ___ volts ac, 60 Hz with single-throw contacts, single pole double-throws (SPDT) contacts for control of mechanically held contactors, rated 1000 W. Switch shall turn on at or below 32 lux (3 foot-candles) and off at 22 to 107 lux (2 to 10 foot-candles). A time delay shall prevent accidental switching from transient light sources. Provide switch:
   1. Integral to the luminaire, rated 1000 W minimum. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.
   2. UV stabilized polycarbonate housing with swivel arm and adjustable window slide, rated 1800 VA, minimum.
   3. High-impact-resistant, noncorroding, and nonconductive molded plastic housing with a locking type receptacle conforming to ANSI C136.10, rated 1800 VA, minimum.
   4. Cast weatherproof aluminum housing with adjustable window slide, rated 1800 VA, minimum.

2.09 EXIT SIGNS

A. UL 924, NFPA 70, NFPA 101.

B. Unit equipment LED Type Exit Signs (Battery Backup). Provide with automatic power failure device, test switch, pilot light, integral self-testing module, and fully automatic high/low trickle charger in a self-contained power pack. Battery shall be sealed electrolyte type, operate unattended, and require no maintenance, including no additional water, for a period of not less than 5 years. LED exit sign shall have emergency run time of 1-1/2 hours (minimum).
C. Remote-Powered Exit Signs. Provide remote ac/dc exit signs with provisions for wiring to external ac and dc power sources. Provide signs with a minimum of two ac lamps for normal illumination and a minimum of two dc lamps for emergency lighting.

2.10 EMERGENCY LIGHTING EQUIPMENT

A. UL 924, NFPA 70, NFPA 101. Provide lamps in wattage indicated.

B. Normal Supply Voltage: 120/277 volt dual voltabe, single phase, 60 Hz, unless otherwise noted.

C. Emergency Lighting Fixture: Emergency lighting units fixture shall be rated for 12 volts unless otherwise shown. Equip units with brown-out sensitive circuit to activate battery when ac input falls to 75 percent of normal voltage and 15 minute time delay feature for areas with HID lighting. Provide integral self-testing module.

D. Backup Battery Pack: Each backup battery pack shall include an automatic power failure device and shall include a test switch operable from outside of the fixture, pilot light visible from outside the fixture, and fully automatic solid-state charger in a self-contained power pack. Battery shall be sealed electrolyte type with capacity as required to supply power to 2 lamps for 90 minutes at a minimum of 1100 lumens output. Backup battery pack shall be suitable for use on both switched and unswitched electrical circuits and shall only energize emergency lamp(s) of fixture when normal power to unswitched source circuit has failed, regardless of ON or OFF state of manual wall switch or occupancy sensor control of associated circuit. Battery backup pack shall not be used to energize fixture lamps so long as power is available to unswitched source circuit, regardless of ON or OFF state of manual wall switch or occupancy sensor control of associated circuit. Backup battery pack shall operate unattended and require no maintenance, including no additional water, for a period of not less than 5 years. Backup battery packs which are provided with fixtures containing solid-state ballasts shall be suitable for use with solid-state ballasts.

2.11 SELF-TESTING MODULE

A. Self-testing module for exit signs and emergency lighting equipment shall perform the following functions:
   1. Continuous monitoring of charger operation and battery voltage with visual indication of normal operation and malfunction.
   2. Monthly discharge cycling of battery with monitoring of transfer circuit function, battery capacity and emergency lamp operation with visual indication of malfunction. The battery capacity test may be conducted by using a synthetic load.
   4. Module shall have low voltage battery disconnect (LVD) and brown-out protection circuit.
2.12 SUPPORT HANGERS FOR LIGHTING FIXTURES IN SUSPENDED CEILINGS

A. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated finish, 0.1055 inches (2.68 mm) in diameter (12 gage).

B. Wires for Humid Spaces: ASTM A 580/A 580M, composition 302 or 304, condition annealed stainless steel 0.1055 inches (2.68 mm) in diameter (12 gage).

C. Straps: Galvanized steel, 1 by 3/16 inch (25 by 4.76 mm), conforming to ASTM A 653/A 653M with a light commercial zinc coating or ASTM A 366/A 366M with an electrodeposited zinc coating conforming to ASTM B 633/A 633M, Type RS.

D. Rods: Threaded steel rods, 3/16 inch (4.76 mm) diameter, zinc or cadmium coated.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturer's directions and approved drawings. Installation shall meet requirements of NFPA 70.

B. Mounting heights specified or indicated shall be to the bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Recessed and semi-recessed fixtures may be supported from suspended ceiling support system ceiling tees when the ceiling system support wires, or straps, or rods, are provided at a minimum for four wires, straps, rods per fixture and located not more than 6 inches (150 mm) from each corner of each fixture. For recessed fixtures, provide support clips securely fastened to ceiling grid members, a minimum of one at or near each corner of each fixture. For round fixtures or fixtures smaller in size than the ceiling grid, provide a minimum of four wires, straps or rods per fixture and locate at each corner of the ceiling grid in which the fixture is located. Do not support fixtures by ceiling acoustical panels. Where fixtures of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently or with at least two ¾ inch (19 mm) metal channels spanning, and secured to, the ceiling tees. Provide wires, straps, rods for lighting fixture support in this section.

C. Electronic Dimming Ballast: All electronic dimming ballasts controlled by the same controller shall be of the same manufacturer. All fluorescent lamps on electronic dimming ballast control shall be seasoned or burned in at full light output for 100 hours before dimming.
D.  Unit Equipment and Emergency Lighting Fixtures.
   1.  Wire unit equipment, exit signs and emergency lighting fixtures ahead of the
       switch to the normal lighting circuit located in the same room or area.
   2.  Emergency Circuit: Wire exit signs and emergency light fixtures on separate
       circuits and serve from a dedicated circuit breaker. Paint control device red and
       provide lockout.

E.  Photocell Switch Aiming: Aim switch according to manufacturer’s recommendations.
     Set adjustable window slide for IES suggested, minimum, lux (foot-candles) photocell
     turn-on.

F.  Fixture locations as indicated on the Drawings are approximate. Verify exact location
     prior to installation. Verify clearance with other equipment such as ducts, pipes,
     conduit, or structural elements.

G.  Install all luminaires free of light leaks, warps, dents or other irregularities.

H.  Install reflector cones, aperture plates, lenses, diffusers, louvers, and other decorative
     elements after completion of wet work, plastering, painting and general cleanup.

I.  Recessed luminaires installed in fire-rated ceilings shall be provided with fire-rated
     enclosures.

J.  Fixtures requiring access for service and maintenance shall be installed so all serviceable
     components are readily accessible.

K.  Support luminaires by method rated at least 5 times supported weight.

L.  At time of acceptance, luminaires and lamps shall be clean, with visible labels removed.
    Touch up any blemishes.

3.02  FIELD QUALITY CONTROL

A.  Upon completion of installation, conduct an operating test to show that equipment
     operates in accordance with requirements of this section.

B.  Electronic Dimming Ballast: Test for full range of dimming capability. Observe for
     visually detectable flicker over full dimming range.

C.  Occupancy Sensor: Test sensors for proper operation. Observe for light control over
     entire area being covered.

END OF SECTION
SECTON 26 57 00
LIGHTING CONTROLS

PART 1 - GENERAL

1.01 SUMMARY

A. Work Included: The work of this Section shall cover all labor, materials, and equipment to furnish Central Dimming Controls herein specified, including:
   1. Commercial Dimming & Switching Panels
   2. Dimming Controls
   3. Accessories

B. Complete System: The Contractor shall provide all items necessary for a complete, safe, fully functional system as described herein including all tools, labor and supervision, even though they may not be specifically enumerated.
   1. Any errors, omissions or ambiguities do not relieve the Contractor of this responsibility, but shall be brought to the attention of the Engineer for clarification.
   2. The Contractor shall be responsible for acquiring, installing, wiring and coordination of all components and equipment.
   3. The Contractor shall furnish all conduit, wire, connectors, hardware and other materials necessary for a complete and properly functional lighting control and dimming system as specified.

C. Coordination:
   1. Contractor shall maintain accurate, as-built Panel Schedules detailing connection and type of lighting loads in the system.
      a. Schedules shall detail, at a minimum:
         1) Circuit ID, Number, Or Designation.
         2) Actual Connected Load, Voltage, And Load Type Per Circuit.
         4) Circuits And Their Respective Control Zones.
      b. Panel Schedules shall be indexed on a per panel per dimmer/relay basis
      c. Panel Schedules shall be updated and provided to the Manufacturer of the Lighting Control System no later than (30) days prior to commissioning.

   2. Contractor shall ensure that connected loads are compatible with the dimming and switching equipment provided. These steps shall include:
      a. Provision of sample LED fixtures with associated drivers to the Manufacturer of the Central Dimming Controls for testing.
      b. Provision of sample Fluorescent fixtures with associated ballasts and lamps to the manufacturer of the Central Dimming Controls for testing.
1.02 REFERENCES

A. American National Standards Institute (ANSI).
   ANSI C62.41 Surge voltages in low-voltage ac power circuits

   ASTM D4674-02a Color stability of plastics exposed to indoor lighting

C. International Energy Conservation Code (IECC)

D. Illuminating Engineering Society of North America (IESNA).
   IESNA LHBK Lighting Handbook

E. National Electrical Manufacturers Association (NEMA).
   NEMA WD1 (R2005) General color requirements for wiring devices

F. National Fire Protection Association (NFPA).
   NFPA 70 National Electrical Code

G. Underwriters Laboratories (UL).
   UL 508 (1999) Standard for industrial control equipment
   UL 1472 (1996) Solid state dimming controls
   UL 924 (2003) Emergency lighting and power equipment

1.03 SUBMITTALS

A. Product Data:
   1. Bill of Materials
      a. Bill of Materials shall include all components in the system and shall include quantity, description, and model #.
      b. Components shall be logically grouped by assembly (station, panel, or device)
   2. Manufacturer’s catalog cut sheets for standard equipment.
      a. Cut sheets must contain full information on dimensions, construction, applications, etc. to permit proper evaluation
      b. Cut sheets must be properly identified as to their intended use.
      c. Options or variations must be clearly noted.
3. A copy of the Manufacturer’s warranty document for this project.

B. Shop Drawings:
   1. Full system schematics and riser diagram(s) illustrating interconnection of system components, including:
      a. Wiring Requirements.
      b. Power Feeds.
      c. Back Box Sizes.
      d. Any Special Installation Considerations.

   2. Load Schedules Indexed By Panel, Clearly Indicating:
      a. Circuit ID, Number, Or Designation.
      b. Actual Connected Load, Voltage, and Load Type Per Circuit.
      d. Circuits and Their Respective Control Zones.

C. Specification Conformance: Clearly indicate one of the following conditions:
   1. The equipment and systems submitted conform exactly with project specifications and drawings.
   2. The equipment and systems submitted meet the intent of the specification via an alternate means.
      a. Provide a detailed statement indicating paragraph by paragraph and line by line wherein the equipment submitted deviates from the specifications.
      b. Note all variations from the specified system on the Shop Drawings in ¼” high bold notations.
      c. Provide a narrative confirming specified function and detailing alternate means for achieving specified function.

D. Submittals for Project Record: The Manufacturer shall provide submittals for Project Record. Submittals for Project Record shall include:
   1. Warranties: All equipment shall be warranted free of defects in materials and workmanship.
      a. All materials provided will be covered for a period of 3 years following date of commissioning.
      1) The warranty shall cover 100% of the parts and manufacturers labor costs required during the warranty period, which are directly attributable to the manufacturer.
      2) Warranty coverage shall begin on the date that the equipment is energized.

   2. Operations and Maintenance Manuals, including:
      a. Operations manuals for system components.
      b. Operations manuals for user interfaces and system program.
      c. Contact information for 24 hour a day, 7 day a week, 365 day a year technical support hotline.
3. As-Built System Drawings, including:
   a. Shop drawings annotated to reflect installed condition of the system
      1) Device Network ID’s.
      2) Room numbers for installed equipment and devices.
      3) Feed circuit panel and breaker designations.
   b. As-wired load schedules per panel reflecting zone, room, and group designations.

1.04 DEFINITIONS

1.05 QUALIFICATIONS

   A. Experience: The manufacturer shall have a minimum of ten (10) years of experience in the
      manufacture, programming, and support of Lighting Control Systems of similar size and
      scope.

   B. Phone Support: The Manufacturer shall maintain a dedicated 24 hour a day, 7 day a week,
      365 day a year toll free technical support hotline.
      a. Calls to this hotline shall be answered by a live support specialist.
      b. Paging and call back systems shall not be an acceptable means of meeting this
         requirement.

   C. Online Support: Installation and operations manuals for all standard products shall be
      available for download at no charge from the Manufacturer’s website.

   D. Field Support: The manufacturer must maintain on staff field service technicians for the
      purpose of programming, commissioning, repairing, and supporting control systems.
      a. Manufacturers relying on outside contractors or field service agents to commission,
         support, program the systems herein specified shall not be acceptable.
      b. On site support shall be available within (24) hours anywhere in the continental
         United States.

1.06 CERTIFICATION

1.07 FIELD MEASUREMENTS

   A. Verify field measurements prior to fabrication.

1.08 SPARE PARTS

   A. Furnish 5 percent of each dimmer or contactor module
PART 2    PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturer[s]: All base bids will include dimming, switching, and control equipment as specified and manufactured by the following approved manufacturer[s]:
   1. Lutron
   2. Vantage
   3. Crestron
   4. Or other approved manufacturer

B. Substitutions:
   1. Other equipment manufacturers seeking acceptance must submit an Application for Approval at least (10) working days prior to the bid opening date.
      a. Approval of alternate manufacturers shall be by addenda.
      b. Submittals for systems by Manufacturers not pre-approved shall be rejected without review.
   2. Applications for approval of alternate manufacturers shall contain, at a minimum, the following information:
      a. Evidence of compliance with Manufacturer Qualifications as outlined below.
      b. A listing of three (3) equivalent installations including:
         1) Name, address and telephone number of Owner
         2) Name, address and telephone number of Architect
         3) Scope of work
      c. Full system riser diagram(s) illustrating interconnection of system components, wiring requirements, back box sizes and any special installation considerations. Drawings shall include load and feed wiring as well as control wiring.
      d. A detailed statement indicating paragraph by paragraph and line by line wherein the equipment submitted deviates from the specifications.
      e. A narrative confirming specified function and detailing alternate means for achieving specified function.
   3. Approval to bid does not guarantee acceptance:
      a. It shall be the responsibility of the Contractor to ensure that equipment and systems provided meet the requirements of this specification
      b. Modifications to other equipment, systems, and infrastructure mandated by the use of alternate manufacturers, equipment, and systems shall be the sole responsibility of the Contractor.
2.02 DIMMING & SWITCHING CABINETS

A. Mechanical
   1. Dimming & switching cabinets shall be factory assembled, wired and 100% tested prior to shipping from factory. The contractor shall be required to provide input feed wiring, load wiring, control wiring and all terminations or connections. No other wiring or assembly by the contractor shall be permitted.
   2. Panels shall be passively cooled via free-convection, unaided by fans. Systems that are fan dependent or fan assisted for cooling of components are not acceptable. Systems that require or recommend regularly scheduled maintenance for air filtration components are not acceptable.
   3. All input feed, load and control terminals shall be front accessible without the need to remove dimmer assemblies or other components.
   4. Branch breakers with optional main breaker shall be provided above dimming and switching modules mounted into the cabinet.
   5. Panels shall be UL listed, CSA certified, NOM approved or CE marked (as appropriate).
   6. Panels shall be shipped with each dimmer in a mechanical BYPASS position via a jumper bar inserted between the input and load terminals to allow dimming panel to be used as a temporary lighting panel with no possibility of dimmer failure due to short-circuit condition.
      a. These jumpers shall carry the full-rated load current and shall be reusable at any time.
      b. Mechanical bypass device must allow for switching operation of connected load with the dimmer removed via a circuit breaker.

B. Electrical
   1. Dimming control cabinet(s) shall contain all dimming modules, control wiring, relays, contactors, power supplies and circuit breakers.
   2. Branch circuit breakers shall be rated at 10,000 AIC unless otherwise noted and be thermal-magnetic in construction for overload and short-circuit protection.
   3. Dimming control cabinets shall be capable of being operated from a normal feed, an emergency feed or a normal / emergency feed.
   4. Normal / Emergency dimming control cabinets shall be fed by a single Normal / Emergency feed through the use of a line side (upstream) normal / emergency power transfer switch supplied by others.

C. Dimming Modules
   1. Dimming modules shall be compatible with the load types that are to be controlled. Each module shall be able to control a minimum of 4 separate circuits – each independently controllable and fed from their own circuit breaker.
2. Dimming modules for incandescent, magnetic low-voltage, two wire fluorescent, and neon / cold cathode loads shall have 6 channels each of which is controlled by a electronic dimmer rated for a minimum of 16 amps continuous per channel with overload and short circuit protection. The modules shall be dual voltage with the capability to control 120VAC or 277VAC loads. The channels within each module shall be phase independent. A positive air gap relay shall be provided on each output.

3. Dimming modules for 0-10V (4-wire) fluorescent dimming ballasted fixtures shall have 4 independent circuits using a an analog 0-10 VDC signal plus an air-gap relay and an LED indicator confirming 24 VDC power supply from network.

4. Dimming modules for 3 wire dimming ballasts shall have 4 independently controlled circuits fed from the same phase of the power supply using a phase controlled dimming signal plus an air gap relay.

D. Relay / Switching Modules
1. Relay modules shall have eight separate channels or circuits that can be independently controlled through the system. Each circuit shall be a SPST mechanically held latched relays or magnetically held air gap relays rated for 50,000 switching cycles under full load. The relay modules shall be capable of handling 120VAC or 277VAC load circuits.

2. Relay / Switching modules shall also have LED indicators that confirm 24 VDC power from the network as well as individual LEDs to indicate which relays are energized.

E. Normal / Emergency Panels
1. Panel shall be capable of operating from a normal feed, an emergency feed, or a normal/emergency feed. Panels requiring additional devices to make them capable of accepting normal/emergency or emergency feeds are not acceptable.

2. Upon the loss of normal input power, a panel operating from a normal/emergency feed shall immediately turn all circuits within that panel to full-on condition when emergency input power is present.

3. During the presence of normal power, circuits designated as emergency circuits shall be controlled via the same controls as circuits designated normal. If both normal and emergency circuits are on the same zone of control, all circuits shall react identically to a control intensity change.

4. Emergency power feed may be provided by an emergency generator, a UPS system, or an IPS system with true sine wave output and a maximum of 10% THD when driving dimmed loads. The generator or UPS system must be capable of operating under no load conditions.

5. Normal / Emergency panels shall be fed by a single Normal / Emergency feed through the use of a line side (upstream) normal/emergency power transfer switch supplied by others.

6. Under Emergency input power feed, unless otherwise indicated all dimmers shall operate at 100% of dimmer output voltage. Under these conditions, semiconductor device will be in the full-on state.

7. Under Emergency input power feed, if required, dimmer shall be capable of operating lighting load at an emergency level lower than 100% dimmer output voltage.
8. Under Emergency input power feed, all local control stations shall be inoperable. Once normal power is restored, all lighting zones shall revert back to their status prior to the emergency condition without requiring any action on the part of the user. Restoration to OFF, ON, or a "default" level is not acceptable.

9. Illumination levels shall be field-programmable to meet local code requirements for Emergency power conditions. Such options include, but are not limited to, providing a constant minimal light level for emergency circuits during normal operation or providing full function dimming under emergency power.

10. System shall be capable of directly interfacing with a voltage detection/sensing device for Emergency lighting. The 3-Phase detection/sensing device shall: be UL 924 listed as Emergency Lighting and Power Equipment, with one dry contact closure input (normally open). The normally open input requires a maintained dry contact closure to activate the Emergency mode. A status indicator will indicate when these inputs are activated, and have a function test switch with status indicator to simulate a phase failure.

2.03 POWER PANELS

A. Panels shall be wall mounted NEMA grade, constructed of sheet steel plates not less than #16 US gauge.

B. Panels shall be pre-wired by manufacturer. Any field wiring shall be accessible from front of panel without need to remove dimmer assemblies or other components.

C. Panels shall be passively cooled via free-convection. Panels that use fans for cooling must be derated by 50%. They shall be capable of continuous operation

D. Electrical branch circuit breakers:
   1. UL listed under UL 489 as a molded case circuit breaker for use on lighting circuits.
   2. Contain a visual trip indicator rated a minimum 10,000 AIC for 120V and 14,000 AIC for 277V.
   3. Thermal-magnetic construction for overload, short-circuit, and over-temperature protection. Use of breakers without thermal protection requires dimmers/relays to have integral thermal protection to prevent failures when overloaded or ambient temperature is above rating of panel.
   4. Accept tag-out/lock-out devices to secure circuit breakers in off position when servicing loads.
   5. Replaceable without moving or replacing dimmer/relay assemblies or other components in panel. Since lighting applications may require loads to be disconnected multiple times throughout its life, breakers need to be rated for this type of operation.
   6. Switch duty rated (SWD) so that the loads can be switched off via the breakers.

E. Panels shall be capable of electronically/digitally assigning each circuit to any zone in the dimming system. Panels using mechanical switches, rewiring, or EPROMS shall not be acceptable.
F. Multiple panels shall be capable of operating as one system.

G. Panels shall be capable of bringing all circuits to a full-on condition upon the loss of normal power and the subsequent presence of emergency power. Electronics shall switch both the intensity signal and the on/off signal of each dimmer connected to an emergency circuit between the local control stations and a full-on constant drive supply.

2.03 LIGHTING CONTROL SYSTEM PROCESSOR

A. The control processor for the lighting control system shall be a Crestron 2 Series control system with a Motorola ColdFire microprocessor with 4MB of Flash Memory, 32MB of SDRAM and 256KB of NVRAM with expandability options.

B. Ethernet connectible with 10/100Base T, Static IP or DHCP/DNS, SSL Protection, auto negotiating, full/half duplex TCP/IP, UDP/IP, SMTP, built-in Web server and email client; supports Crestron e-control2 Xpanel and RoomView applications.

C. Connections: minimum of 4 and up to 8 Digital input/output or analog input ports (referenced to GND)
   1. Digital input: rated for 0-24VDC; input impedance 20K ohms; logic threshold 1.24 VDC.
   2. Digital output: 250 mA sync from maximum 24VDC; catch diodes for use with “real world” loads.
   3. Analog input: Rated for 0-10VDC, protected to 24 VDC maximum; input impedance 20K ohms.
   4. Programmable 5V, 2K ohms pull-up resistor per pin.

D. Computer ports: (1) DB9 female RS-232 computer console port shall be provided on the processor.

E. Relay outputs: (8) normally open isolated relays rated 1A, 30V AC/DC with MOV arc suppression across contacts & (2) 8 pin 3.5mm detachable terminal blocks.

F. Power supply: processor shall provide an internal power supply to power Cresnet devices connected to (32) 4-pin 3.5 mm detachable terminal blocks, representing (4) Cresnet ports (paralleled) for each of (8) segments, providing up to a maximum load of 50 watts (2 amps @ 24 Volts DC). With an increased capacity of 75 watts using an external power supply.

G. Backup processor capability: the processor shall monitor itself through an internal “watchdog” circuit which is capable of transferring control of the complete system supported by that processor to a second backup processor in the event of inactivity signifying a failure.

2.04 POWER INTERFACES

A. Phase independent of control input

B. Dimmer to meet short circuit test defined by UL 20
C. Replacing power interface does not require the reprogramming of system or processor.

2.05 LOW-VOLTAGE WALL STATIONS

A. Upon button press, LEDs to illuminate immediately.

B. Allow for easy reprogramming without replacing unit.

C. Provide faceplates with concealed mounting hardware.

D. Engrave wall stations with appropriate button, zone, and scene descriptions prior to final fabrication.

E. Zones controlled may be temporarily overridden without permanently altering memory stored scene values.

2.06 LOW-VOLTAGE CONTROL INTERFACES:

A. Contact Closure Interfaces:
   1. Input open circuit voltage not to exceed 36V.
      a. Input short circuit current not to exceed 0.5 mA.
      b. Mechanical contact closures to be dry contact rated.
      c. Solid state contact closures:
         1) Output off-state leakage current not to exceed 50mA.
         2) Output on-state saturation voltage not to be less than 2V.
   2. The contact closure input device will accept both momentary and maintained contact closures.

B. Serial Interfaces:

Provide ability for system to communicate by means of RS232 serial communication by means of user-supplied PC or digital audiovisual equipment. Control to be located within 50 feet (15 meters) of RS232 source.

1. RS232 shall provide access to:
   a. Fade zone to a level.
   b. Fine-tuning of preset levels with scene raise/lower.
   c. Lock out scenes and zones.
   d. Fine-tuning of light levels with individual zone raise/lower.
   e. Enable/disable wall station.
   f. Scene selections.

2. Astronomical time clock and programmer interface shall provide access to:
   a. Scene selections.
   b. Fade zone to a level.
   c. Fine-tuning of preset levels with scene raise/lower.
   d. Lock out scenes and zones.
   e. Fine-tuning of light levels with individual zone raise/lower.
   f. Enable/disable wall station.
3. Software to provide access to setup the following:
   a. Program low voltage controls.
   b. Set up and run time clock schedules.
   c. Set up and run sequences.
   d. Set and report time.
   e. Archive system information.

C. Ethernet Interfaces: Provide ability to communicate by means of TCP/IP over Ethernet by means of user-supplied PC or digital audiovisual equipment. Control to be located within 300 feet (100 meters) of Ethernet source.
   1. Ethernet interface shall provide access to:
      a. Scene selections.
      b. Fade zone to a level.
      c. Fine-tuning of preset levels with scene raise/lower.
      d. Lock out scenes and zones.
      e. Fine-tuning of light levels with individual zone raise/lower.
      f. Enable/disable wall station.

D. Infra-Red Interface:
   1. Provide ability to integrate third party infrared controls or remotes into preset lighting control system.

E. Motorized Shade Interface:
   1. Provide ability to integrate third party shade controls or remotes into preset lighting control system.

2.06 TOUCHPANELS

A. Touchpanels shall be manufactured by the same manufacturer as the rest of the lighting controls system. Touchpanels supplied by others are not acceptable.

B. The display shall be an active matrix color LCD screen in panels of 5 inches diagonal or larger with edge lit fluorescent illumination and a minimum viewing angle of +/- 60 degrees on the horizontal and a minimum of +40/-55 degrees on the vertical axis.

C. Touchpanel manufacturer shall also provide optional touchpanels that have video capability to display video input.

D. Touchpanel manufacturer shall also provide optional touchpanels that have capability for built in audio speakers.

E. Pushbuttons (if needed) shall be replaceable, engravable and programmable.

F. Touchpanel design and programming shall be included in the base cost of the system as determined by the manufacturer, and based on the scope of the project. Additional changes and programming of the touchpanel shall be available for additional fees.
2.07 SENSORS

A. Ceiling-Mounted Infrared Receivers have 360 degree reception of wireless infrared remote controls.

B. Interior Daylight Sensors: Open-loop basis for daylight sensor control scheme.

C. Exterior Daylight Sensors:
   1. Calibrated with independent turn-on and turn-off thresholds; minimum 2 foot-candles difference between the turn-on and turn-off thresholds.
   2. Enclosed in weatherproof housing with shading and lens protection visor.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer’s installation instructions.

D. Provide complete installation of system in accordance with Contract Documents.

E. Define each dimmer’s load type, assign each load to a zone, and set control functions.

F. Provide equipment at locations and in quantities indicated on Drawings. Provide any additional equipment required to provide control intent.

G. Mount exterior daylight sensors to point due north with constant view of daylight.

H. Ensure that daylight sensor placement minimizes sensors view of electric light sources; ceiling mounted and fixture-mounted daylight sensors shall not have direct view of luminaries.

I. Upon completion of the installation of, and prior to the removal of the bypass jumpers, the electrical contractor shall completely test all line voltage power and low voltage control wiring for continuity and accuracy of connections. The jumpers shall remain in place until all loads have been fully tested and found free of miswires, short circuits, or other wiring defects.

J. Run separate neutrals for all branch load circuits.

3.02 FIELD QUALITY CONTROL

A. All equipment shall be fully tested for proper operation prior to shipment from the factory.

3.03 SYSTEM COMMISSIONING

A. Provide factory certified field service engineer with minimum 2-years in training who is certified by the manufacturer on the equipment installed.
B. Field engineer shall verify the following:
   1. Verify connection and location of controls.
   2. Energize processor panel and download system data program.
   3. Verify proper connection of panel links (low voltage/data) and address panel.
   4. Download system panel data to dimming-switching panels
   5. Check dimming panel load types and currents and remove by-pass jumpers.
   6. Verify system operation control by control, circuit by circuit.
   7. Verify proper operation of manufacturers interfacing equipment.
   8. Verify proper operation of manufacturers supplied PC and installed programs.
   9. Verify operation of PC modem and test dial-up access.
  10. Obtain sign-off on system functions.

C. Upon completion of the system check-out, the engineer shall demonstrate the operation of the system to the appropriate owner’s representative.

END OF SECTION
SECTION 26 95 00

ELECTRICAL SYSTEMS COMMISSIONING

PART 1    GENERAL

1.01    DESCRIPTION

A. The purpose of this section is to specify the Contractor’s responsibilities and participation in the commissioning process.

B. Commissioning testing shall be performed by the Contractor under the direction of the Commissioning Authority (CxA). Commissioning is primarily the responsibility of the CxA, with start-up, testing and support for commissioning the responsibility of the Contractors. The commissioning process does not relieve the Contractor from participation in the process or diminish the role and obligations to complete all portions of work in a satisfactory and fully operational manner.

C. Work of Division 26 includes:
   1. Testing and start-up of the electrical equipment.
   2. Providing qualified personnel to perform commissioning/functional tests, including seasonal testing required after the initial commissioning to verify equipment/system performance.
   3. Completion and endorsement of Pre-functional Tests Checklists provided by the CxA to assure that Division 26 equipment and systems are fully operational and ready for functional testing.
   4. Providing equipment, materials and labor necessary to correct deficiencies found during the commissioning process which fulfill contract and warranty requirements.
   5. Providing operation and maintenance information and as-built drawings to the CxA for review verification and organization prior to distribution.
   6. Providing assistance to the CxA to develop, edit and document system operation descriptions.
   7. Providing training for the systems specified in this Division.

1.02    RELATED WORK

A. All installation, testing and start-up procedures and documentation requirements specified within Division 26 and related portions of this project.

B. Section 01 91 00 – Commissioning

C. Commissioning Functional Test Procedures that required participation of the Division 26 Contractors.

D. Cooperate with the CxA in the following manner:
   1. Provide all testing and start-up procedures and documentation requirements specified within Division 1 and Division 26 and related portions of this project.
2. Allow sufficient time before final completion dates so electrical systems start-up, test and balance, and commissioning can be accomplished.
3. Provide labor and material to make required connections, circuitry and delay.
4. Put all electrical equipment into full operation and continue operation of the same during each waking day of the testing, balancing and commissioning.
5. For specified electrical systems and component testing by a third-party testing Contractor, coordinate with the CxA the scope and schedule of that testing for observation by the CxA during the actual testing.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

A. Standard test equipment for commissioning will be provided by the CxA.

B. Division 26 Contractor shall provide standard and specialized test equipment as necessary to test and start up the electrical systems.

C. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment through the installing contractor. Manufacturer shall provide the test equipment, demonstrate its use and assist the CxA in the commissioning process.

D. The Contractor shall provide all equipment, software and all test programming support as necessary to start up, calibrate, debug and verify proper function of the control/facility management system. This equipment and software shall be provided for use by both the test and balance contractor and the CxA.

PART 3 EXECUTION

3.01 WORK PRIOR TO COMMISSIONING

A. Complete all phases of work so the systems can be energized, started, tested and otherwise commissioned. Division 26 has primary start-up responsibilities with obligations to complete systems, including all sub-systems, so they are functional. This includes the complete installation of all equipment materials, raceways, wire, terminations, controls, etc., per the Contract Documents and related directives, clarifications, change orders, etc.

B. A Commissioning Plan will be developed by the CxA. Upon request of the CxA, the Contractor shall provide assistance and consultation. The Commissioning Plan will be developed prior to completion of the installation. The Contractor is obligated to assist the CxA in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation. If Contractor-initiated system changes have been made that alter the commissioning process, the CxA will notify the Architect and the Contractor may be obligated to compensate the CxA to test the revised product or confirm the suitability/unsuitability of the substitution or revision.
C. Specific pre-commissioning responsibilities of Division 26 are as follows:

1. Normal start-up services required bringing each system into a fully operational state. This includes motor rotational check cleaning, lug tightening, control sequences of operation, etc. The CxA will not begin the commissioning process until each system is complete, including normal contractor start-up and debugging.

2. The Contractor shall perform pre-functional tests on the systems to be commissioned to verify that all aspects of the work are complete in compliance with the plans and Specifications. Contractor start-up forms may be substituted for the pre-functional test forms with prior approval by the CxA.

3. Factory start-up services will be provided for key equipment and systems specified in Division 26. Factory start-up activities to be documented and submitted. The Contractor shall coordinate this work with the manufacturer and the CxA.

4. Notify Construction Manager and CxA when systems are ready for functional testing.

D. Commissioning is intended to begin upon completion of a system. Commissioning may proceed prior to the completion of systems and/or sub-systems, if expediting this work is in the best interests of the Owner. Commissioning activities and schedule will be coordinated with the Contractor. Start of commissioning before system completion will not relieve the Contractor from completing those systems as per the schedule.

3.02 PARTICIPATION IN COMMISSIONING

A. Commissioning testing shall be performed by the Contractor under the direction of the Commissioning Authority (CxA). Provide skilled technicians to start up and debug all systems within this division of work. These same technicians shall be made available to assist the CxA 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 by the CxA and coordinated by the Contractor. Contractor will ensure the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments and/or problem resolutions.

B. System problems and discrepancies may require additional technician time, CxA time, redesign and/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 CxA reserves the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment, system and/or sub-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 CxA to get the job done. A liaison or intermediary between the CxA and qualified factory representatives does not constitute the availability of a qualified technician for purpose of this work.
3.03 WORK TO RESOLVE DEFICIENCIES

A. In some systems, maladjustments, misapplied equipment, and/or deficient performance under varying loads will result in a system that does not meet the original design intent. Correction of work will be completed under direction of the Architect, with input from the Contractor, equipment supplier and CxA. Whereas all members will have input and the opportunity to discuss, debate and work out problems, the Architect/Engineer of Record will have final jurisdiction on the necessary work to be done to achieve performance.

3.04 ADDITIONAL COMMISSIONING

A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers and CxA shall include a reasonable reserve to complete this work as part of their standard contractual obligations.

B. The cost of compensation of the CxA for repeat testing or troubleshooting due to systems that do not meet specified performance shall be borne by the Contractor.

C. Corrective work shall be completed in a timely fashion to permit the timely completion of the commissioning process. Experimentation to render system performance will be permitted. If the CxA deems the experimentation work to be ineffective or untimely to the commissioning process, the CxA will notify the Architect/Engineer of Record indicating the nature of the problem, expected steps to be taken and the deadline for completion of activities. If the deadline passes without resolution of the problem, the Owner reserves the right to obtain supplementary services and equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor’s responsibility.

3.05 SYSTEMS TO BE COMMISSIONED

A. Systems to be commissioned include:
1. Emergency power systems
2. Lighting and lighting control systems
3. Fire alarm systems (with functional testing of all devices, including 10% of detectors with smoke.)

3.06 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

A. Seasonal commissioning pertains to testing under full-load conditions during peak heating and peak cooling seasons, as well as part-load conditions in the spring and fall. Initial commissioning will be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. All equipment and systems will be tested and commissioned in a peak season to observe full-load performance. Heating equipment will be tested during winter design extremes. Cooling equipment will be tested during summer design extremes, with a fully occupied
building. Each Contractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required to demonstrate performance.

C. Subsequent commissioning may be required under conditions of minimum and/or maximum occupancy or use. All equipment and systems affected by occupancy variations will be tested and commissioned at the minimum and peak loads to observe system performance. Each Contactor and supplier will be responsible to participate in the occupancy sensitive testing of systems to provide verification of adequate performance.

3.07 POST-OCCUPANCY REVIEW

A. Subsequent commissioning will be required approximately 10 months after substantial completion of the project. The facility operation will be reviewed using BAS trend data, limited functional testing and interviews with the O&M staff and occupants. The Contractor will assist the post-occupancy review by assisting with functional testing as needed. The commissioning activities may identify items for correction by the contractor. [to be included with enhanced LEED commissioning]

3.08 TRAINING

A. This Contractor will be required to participate in the training of the Owner’s engineering and maintenance staff for each electrical system and the related components. Training may be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids, or in the field with the specific equipment. The type of training will be per the Owner’s option.

B. The Contractor will be responsible for the generic training as well as instructing the Owner’s staff on the system peculiarities specific to this project.

3.09 SYSTEMS DOCUMENTATION

A. In addition to the requirements of Division 1, update Contract Documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. All drawings shall be red-lined on two (2) sets. Division 26 as-built drawings shall include updated architectural floor plans and the individual electrical systems in relation to actual building layout.

B. Maintain as-built red-lines on the job site as required in Division 1. Given the size and complexity of this project, red-lining of the drawings at completion of construction based on memory of key personnel is not satisfactory. Continuous and regular red-lining and/or posting of drawings is considered essential and mandatory.
C. In addition to the stated requirements for operation and maintenance data, provide one (1) copy of equipment technical literature, operation and maintenance literature and shop drawings to the CxA as soon as they are available. This requirement is for review of these documents prior to distribution of multiple copies for the Owner’s final use.

END OF SECTION
SECTION 27 13 43

TELECOMMUNICATIONS RACEWAYS AND ACCESSORIES

PART 1 - GENERAL

1.01 DESCRIPTION

A. General: Provide telecommunications raceways and accessories in accordance with the Contract Documents

1.02 QUALITY ASSURANCE

A. Telephone service provider approval of incoming service installation.
B. Cable television service provider approval of incoming service installation.

ASTM D4674-02a Color stability of plastics exposed to indoor lighting

1.03 STANDARDS

A. Telephone service provider requirements.
B. BICSI Tele.
C. EIA/TIA.
D. NEMA VE.
E. Cable television service provider requirements.
G. Underwriters Laboratory (UL)

1.04 SUBMITTALS

A. Product data sheets for all equipment covered by this specification section, including but not limited to cable tray, cable, equipment racks, patch panels, punch down blocks etc.
B. Coordinate cable tray layout drawing, 1/8 inch scale minimum.
C. Proposed configuration of each outlet assembly.
D. Copies of the certification of the company and names of staff who will be performing the installation and terminations.
1.05 QUALIFICATIONS

A. Contractor shall be an approved Mohawk Accredited Contractor (MAC) and provide Colorado State University-Pueblo a Mohawk 25-year warranty. A copy of the MAC certification document must be submitted with the contractor’s bid in order for the bid to be considered. The contractor is responsible for workmanship and installation practices in accordance with MAC. To become a MAC contact Ty Warren, Mohawk Representative Aspen Power & Telecommunications Sales Inc at 720-929-8550.

B. Approved MAC shall have 5 years minimum of specialization in communication cabling installation.

1.06 WARRANTY

A. Provide Colorado State University – Pueblo a Mohawk 25-year warranty.

PART 2 - PRODUCTS

2.01 EQUIVALENT PRODUCTS

A. All products shall be manufactured by those listed in “Products” section of this specification. All copper, coaxial, and optical fiber cable products shall be manufactured by Mohawk. No substitutions will be allowed.

2.02 HORIZONTAL CABLEING

A. The maximum allowable horizontal cable length is 90 meters. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet in the horizontal cross-connect.

   1. 4-Pair UTP cable: Category 5E Enhanced (+) – Mohawk M55988RB. Category 3 – Mohawk M56061RB. In applications where non-plenum rated cable is required, use equivalent Mohawk non-plenum rated cable.

B. Horizontal cabling system shall consist of a minimum of (2) 4-pair category 5E Enhanced (+) and (1) 4-pair category 3 Unshielded Twisted Pair (UTP) Copper Cables to each outlet unless otherwise noted on the Drawings.

2.03 PATCH CORDS

A. Patch cords shall be provided and installed by the owner.

2.04 TELECOMMUNICATIONS BACKBOARDS

A. Fire retardant, void-free plywood.

B. ¾ inch thick. Dimensions as shown on Drawings.
2.05 SLEEVES

A. Sleeves shall be 4 inch rigid steel nipples. Extend floor sleeves a minimum of 4 inches above and below finished floor. Extend wall sleeves a minimum of 4 inches on either side of wall. Sleeve ends shall be threaded. Provide bushings on all sleeve ends.

B. Provide sleeves between floors of telecommunication closets as in quantities and locations required to route backbone or cable tray as shown on the Drawings.

2.06 CABLE TRAY

A. Cable tray systems shall consist of straight sections, fittings, and accessories as defined in NEMA VE-1 and UL classified as equipment grounding conductors. Provide radiused elbows, tees, crosses, splice plates, wall and overhead supports, and other fittings necessary for a complete, continuously grounded system.

B. Cable Tray materials:
   1. Aluminum: Straight sections and fitting siderails and rungs shall be extruded from Aluminum Association Alloy 6063. Fabricated parts shall be made from Aluminum Association Alloy 5052. Splice plates shall be of wedge lock design, using four square neck carriage bolts and serrated flange locknuts.
   2. Pre-Galvanized Steel: Straight sections and fitting siderails and rungs shall be made from steel meeting the minimum mechanical properties of ASTM A446, Grade A and mill galvanized in accordance with ASTM A525, Coating Designation G90. Splice plates shall be manufactured from high strength steel, using ribbed carriage bolts and serrated flange locknuts.
   3. Stainless Steel: Tray sections, fittings and covers and accessories shall be manufactured from AISI Type 304 or Type 316 stainless steel. Transverse members (rungs) ro corrugated bottoms shall be welded to the siderails with Type 316 stainless steel welding wire.

C. Cable Tray Types:
   1. Solid Trough: Solid bottom trough type trays shall be of three piece construction consisting of two longitudinal members (siderails) with a solid corrugated bottom welded to the siderails. The peaks of the solid corrugated bottom shall have a minimum flat cable bearing surface of 2 ¾ inches and shall be spaced 6 inches on center.

D. Cable Tray Size:
   1. Height: Cable tray shall have an overall sidewall height of 4 inches unless otherwise shown on Drawings.
   2. Width: Widths shall be 12 inches unless otherwise shown on Drawings.

E. Loading capacity shall meet NEMA Class 8C with a safety factor of 1.5.

F. Acceptable manufacturer: B-Line, Globe, or P-W Industries.
2.07 COPPER TERMINATION BLOCKS

A. The voice cross connect shall be a passive connection between the horizontal termination blocks and backbone termination blocks. Management rings shall be mounted between the vertical columns of the blocks to provide management of the cross-connect wire. Blocks shall be oriented so that the backbone terminations are located on the left and horizontal terminations are located on the right of the termination field when facing the backboard. 66 M1-50 style blocks shall be mounted on 89B style brackets.

2.08 BACKBONE CABLE

A. Backbone cable shall be installed between MDF and IDF (IT) Rooms. Backbone cable shall consist of (1) 50-Pair Riser Cable, (1) 2SM/4MM Optical Fiber Cable, and (1)RF-11/U Coaxial cable. Exposed optical fiber cable shall be protected by plenum rated inner-duct installed between the termination of the conduit containing the cable and the fiber optic patch panel installed in the equipment rack.

2.09 EQUIPMENT RACKS – provided by owner

A. Vertical cable management and support for the patch cords at the front of the rack and wire management, support, and protection for the horizontal cables shall be installed on each rack. Wire management shall also be mounted above each patch panel and or piece of equipment on the rack. Velcro cable ties shall be used to support and anchor the horizontal cable to cable management on the rack.

2.10 TELECOMMUNICATIONS OUTLET/CONNECTORS


B. Workstation Outlets: Accommodate a minimum (3) modular jacks mounted in single faceplate. Provide blank fillers when extra ports are not used.
   1. Plastic Faceplate: High-impact plastic. Coordinate color with Division 26 Section "Wiring Devices".
   2. Metal Faceplate: Stainless steel complying with requirements in Division 26 "Wiring Devices".
   3. For use with snap-in jacks accommodating any combinations of UTP, optical fiber, and coaxial work area cords.
      a. Flush mounting jacks, positioning the cord at a 45-degree angle.
   4. Legend: Factory labeled by silk-screening or engraving
   5. Legend: Machine printed, in the field, using adhesive-tape label.
2.11 OTHER APPROVED PRODUCTS

A. 50-Pair UTP Riser Cable: Mohawk M56126

B. Optical Fiber Cable: Mohawk FOH56206

C. Coaxial Cable: RG-6/U-Mohawk M71002; RG-11/U-Mohawk M71001

D. UTP Connector: Category 5E Enhanced – Leviton 5G110-RR5, Category 3 – Leviton 4106-RE6, Wall Plate – Leviton 41080-IP(where “_” shall be the port quality required)

E. Fiber Optic Cabinet: Radiant R12NCST/R24NCST

F. ST MM Bulkhead Connector: Radiant STA/MM

G. ST SM Bulkhead Connector: Radiant STA/SM

H. Fiber Optic Connector: Multi-mode – 3M 6100 Hot Melt, Single Mode – 3M 8100YS Hot Melt


J. 19” Equipment Rack: Homaco 19-84-T2SD

K. Patch Panel: Leviton 5G596-U96

L. Cable Management: Tie Wrap Bar – Leviton 49258-TWB, Manager Ring – Leviton 49260-MR3, Patch Cord Manager – Leviton 49253-LPM

M. Termination Blocks/Brackets: Category 3 Cable – 66 Block – Suttle #SE-66M1-50-C5, Bracket – Suttle #SE-A89B

PART 3 - EXECUTION

3.01 GENERAL

A. Provide high impact thermoplastic insulating bushings on sleeve and raceway ends. Provide metallic capped insulating bushings on used service provider incoming conduits.

B. Fire seal floor sleeves and sleeves in fire rated walls to maintain fire rating of wall after telephone cables are installed.

C. Arrange raceway runs less than 100 feet from point to point so that they contain no more than two 90 degree standard factory bends or three 90 degree, 24 inch radius bends. Provide pull boxes in raceway runs exceeding 100 feet from point to point with more than one 90 degree bend.
D. The same orientation and positioning of jacks and connectors shall be utilized throughout the installation.

E. Provide fire stopping per specifications section “Firestopping” for all telecommunications penetrating item, including but not limited to: riser slots, sleeves, cables, conduit, cable tray, and raceways.

3.02 CABLE TRAY

A. Cable tray shall be supported at a maximum of 8 foot centers and at each bend, tee, cross, and elbow fitting. Supports shall be threaded rod trapeze style hangers or wall brackets. Side rails shall bear on the supports; rungs shall not bear on the supports.

B. Cable tray shall be installed level. Manufactured offsets shall be used to change height or direction.

C. Coordinate location of cable trays with other trades to avoid conflicts and maintain accessibility. Where installed above a ceiling, cable trays shall not be less than 12 inches above the bottom of the finished ceiling. Vertical clearance above the tray shall be a minimum of 12 inches.

D. Cable tray shall be continuous. Where cable tray run is interrupted at a fire rated wall, provide three 4 inch sleeves in fire rated wall. Provide bonding jumpers where cable trays are interrupted at fire rated walls and floors or are otherwise rendered electrically discontinuous.

E. Cable tray installed in an environmental air plenum shall be solid bottom with continuous cover, rated for installation in an environmental air plenum.

3.03 HORIZONTAL DISTRIBUTION CABLE

A. All horizontal data station cable and voice cable shall terminate on modular patch panels or 66 cross-connecting blocks in their respective IT room as shown on the Drawings.

B. All horizontal cabling shall be terminated according to the number scheme in ascending numerical order at the appropriate modular patch panel or 66 cross-connecting blocks. Any deviation from the number scheme will result in the replacement and re-termination of the cable and jacks by the contractor without change order.

C. Cable shall have no physical defects in the outer jacket. Replace all cables with defects. Test all cables and replace any cables that do not meet testing requirements.

D. No UTP cable shall be installed with more than 25 lbs of pull force. Utilize cable lubricant to reduce pulling friction to acceptable levels on pulls inside conduit. Utilize tensile rated cords to test conduit and pulling setups before pulling cable.
3.04 OPTICAL FIBER TERMINATION HARDWARE

A. Neatly coil fiber slack within the enclosure. No slack loops are allowed external to the fiber panel.

B. Attach each cable individually to the respective enclosure by mechanical means. Attach the cable strain relief bracket securely to the cable strength member in the enclosure.

C. Strip each fiber bundle upon entering the enclosure and route individual fibers in the enclosure.

D. Label each cable clearly at the entrance to the enclosure.

E. Connectorize and terminate all strands to their respective bulkhead.

3.05 TELECOMMUNICATIONS BACKBOARDS

A. Mount horizontally 32" above finished floor. Plywood shall be installed from wall to wall horizontally with no gaps.

B. Paint white with two coats of fire retardant paint.

3.06 EQUIPMENT RACKS

A. Securely attach racks to floor using half inch hardware.

B. Provide 20% spare rack mounting screws to owner.

3.07 BACKBONE CABLE

A. Install separately from horizontal distribution cables.

B. Co-install 1/8th inch minimum nylon pull cord with all cable inside conduit.

C. Fasten backbone cables securely to IT room wall on each floor.

D. Securely attach backbone cables at the top of the cable run with a wire mesh grip and on alternating floors.

E. Vertical runs of cable shall be supported by conduit, cable tray, or open top cable hangers to provide proper support for the weight of the cable.

3.08 HORIZONTAL CROSS-CONNECT & COPPER TERMINATION HARDWARE

A. Dress and terminate all cables in accordance with manufacturer’s recommendations.

B. Pair untwist at the termination shall not exceed 0.5 inches.
C. Bend radius of the cable in the termination area shall not be less than 4 times the outside diameter of the cable.

D. Cables shall be neatly bundled and dressed to their respective panels or blocks. Each panel or block shall be fed by an individual bundle separated and dressed back to the point of cable entrance into the rack or frame.

E. The cable jacket shall be maintained to within 0.5 inches of the termination point.

F. Each cable shall be clearly labeled on the jacket behind the patch panel at a location that can be viewed without removing the bundle support ties.

3.09 TESTING AND ACCEPTANCE

A. Test all cables and hardware. Very cabling system performance meets ANSI/TIA/EIA-568-B. Verify performance of all cables prior to acceptance. Any defective cable or components shall be replaced by the contractor prior to acceptance.

B. At the completion of the installation, in-progress and final inspections, receipt of the test and as-built documentation, and the successful performance of the system for a two-week period will constitute acceptance of the system. The telecommunications contractor shall provide a one year warranty from the date of final acceptance.

C. Test all twisted-pair copper cable links for continuity, split pairs, crossed pairs, pair reversals, shorts, opens or low performance. Verify category performance.
   1. Continuity: Test shall record pass/fail per test unit manufacturer’s recommendations. Reference cable’s unique identification number and circuit or pair number. Correct any faults in cable prior to acceptance.
   2. Length: Test each cable link for installed length using a TDR device. Test cables from patch panel, block to block, patch panel to outlet or block to outlet as appropriate. Cable lengths shall conform to maximum distances set forth in the ANSI/TIA/EIA-568-B Standard. Cable lengths shall be recorded Reference cable’s unique identification number and circuit or pair number. For multi-pair cables, record the shortest pair length.
   3. Category 5E Performance: Test the following:
      a. Wire Map (5E)
      b. Length (5E)
      c. Insertion Loss (5E)
      d. NEXT (Near end crosstalk) (5E)
      e. Return Loss (5E)
      f. ELFEXT Loss (5E)
      g. Propagation Delay (5E)
      h. Delay skew (5E)
      i. PSNEXT (Power sum near-end crosstalk loss) (5E)
      j. PSELFEXT (Power sum equal level far-end crosstalk loss) (5E)
4. Fiber: Perform all fiber testing in a complete end-to-end system. No splices. Utilize end-to-end power meter per EIA/TIA-455-53A. System loss measurements shall be provided at 850 and/or 1300 nanometers for multi-mode fibers and 1310 and/or 1550 nanometers for single mode fibers. Test for continuity of each fiber. Where links are combined to complete a circuit between devices, test each link from end-to-end.

5. Backbone Multi-Fiber: Utilize end-to-end power meter per EIA/TIA-455-53A. Test at both 850 nanometers and 1300 nanometers for multi-mode fiber. Test at both 1310 and 1550 nanometers for single-mode fiber. Test in both directions.

3.10 DOCUMENTATION

A. Provide three full documentation sets to the owner at completion of testing. Submit documentation within 10 working days of the completion of each testing phase (subsystem, cable type, area, floor, etc).

B. Machine generated final copies of all drawings and documentation shall be submitted within 30 working day of the completion of each testing phase. Provide copies of the original test results at the request of the owner.

C. Provide 10% random field re-test at request of the owner at no additional cost. Test shall be performed according to TESTING AND ACCEPTANCE. If findings contradict results of original testing, additional testing can be requested by the owner to the extent determined necessary, up-to, and including a 100% re-test. Perform re-test at no additional cost.

D. Provide test results on a compact disk within weeks of the completion of construction. Disk shall be clearly marked on the outside cover “Academic Resources Building Telecommunications Test Documentation”. Include the month and year of the test. Test results shall include the following:
1. Test frequencies
2. Cable type
3. Conductor pair and cable (or outlet) identification number
4. Manufacturer
5. Model number
6. Serial number
7. Software version
8. Last calibration date (Minimum of annual calibration is required for all test equipment)
9. Detailed description of test method used and the settings of the test equipment used.

E. Record (as-built) drawings shall include cable routes and all outlet locations. Outlet locations shall be identified by their unique sequential identification number. Provide record drawings electronically.
3.11 IDENTIFICATION AND LABELING

A. Clearly identify all components of the telecommunication system, including but not limited to: racks, cables, panels, and outlets.

B. Labeling shall designate the cables origin and destination and a unique identifier for each cable in the system.

C. Racks and patch panels shall be labeled to identify the location within the cable system infrastructure.

D. Record all labeling information on the as-built record drawings.

E. Labels shall be generated using a Brady TLS-2200 or similar thermal labeling device. Self-laminating labels shall be used on cable jackets, and appropriately sized to the outer diameter of the cable.

3.12 TELECOMMUNICATION OUTLETS

A. General:
   1. Provide a single gang plaster ring. Provide ¾” conduit to nearest cable tray or to nearest IT room.
   2. Provide a stainless steel cover plate with grommeted hole for furniture system connections.
   3. Cables shall be coiled in the in-wall or surface mounted boxes. Do not exceed manufacturer’s bend radius. No more than 12 inches of UTP or coaxial cable slack shall be stored in an in-wall box, modular raceway, or insulated wall.
   4. Pair untwist at the termination shall not exceed 0.5 inches.
   5. Bend radius of the cable in the termination area shall not be less than 4 times the outside diameter of the cable.
   6. The cable jacket shall be maintained to within 0.5 inches of the termination point.
   7. Data jacks shall be located in the bottom position(s) of each faceplate. In horizontally mounted faceplates, data jacks shall occupy the right most position(s). Voice jacks shall be located in the top position(s) and left position(s) respectively.

B. Television Outlets:
   1. Provide separate outlets for television outlets. Television outlets shall be similar to telecommunications outlets.
C. Horizontal cabling system shall be installed from the outlet to the nearest Telecommunications Room on the same floor and routed to the appropriate rack/termination block serving that area and terminated as specified elsewhere in this specification.

D. All cables and related terminations, support and grounding hardware shall be wired, tested, labeled and documented by the contractor as detailed in this specification.

END OF SECTION
SECTION 27 40 00

AUDIO-VIDEO COMMUNICATIONS

PART 1 - GENERAL

1.01 OVERVIEW

A. There are a number of audio-visually equipped spaces at Colorado State University at Pueblo including: Large Multimedia Classrooms, Multimedia Rooms, Audio Rooms, Tiered Classroom, Medium Classroom, Conference Rooms, Multimedia Studio, Multimedia Open Lab, ITC Classroom, and selected Group Rooms.

B. Large Tech Lab, Room 121, 136: Quantity two (2). Each Large Tech Lab shall display video images from a ceiling-mounted projector to a 113-inch diagonal 16:10 motorized projection screen. The system shall include a multi-format switcher. Video sources shall be one (1) OFE supplied computer, one (1) input point for a laptop computer and one (1) High Definition DVD player and an annotation device. Audio shall be heard via ceiling mounted speakers. A hardwired control system shall be provided. System control shall include, but not be limited to, projector on/off, screen up/down, source selection, volume up/down, DVD play, pause, stop, fast forward and rewind.

C. Multimedia Room 122, 127: Quantity two (2). Each Multimedia Room shall display video images on a 52-inch wall-mounted flat panel display. Video sources shall include two (2) local computers. A video switcher shall be provided to allow either computer to be displayed. An audio headset with microphone shall be supplied and audio shall be heard via headset or via the displays built-in speakers. The video switcher shall be manually controlled and the flat panel display shall be controlled by the manufacturer supplied hand held remote control. A wired microphone with floor stand shall be provided.

D. Tech Lab Audio Room 128, 137: Quantity two (2). Each Tech Lab Audio Room shall display video images on a 52-inch wall-mounted flat panel display. Video sources shall include video images from the two (2) OFE lab computers or High Definition DVD player. A video switcher shall be provided to allow either computer to be displayed. An audio headset with microphone shall be supplied and audio shall be heard via headset or via the displays built-in speakers. The video switcher shall be manually controlled and the flat panel display shall be controlled by the manufacturer supplied hand held remote control.

E. Tiered Classroom 109: The Tiered Classroom shall display images using a projection system that consists of a projector lift, an HD capable projector and a 164-inch diagonal 16:10 motorized projection screen. Sources shall include, but not be limited to, two (2) laptop computer video inputs, one (1) High Definition DVD player, television signals, annotation device and other sources. This room shall include speakers, amplifiers, and processing for 5.1 surround sound using a processor with multiple inputs for analog, digital and optical and capable of decoding 5.1 program material in standard formats. Audio for lectures is also supported by a number of ceiling-mounted loudspeakers. Two (2) wireless microphones and two (2) wired microphones shall be provided. An audio DSP with automatic microphone mixer, parametric equalization, dynamics and routing shall be provided to allow the system to be operated without a technician. An analog mixing console is provided for presentations where
an operator is required. Control of the system shall be by a wireless touch panel. Control shall include but not be limited to system on/off, projection screen up/down, projector on/off, display source, display format, projector retract/operate/service, audio stand-alone/operator, lighting presets, source volume up/down, microphone volume up/down, television channel selection, DVD play, pause, stop, fast forward and rewind. An assisted listening system shall be included for this space.

F. Medium Classroom 108: The Medium Classroom shall display images utilizing two (2) ceiling mounted projectors and two (2) 113 inch diagonal 16:10 motorized projection screens. Each system shall display the same source. Sources shall include, but not be limited to, one (1) laptop computer input, television signals, annotation device, feed from Room 109 and High Definition DVD player. Audio is heard via ceiling mounted speakers. Two (2) wireless microphone systems shall be provided. Control of the system shall be by a wireless touch panel. Control shall include but not be limited to system on/off, projection screen up/down, projector on/off, display source, display format, source volume up/down, microphone volume up/down, television channel selection, DVD play, pause, stop, fast forward and rewind. A lectern, provided by others shall be provided with an equipment rack to house the HD DVD player and local source switcher. An assisted listening system shall be provided for this space.

G. Small Classroom 201, 202: Quantity two (2). Each Small Classroom shall display video images using a ceiling mounted projector and a 113-inch diagonal 16:10 motorized projection screen. Sources shall include, but not be limited to, one (1) laptop computer, annotation device and a High Definition DVD player. Audio shall be heard via ceiling mounted speakers. A hardwired control system shall be provided. Control functions shall include, but not be limited to, projector on/off, screen up/down, system volume, source selection, and DVD play, pause, stop, fast forward and rewind.

H. Small Conference Room 190, 225, 362: Quantity (3). Each Small Conference Room shall display video images on a 52-inch wall-mounted flat panel display. Video source shall be a connection point for a laptop computer. Audio shall be heard via the displays built-in speakers. The flat panel display shall be controlled by the manufacturer supplied hand held remote control.

I. Multimedia Studio 221, 222: Quantity two (2). Each Multimedia Room shall display video images on a 52-inch wall-mounted flat panel display. Video sources shall include two (2) local computers and a High Definition DVD player. A video switcher shall be provided to allow either computer to be displayed. Audio shall be heard via the displays built-in speakers. The video switcher shall be manually controlled and the flat panel display shall be controlled by the manufacturer supplied hand held remote control. A headset with microphone shall be provided.

J. Multimedia Open Lab 229: The Multimedia Open Lab shall display video images on a 52-inch wall-mounted flat panel display. Video source shall be a connection point for a laptop computer. Audio shall be heard via the displays built-in speakers. The flat panel display shall be controlled by the manufacturer supplied hand held remote control.

K. ITC Classroom 217: The ITC classroom shall display images utilizing two (2) ceiling mounted projectors and two (2) 113 inch diagonal 16:10 motorized projection screens, with both screens displaying the video system source. Sources shall include, but not be limited to, two
(2) laptop computer inputs, annotation device and High Definition DVD player. Audio is heard over ceiling mounted speakers. A hardwired control system shall be provided. Control functions shall include, but not be limited to, projector on/off, screen up/down, source selection, and DVD play, pause, stop, fast forward and rewind.

L. ITC Audio 230, 231: Quantity two (2). Each ITC Audio shall display video images on a 52-inch wall-mounted flat panel display. Video sources shall include video images from the two (2) OFE lab computers or High Definition DVD player. A video switcher shall be provided to allow either computer to be displayed. An audio headset with microphone shall be supplied and audio shall be heard via headset or via the displays built-in speakers. The video switcher shall be manually controlled and the flat panel display shall be controlled by the manufacturer supplied hand held remote control.

M. Group Room 211, 212: Quantity two (2). Each Group Room shall display video images on a 52-inch wall-mounted flat panel display. Video source shall be a connection point for a laptop computer. Audio shall be heard via the displays built-in speakers. The flat panel display shall be controlled by the manufacturer supplied hand held remote control.

1.02 DEFINITIONS OF TERMS

A. The term “Consultant” as used in this section shall refer to Technology Plus, Inc.

B. The term “Contractor” as used in this section shall refer to the entity with the responsibility for installation and performance of the work specified herein.

1.03 QUALIFICATIONS

A. Provide written and verifiable evidence of each of the listed qualifications:
   1. The bidders must demonstrate that they have the experience, capability and resources necessary to perform the work and complete according to schedule.
   2. The Contractor shall meet all applicable regulations.
   3. The Contractor shall be a firm normally employed in the commercial and performance audiovisual industry.

B. The Contractor must adhere to the engineering, installation and testing procedures and utilize the authorized manufacturer components and distribution channels.

C. The Contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.

D. The Contractor shall own and maintain tools and equipment necessary for successful installation, equalization and testing of the systems and have personnel who are adequately trained in the use of such tools and equipment.
E. A resume of qualifications shall be submitted with the Contractor’s proposal indicating the following:
   1. A list of five recently completed projects, using the product proposed or product of similar type and size, with contact names and telephone numbers for each.
   2. A technical resume of experience for the Contractor’s Project Manager and on-site installation Supervisor who shall be assigned to this project.
   3. Be a direct dealer for key equipment
   4. Bondable to one (1) percent or as required on the project

1.04 CONTRACTOR’S RESPONSIBILITIES

A. The intent of this specification is to provide the groundwork for a complete and satisfactory operating system. All equipment and installation material required to fulfill the above shall be furnished whether or not specified or on the drawings.

B. The work herein specified shall be performed by fully competent workers, in a thorough manner. All work shall be completed to the satisfaction of the Consultant.

C. The Contactor will provide shop drawings and cut sheets for review and approval before any work will commence. This will include all information necessary for the complete wiring and installation of the system.

D. The Contractor will provide a schedule for fabrication, rack builds, cable pulls, equipment installation, termination and acceptance testing.

E. The Contractor will provide on-site coordination with other trades and on-going supervision for the project.

F. Any questions concerning this document should be addressed in writing to:
   1. Howard Steele: howards@technologyplus.com

G. The Contractor shall provide training sessions as described in this document.

H. The Contractor is responsible for providing weekly status reports to the General Contractor and the Consultant outlining the progress on the project. The following should be included in this status report:
   1. Percentage of completion of rack fabrication and other in-house work
   2. Percentage of completion of wire pulls and other wire installation
   3. Date of equipment arrival on-site
   4. Percentage of completion of wire termination and equipment installation
   5. Non-conformance to schedule or other issues

I. All materials and equipment supplied by the Contractor shall be new, the latest model and meet or exceed the published specifications of the manufacturer, unless otherwise approved by the Consultant.

J. All equipment shall meet applicable code requirements.
K. Standards:
1. All work shall be performed in accordance with the latest revisions of the following standards and codes:
   a. Local Building Codes
   b. Local Electrical Codes
   c. NEC National Electrical Code

L. Other References:
1. ANSI/TIA/EIA-569-B - Commercial Building Standard for Telecommunications Pathways and Spaces
2. ANSI/TIA/EIA-607-A - Commercial Building Grounding and Bonding Requirements for Telecommunications
3. ISO/IEC 11801 - Generic Cabling Standard
5. UL -1283 Standard for Safety - Electromagnetic Interference Filters
7. NFPA 70 National Electrical Code
8. NFPA 75 Standard for the Protection Electronic Computer Systems

M. The Contractor will submit the following:
1. Shop drawings, showing all manufacturers’ product model and type
2. Number identification for all cables and wires
3. Detailed information on the input and output connections for each device.
4. Drawings of rack equipment locations
5. Details of any custom design devices.
6. The Contractor will provide two (2) copies each of the following:
   a. Test results for all systems
   b. Operation manuals for each piece of equipment
   c. “As-Built” drawings
   d. Systems Operation and Maintenance Manuals
   e. Any software specifically written for the project
   f. Source code for all programmed systems
   g. All details specific to the software-equipment functionality

1.05 SUB-CONTRACT

A. No sub-contract will be permitted for the Contractor’s responsibilities, unless specifically identified in the bid submission and approved by the Owner and Consultant.

B. Should sub-contractor be utilized, the Contractor shall have sole responsibility for the satisfactory implementation and performance of the system.
1.06 SYSTEM WARRANTY REQUIREMENTS

A. Warranty Statement:
1. The Contractor shall include a statement of warranty on the installed system and all equipment. The warranty period shall be for one (1) year from the date of acceptance or the first beneficial use, whichever is first, against defective materials, design, workmanship and improper adjustment. Any defective material shall be removed, repaired or replaced and installed at no cost to the Owner, provided it does not show abuse.
2. The Contractor will warranty all equipment for that period, superseding the manufacturers’ warranty where necessary. The warranty shall include all costs incurred by the Contractor for removing, repairing and re-installing malfunctioning equipment.
3. Some Manufacturers require that only authorized dealers install and warranty their equipment. If the Manufacturer does not authorize the Contractor, it is the Contractor’s responsibility to make the appropriate arrangements and bear all cost and consequences of that arrangement.
4. The warranty shall include a four (4) site visits to perform preventive maintenance, repairs and adjustments as necessary, to ensure that the system performance meets specifications.
5. All manufacturers’ equipment warranties are to be activated in the Owner’s name and will commence on the date of system acceptance. The Contractor will warrant contractor-modified equipment for the warranty period described above.

B. Support:
1. The Contractor will respond to a request for service within two (2) hours by telephone and onsite support, if required, will occur within twenty-four (24) hours after the request for service.
2. Telephone support will be available during the Contractor’s published normal business hours Monday through Friday.

C. Service Contract:
1. The Contractor shall offer a separate service contract for two (2) years on a year-to-year basis. This service contract shall cover a minimum of two (2) visits per year and scheduled as per the Owner’s request, to perform preventive maintenance, repairs and adjustments, as necessary.
2. The service contract will include the scheduled replacement of lamps for projectors and other display devices. This contract should also include adjustment of equipment to maintain optimum image and sound quality as well as maintaining all other components of all installed systems to meet the specifications of this document.
3. The service contract shall commence immediately after expiration of the warranty period.
4. The contract should include separate costs and contact information for emergency and after hour’s service.
1.07 EQUIPMENT DELIVERY AND STORAGE

A. Costs of all shipping and storage requirements shall be borne by the Contractor unless otherwise directed in writing by the Consultant. The Contractor will make appropriate arrangements and coordinate with authorized personnel at the site for the acceptance, protection and storage of the delivered equipment. Unless specific arrangements are made the Contractor will be responsible for all equipment delivered to the site until formal acceptance by the Owner.

1.08 SITE REQUIREMENTS

A. The Contractor will clean up the project site on a daily basis. The Contractor will be responsible for the coordination of their work with other trades who are working in the same location on the project site. The Contractor will be responsible for repairing any damage caused to the premises by the Contractor’s installation activities.

1.09 OWNER TRAINING

A. The Contractor will provide training by a qualified instructor to personnel designated by the Owner. In the event the Contractor does not have an instructor on staff, a Manufacturer’s representative will be provided by the Contractor at no additional cost to provide the training.

B. All training shall take place after the system acceptance tests and the systems are fully operational.

C. The training will be divided into four (4) sessions of two (2) hours each and this training is to be done with the Owner’s designated representatives. The Contractor will provide the schedule for training and a sign in sheet.

D. Should the Owner request additional training; the Contractor will make the appropriate arrangements and provide to the Owner the costs for this training.

1.10 PUBLICATION

A. No information relative to this job may be released for publication without prior written approval from the Owner, Architect and the Consultant.

1.11 INSURANCE

A. The Contractor shall procure and maintain the required comprehensive liability and property damage insurance as required by the General Contractor for the duration of this project.
## PART 2 - PRODUCTS

### 2.01 EQUIPMENT

**QTY ONE (1)**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
<th>Brand</th>
<th>Model</th>
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Multimedia Open Lab 229

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### CSU Pueblo Academic Resource Center

**ITC Classroom 217**

#### VIDEO

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### CSU Pueblo Academic Resource Center

**Medium Classroom 108**

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### QTY ONE (1)

**CSU Pueblo Academic Resource Center**
Large Conference Room 317

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PART 3 - EXECUTION

3.01 GENERAL

A. General:
   1. Installation practices shall be in accordance with, but not limited to, the specifications and drawings and shall be performed in accordance with the applicable standards, requirements and recommendations including those of the National, State and Local authorities having jurisdiction.
   2. Any variation of the above requires a written request for modification submitted through the proper channels, and the changes will not commence without receiving written approval.

B. Physical Installation:
   1. All equipment shall be secured in place unless requirements of portability dictate otherwise.
   2. Fastenings and supports of the equipment shall be adequate to support their loads with a safety factor of at least three (3). All boxes, equipment, etc., shall be secured plumb and square.
   3. Aesthetic factors should be considered for the installation of all equipment, racks, projectors and other visible items to ensure a pleasant appearance. If in doubt, a request should be made, in writing, through the proper channels to verify the items in question before installation.

C. Trim Components:
   1. All trim components should match where applicable to the furniture, ceiling and walls. The Contractor should obtain a sample if required by the Architect or Consultant.

D. Cable Installation:
   1. Wire bundles will adhere to industry standards and be neat and free of cable twists or crossovers.
   2. Cables will be marked with a permanent, printer generated cable marker at each end, which corresponds to information shown on drawings.
   3. Cables will be grouped according to the signal levels. Separate groups will be formed for the following signal types:
      a. Low level audio.
      b. High level audio.
      c. Loudspeaker cables.
      d. Control cables.
      e. Video cables.
      f. Data cables.
   4. No splices are permitted without the approval of the Consultant.

E. Equipment Rack Wiring:
   1. Power, control and high-level cables should be run on one side of the equipment rack and all other cables run on the opposite side of the equipment rack.
   2. All cables should be tied or laced as required.
3. Use of a wire management system or rack frame is required for all vertical cable bundles.
4. Teflon or heat-shrink tubing shall be used to insulate the ground or drain wire.
5. Connections made with screw actuated pressure type terminal strips shall be made following the connector manufacturer’s recommendations. Wires should not be tinned.
6. All cable entry will be through the tops or base of the rack.
7. Approved wire and cable types:
   a. RF (Horizontal) Submit type
   b. RF (Vertical) Submit type
   c. RGBHV Extron MHR5
   d. Video Digital and Analog Belden 1505A
   e. Digital Audio Belden 1800B
   f. Analog Audio Belden 8451
   g. Speaker Submit type
   h. Control Submit type
   i. CAT 5e Belden Brilliance
   j. CAT 6 Submit type
8. The above list is for non-plenum cable. If plenum cable is required, use the equivalent plenum version of the above listed cable types.
9. Cables running in plenum areas without conduit shall be plenum rated cable. It is the responsibility of the Contractor to inspect the required drawings and verify plenum cable requirements.
10. All cable installation must comply with the bend radius requirements recommended by the cable manufacturer.
11. Consultant must approve the substitution of other cable types and manufacturers.

F. Grounding Procedures:
1. Primary Ground:
   a. A single primary ground shall be established for the systems in the project. Ground conductors from each system will connect to this primary system ground.
   b. A system ground will be provided in each equipment rack and shall consist of a copper buss bar large enough to accommodate all ground conductors.
   c. A copper conductor having a maximum of .10 Ω total resistances will connect the equipment rack ground buss bar to the primary ground.
2. Video Connectors:
   a. All BNC connectors will be insulated from the mounting panel.
3. Audio Connectors:
   a. All bushing type audio connectors will be insulated from the mounting panel.
4. Audio Cable Shields:
   a. All audio cable shields shall be grounded at one end only except microphones cables, where the shield shall be connected at both ends but grounded at the patch panel or equipment input only.
b. It shall be the responsibility of the Contractor to follow good engineering practices in the grounding of the system. Any deviations to the above must be approved by the Consultant prior to implementation.

3.02 CONTRACTOR SYSTEM CHECKOUT

A. Contractor will show by proof of performance test that the system is equal to or better than the equipment specifications listed herein. The proof shall be by actual tests.

B. During performance testing, all equipment shall be operated as would be expected under normal system operation conditions. All results will be documented in spreadsheet form.

C. Signal Paths:
   1. Test all switch cross points and pathways and document the results.

D. Video (Composite, Component, SDI, MPEG):
   1. Test and verify all video signal paths from every source to every destination and document the results.
   2. Utilize a signal generator capable of outputting the appropriate signal type(s) required for the system and view the image quality.
   3. Test, measure and adjust equipment as needed to meet industry standards for displaying such signal types and document the results.
   4. Check that the image is correctly displayed on the monitor(s).
   5. Measure the signal to noise ratio and document the results.

E. RGB:
   1. Test and verify all RGB signal paths from every source to every destination and document the results.
   2. Utilize a signal generator capable of outputting the appropriate signal type(s) required for the system and view the image quality.
   3. Check that the image is correctly displayed on all monitor(s).
   4. Utilize the test patterns required to properly evaluate image quality for each source and destination.

F. Optical:
   1. Video display units shall be solidly mounted and braced. No vibration or movement of the image shall be observed.
   2. The total averaged light output from a video display, in lumens, shall be within plus-or-minus 15.0% of that specified by the projector manufacturer.
   3. The light fall-off from the center of the projected image to all four (4) corners, as measured at the projected image plane, shall not exceed 45% for display images. The light intensity shall be measured at all five positions of the projected image.

G. Audio:
   1. Test and verify all audio paths from every source to every destination and document the results.
   2. Connect the output of the appropriate audio signal generator to each input connector and test for a clean signal path to each output and document the results.
3. Monitor systems and signals and verify that the systems are free from audible noise and hum.
4. Unless specified otherwise, by the equipment manufacturer, all electronic equipment shall be 20Hz to 20 kHz, ± 1.0 db.

H. Control System:
1. Test that all equipment to be controlled responds to the commands issued by the control system.
2. Test every controller for proper operation.
3. Verify that the control keypads, remotes and touch screen panel layouts match the layout provided by the Consultant.
4. Verify that the control keypads, remotes and touch screen panel functionality match the functionality requirements as provided by the Consultant.
5. At the conclusion of the tests, calibrate the system.

I. Establish and mark settings for all controls and mark accordingly. These settings will be included in the As-Built drawings.

J. Provide one set of As-Built drawings, manuals and other documentation to the Consultant for approval.

3.03 SYSTEM ACCEPTANCE TESTING

A. The Contractor will furnish all test equipment to perform all tests recommended by the manufacturers during commissioning.

B. The integrated system as shown on the drawings must be tested and commissioned as a fully functional system.

C. The Owner or its designated representative may perform or have any tests performed that the Owner requests to verify the testing of the system.

D. The Contractor shall provide a complete test plan to the Project Manager seven (7) days prior to the proposed test date, specifying capabilities and functions to be tested. All test results shall be forwarded to the Project Manager upon completion.

E. Each component will be tested per the manufacturer’s recommended tests, to ensure equipment is functioning properly.

F. The Owner may have representation at any and all testing.

G. The Owner may perform any tests the Owner believes appropriate before accepting the system.

H. A physical inventory will be taken of all equipment on site and will be compared to an equipment list included in the contract documents and as invoiced by the Contractor.

I. The Contractor will demonstrate the operation of the system and all equipment.
J. Final As-Built drawings and manuals will be available at this time.
   1. Manufacturers’ catalog sheets and specifications for all equipment.
   2. Operating manuals for all equipment
   3. Source code for all equipment that require programming
   4. Test reports for each component and for the entire system
   5. All test results will be submitted in hard paper copy and electronic file form
   6. As-Built drawings in AutoCAD

K. Two (2) complete sets of these documents delivered to the Owner.

L. If further adjustment is required or defective equipment is discovered, testing may be suspended and rescheduled at the option of the Consultant.

M. The Consultant may charge for additional time required by the Consultant and/or others to over-see the system repair and testing due to improper system installation or incorrect operation of the system. The costs shall be the responsibility of the Contractor.

3.04 CONSULTANT AND CONTRACTOR RECOGNITION

A. The installation will bear the following identification plate mounted at the top of the agreed to equipment rack:

SYSTEMS DESIGNED BY:
TECHNOLOGY PLUS, INC.
AURORA, CO. 80014
303-340-8228

SYSTEMS INSTALLED BY:
(Contractor)

END OF SECTION
PART 1 - GENERAL

1.01 REFERENCES

A. American National Standards Institute (ANSI).
   ANSI A17.1 Safety Code for Elevators and Escalators

B. Americans with Disabilities Act (ADA).

C. International Electrical and Electronics Engineers (IEEE).
   IEEE C62.41 Surge Voltages in Low-Voltage AC Power Circuits

D. National Electrical Manufacturers Association (NEMA).
   NEMA 250 Enclosures for Electrical Equipment

E. National Fire Protection Association (NFPA).
   NFPA 10 Portable Fire Extinguishers
   NFPA 12 Carbon Dioxide Extinguishing Systems
   NFPA 12A Halon 1301, Fire Extinguishing Systems
   NFPA 13 Installation of Sprinkler Systems
   NFPA 14 Installation of Standpipe and Hose Systems
   NFPA 15 Water Spray Fixed Systems for Fire Protection
   NFPA 17 Dry Chemical Extinguishing Systems
   NFPA 70 National Electric Code (NEC)
   NFPA 80 Fire Doors and Fire Windows
   NFPA 90A Installation of Air Conditioning and Ventilating Systems
   NFPA 90B Installation of Warm Air Heating and Air Conditioning Systems
   NFPA 101 Safety to Life From Fire in Buildings and Structures

F. Underwriters Laboratories Inc. (UL).

The systems and components shall comprise UL listed systems listed for use in Fire Protective Signaling Systems under the following standards and documents and bear listing mark of laboratory. In absence of listing mark, submit documentation of applicable listing.

Fire Protection Equipment Directory, listed equipment, assemblies, and materials.

Electrical Appliance and Utilization Equipment Directory

Electrical Construction Materials Directory
UL 38  Manually Activated Signaling Boxes
UL 217  Smoke Detectors Single Station
UL 228  Door Holders for Fire Protective Signaling Systems
UL 268  Smoke Detectors for Fire Protective Signaling Systems
UL 268A Smoke Detectors for Duct Application
UL 346 Waterflow Indicators for Fire Protective Signaling Systems
UL 464 Audible Signaling Appliances
UL 521  Heat Detectors for Fire Protective Signaling Systems
UL 864  Control Units for Fire Protective Signaling Systems
UL 1480  Speakers for Fire Protective Signaling Systems
UL 1481  Power Supplies for Fire Protective Signaling Systems
UL 1638  Visual Signaling Appliances - Private Mode Emergency and General Utility Signaling
UL 1711  Amplifiers for Fire Protective Signaling Systems
UL 1971  Signaling Devices for the Hearing Impaired


H. International Fire Code (IFC).

1.02 SUBMITTALS

A. At option of Owner, Submittals and Shop drawings will be provided to Authority Having Jurisdiction (AHJ) per 2003 IBC Section 106.1.1.1 for Submittal Documents.

B. Submit Submittals and Shop drawings within time period as specified elsewhere, but not later than 30 days after Notice to Proceed. If project includes fire alarm and detection systems work in more than one building, the submittal and shop drawing items applicable to each building shall be grouped by building. Include the following:

1. Complete list of equipment to be provided, including quantities of equipment, equipment catalog information ("cut") sheets, and physical sizes. Include manufacturers, model numbers, and listing information for all equipment, devices and materials.

2. Interior and exterior front elevations of the FACPs.

3. One line riser diagram for complete system, including existing FACPs.

4. Typical preliminary wiring diagrams for all devices of the FACPs, including provisions for expansion and wire quantities.

5. Battery Sizing Calculation: Battery calculations shall substantiate operating, supervisory, and alarm power requirements. Include ampere-hour requirements for each system component and each FACP component, and the battery recharging period.

6. Conductor types and sizes for each circuit.

7. Voltage Drop Calculations: Voltage drop calculations for notification appliance circuits to indicate that sufficient voltage is available for proper appliance operation.

8. Candela setting of each strobe device and wattage tap setting of each speaker device.
9. Specific identification of each power connection, including circuit breaker, circuit number, and panelboard source.

10. Complete system operation narrative and software descriptions.

11. Spare Parts: Provide spare parts data for each different item of material and equipment specified. Data shall include a complete list of parts and supplies with the current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 year of service and at annual intervals thereafter.

12. AutoCAD drawings, scaled, partial floor plans showing the position of existing FACPs, and proposed location of new FACPs, cable and conduit routing, with conduit nominal dimension, quantity, and type of cable and conductors.

13. Provide drawings of terminal box interior elevation with terminal strips. Include terminal strip wiring diagrams showing terminal identifications and terminated circuit conductor identifying labeling.

14. Reproducible copy of scaled floor plans, prepared using AutoCAD version 2004 or later, indicating details of ceiling height, ceiling construction, and use of each room, and showing actual placement of devices. Use symbols identical to symbols shown on contract documents. Detail shop drawings, consisting of a complete list of equipment and material, including manufacturer’s descriptive and technical literature, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical detectors. The contractor shall check the layout based on the actual detectors to be installed and make any necessary revisions in the detail shop drawings. The detail shop drawings shall also contain complete wiring and schematic diagrams for the equipment furnished, equipment layout, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. At the sole discretion of the Owner, Owner may provide AutoCAD electronic file floor plans for use upon request. Detailed point-to-point wiring diagrams, showing all points of connection. Diagrams shall include connection between system devices, appliances, control panels, supervised devices, and interfacing wiring and control diagrams of all equipment that is activated or controlled by the FACP.

15. Instructions:
   a. Operation instructions outlining step-by-step procedures required for system startup, operation, and shutdown. The instructions shall include the manufacturer’s name, model number, service manual, parts list, and brief description of all equipment and their basic operating features.
   b. Maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The instructions shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed.
   c. Instructions shall be approved prior to training.

16. Test Procedures: Detailed test procedures for fire detection and alarm system 30 days prior to performing preliminary system tests.
17. Test Reports: Test Reports in booklet form showing all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall document all readings, test results and indicate the final position of controls and detector sensitivity settings.

18. Certifications: Certified copies of current approvals or listings issued by UL, FM or other nationally recognized testing laboratory, showing compliance with specified standards.

C. Qualification Requirements. Provide documentation showing Contractor has five years, minimum, commercial or industrial fire alarm installation experience. Each Foreman and Journeyman shall have a minimum of two years documented fire alarm installation experience. Submit individual resume for each foreman and journeyman noting relevant work, including project names, project completion dates, reference names and phone numbers.

D. Operations and maintenance (O&M) manuals shall be submitted within 30 days of the final accepted fire alarm test. O&M manual items applicable to each building shall be grouped by building and shall contain:
   1. All items of paragraph "Submittals," corrected to include all shop drawing comments and to reflect actual space for installation.
   2. Complete schematic and interconnection wiring diagrams, internal and external, including Junction box wiring with all terminal strip and wire numbers identified.
   3. Completed, as-constructed wiring diagrams for all devices and FACPs, including provisions for expansion, and wire quantities.

1.03 DEFINITIONS

A. The terms manual fire alarm station, manual alarm station, manual pull station, pull station, and manually actuated signaling boxes are used interchangeably in the specifications and on the drawings; all shall mean manual fire alarm box as defined by the National Fire Alarm Code (NFAC) and described in these specifications.

B. The terms visible notification appliance, visual notification appliance, alarm strobe, strobe, visible signaling appliance are used interchangeably in the specifications and on the drawings; all shall mean visible notification appliance as defined in the National Fire Alarm Code (NFAC) and described in these specifications.

C. The terms audible notification appliance, audible signaling appliance, and audible appliance are used interchangeably in the specifications and on the drawings; all shall mean audible notification appliance as defined by the National Fire Alarm Code (NFAC) and described in these specifications.

D. The term alarm announcement, emergency voice announcement, message announcement, voice message announcement, and occupant notification are used interchangeably in the specifications and on the drawings; all shall mean message announcement as defined by the National Fire Alarm Code (NFAC), International Building Code (IBC), International Fire Code (IFC), and described in these specifications.
E. The terms fire alarm control panel (FACP), fire alarm control unit (FACU), control units for fire protective signaling systems, control unit, and control panel are used interchangeably in the specifications and on the drawings; all shall mean fire alarm control panel as defined by the National Fire Alarm Code (NFAC) and described in these specifications.

F. The terms horn strobe, combination horn strobe, horn-strobe, combination horn-strobe, horn/strobe, and combination horn/strobe are used interchangeably in the specifications and on the drawings; all shall mean notification appliances that have both audible horn and visible strobe notification appliances as defined by the NFAC and described in these specifications.

G. The terms speaker strobe, combination speaker strobe, speaker-strobe, combination speaker-strobe, speaker/strobe, and combination speaker/strobe are used interchangeably in the specifications and on the drawings; all shall mean notification appliances that have both audible speaker and visible strobe notification appliances as defined by the NFAC and described in these specifications.

H. The term notification appliance and the abbreviation NA are used interchangeably in the specifications and on the drawings; all shall mean Notification Appliances as defined in the NFAC and described in these specifications and are applicable to this project. The abbreviation NA shall not mean, and shall not be interpreted to mean, Not Applicable.

I. The terms fire department, fire signal receiving facility, supervising station are used interchangeably in the specification and on the drawings; all shall mean the facility which provides 24-hour attended monitoring service.

J. FATC: Fire Alarm Terminal Cabinet

K. DVC: Digital Voice Communicator

L. FCC: Fire Command Center

1.04 GENERAL REQUIREMENTS

A. Nameplates. Major components of equipment shall have the manufacturer’s name, address, type or style, voltage and current rating, and catalog number on a noncorrosive and nonheat-sensitive plate which is securely attached to the equipment.

B. All control panels, subpanels, and equipment panels for fire alarm use shall be hinged and contain door locks. Key locks alike as directed. Provide tags with stamped identification number for keys and locks.

C. Paint coverplate of all fire alarm junction boxes red and label with circuit information.

D. Verification of Dimensions. The contractor shall become familiar with all details of the work, verify all dimensions in the field, and shall advise in writing of any discrepancy before performing the work.
E. Compliance. The fire alarm and detection system shall be configured in accordance with NFPA 72. The equipment furnished shall be compatible and be UL listed, or FM approved, or approved or listed by a nationally recognized testing laboratory in accordance with the applicable NFPA standards.

F. Manufacturer’s Services.
1. Services of a manufacturer's representative who is experienced in the installation, adjustment, testing, and operation of the equipment specified shall be provided. The representative shall supervise the installation, adjustment, and testing of the equipment.
2. Each manufacturer, or his authorized branch distributor or representative, of the fire alarm system equipment shall confirm that there is an established agency within 75 miles of the project site that maintains a full complement of parts and offers 24 hour emergency response service for all equipment being furnished and that the local agency will supply parts without delay at reasonable cost. This confirmation shall be in writing and shall be submitted along with the Contractor's bid price. The entire fire alarm system shall be installed, tested, and adjusted under the supervision of a factory-trained and licensed engineer/technician.
3. Upon completion of the contract, the manufacturer's representative must be able to execute a full-service contract for the maintenance and upkeep of the system in accordance with the current recommended practices from the National Fire Protection Association and the equipment manufacturer. The Contractor must have 24-hour service capability in the event of a system malfunction and be capable of providing emergency service within 4 hours of receiving notification and response time shall be guaranteed within 4 hours of providing notification.

1.05 SYSTEM REQUIREMENTS

A. Provide FADS configured with control and monitoring and alarm functions as shown and specified. Provide for operator interactions, total system supervision, coordination, control, and monitoring. The system shall provide receiving, processing, displaying, monitoring, alarm, recording, and control functions shown and as required to accomplish operation sequences shown, specified, and existing.

B. The FADS shall interconnect and fully support the functional operation of existing equipment and the interoperation of existing and future systems. Interconnection of these systems shall not invalidate the UL listing of the FADS.

C. Provide UL listed system in compliance with Protected Premises Fire Alarm System per NFPA 72, noncoded, 24 VDC system.
1. Initiating Device Circuits (IDC): Style E, Class A.
2. Signaling Line Circuits (SLC): Style 7, Class A.
D. FADS shall comply with NFPA requirements for an analog active multiplex system using only analog addressable initiating devices with all circuits and data transmission media fully supervised. FADS shall be configured generally as shown and shall fully comply with Referenced standards and NFPA requirements for Protected Premises Fire Alarm Systems and shall be UL 864, Category UOIJZ listed for use as an integrated Fire Protective Signaling System.

E. Unless otherwise noted, provide duct smoke detectors listed for the air velocity present and for use in air distribution systems located in serviceable locations as follows:
   1. As shown.
   2. In return air systems with a design capacity greater than 2000 cfm (0.9 m³/s), in the return air duct or plenum upstream of any filters, exhaust air connections, outdoor air connections, or decontamination equipment and appliances.
   3. For multiple air-handling systems which share common supply or return air ducts or plenums with a combined design capacity greater than 2000 cfm (0.9 m³/s), in the return air duct or plenum upstream of any filters, exhaust air connections, outdoor air connections, or decontamination equipment and appliances.
   4. For return air risers which serve two or more stories and serve any portion of a return air system having a design capacity greater than 15,000 cfm (7.1 m³/s), provide smoke detectors at each story. Position such smoke detectors upstream of the connection between the return air riser and any air ducts or plenums.
   5. Spacing of detectors and duct detector sampling tubes shall comply with detector manufacturer’s recommendations and with requirements of both NFPA 72 Section 5.14.4.2 and 5.14.5 and recommendations of NFPA 72 Handbook Appendices and Annexes for the referenced sections.
   6. Fans, including exhaust fans, whose sole function is to remove air from the inside of the building to the outside of the building, shall not require duct smoke detectors unless duct smoke detectors are specifically shown.

F. Fan shut down circuits shall be fully supervised by, and controlled directly from, the FACP.

G. Door holders which upon loss of power cause the doors to become self-closing shall not require supervision.

H. System shall operate with manual stations, detectors, sprinkler circuits, occupant notification appliances, and the like, as follows:
   1. An alarm condition in the FACP shall typically initiate:
      a. All audible and visible notification appliances and devices shall be energized continuously throughout the building until manually reset, or silenced, or both.
      b. Visible and audible indication of alarm origin on FACP and remote annunciators, on the initiating device, and on its corresponding remote visible indicator(s).
c. Activation of controls, and sequence of controls, for shutdown of air handling units.
d. Transmission of system ALARM signals to the fire signal receiving facility. Transmit individual device address and status unless transmission of one system Common ALARM signal is shown.
e. Close doors which are held open electrically. Vestibule doors shall not have door holders. Provide magnetic door holders for all doors in fire-rated separations.
f. Elevator operation consistent with ANSI A17.1b.
g. Unlocking of stairwell and exit doors per NFPA 80 and NFPA 101.
h. Release of fire and smoke dampers per NFPA 90A and NFPA 90B.
i. Monitoring of self-contained automatic fire extinguishing systems or suppression systems and equipment per NFPA 12, NFPA 12A, NFPA 13, NFPA 14, NFPA 15, and NFPA 17.
j. Lighting control necessary to provide essential illumination during fire alarm conditions, per NFPA 70 and NFPA 101.
k. Emergency shutoff of hazardous gas and fuel systems.
l. Control of building environmental heating, ventilating, and air conditioning equipment.

2. A trouble or supervisory condition in the FACP shall typically cause:
   a. Visible and audible indication of trouble or supervisory signal origin on FACP and remote annunciators. A common audible signal may be used for both a trouble and a supervisory signal when permitted by NFPA 72 if separate and distinct visible signals are provided for trouble and for supervisory signal.
   b. Transmission of system trouble and supervisory signal to the fire signal receiving facility.
   c. Manually acknowledging function at FACP shall silence audible trouble or supervisory alarm; visual alarm shall be displayed until cause of trouble or supervisory signal is cleared.
   d. Activation of any duct smoke detector, or activation of any elevator smoke detector used for elevator capture, shall not be considered an alarm signal but shall be considered a supervisory signal.

3. Device layout shall be as follows, unless otherwise specified or shown:
   a. Each initiating device shall have a unique address.
   b. All devices shall be labeled on shop drawings, operation and maintenance (O&M) manuals and in the FACPs and annunciators per Attachment 13850-A.

   I. Supervisory signals shall indicate abnormal conditions in devices monitored and sound local supervisory alarm in the FACP, activate visible annunciator, and send supervisory signal to the fire signal receiving station.
J. Elevator Control and Interface.
   1. Provide smoke detectors, not necessarily shown, complete with conduit, wire
      and interconnection to FACPs as follows:
         a. At top of elevator shafts and hoistways which contain sprinklers.
         b. In elevator machine rooms.
         c. At each elevator lobby.
   2. Provide elevator controller power supply shunt-trip-operated devices and
      120VAC, single-phase shunt trip power circuit in raceway and monitored by
      FACP. Loss of shunt trip power circuit voltage shall annunciate an addressable
      supervisory signal at the FACP.
   3. Provide signal outputs including conduit and wire from FACPs extended to
      elevator controller enclosures adequate to implement elevator control and
      Phase I emergency recall operation per ANSI A17.1 Rule 211.3.
   4. Loop and stow 48 inches, minimum, coiled length of control conductors interior
      to elevator controller enclosures. Conductor terminations and elevator
      controller modifications to implement modified elevator sequence of operation
      are in contract.
   5. Designated (i.e., primary) levels, and alternate (i.e., secondary) levels, shall be as
      directed by the Authority Having Jurisdiction (AHJ).
   6. Provide heat detectors, not necessarily shown, in elevator machine rooms, and
      at top of elevator shafts and hoistways, not necessarily shown, complete with
      conduit, wire and interconnection to FACPs. Provide such heat detectors
      located within 2 feet of each sprinkler head. Such detectors shall have a lower
      temperature rating and a higher sensitivity than the associated sprinkler.
      Provide signal outputs, including conduit and wire, to elevator controller power
      supply shunt trip devices.

K. System Zoning
   1. Electric Fire Pump:
      a. Controller has operated into a motor running position.
      b. Loss of line power on line side of motor starter, in any phase.
      c. Phase reversal on line side of motor starter.
      d. Controller connected to alternate source
   2. Pre-Action Fire Protection Systems:
      a. System alarm (1 zone per system).
      b. System trouble (1 zone per system).
      c. Provide for 1 system.
   3. Fire Speakers and Visual Alarm Strobes:
      a. Each floor of the building (above and below grade) shall be a separate,
         individual zone.
      b. Each stairwell shall be a separate, individual zone.
      c. Each elevator bank shall be a separate, individual zone.
4. **Firefighter’s Telephone System:**
   a. **Plug in jacks**
      1) Each stairwell shall be a separate, individual zone.
      2) Each bank of elevator cabs shall be a separate, individual zone.
      3) Each elevator lobby bank riser shall be a separate, individual zone.
      4) The fire pump room shall be a separate, individual zone.
   b. **Emergency telephones**
      1) Each stairwell shall be a separate, individual zone.

1.06 **OPERATIONAL FEATURES**

A. The system shall have the following operating features:

1. Electrical supervision of all circuits.
2. Electrical supervision of the primary power (ac) supply, battery voltage, placement of alarm signaling line circuit (SLC) module (card, PC board) within the FACP.
3. Trouble buzzer and trouble lamp (light emitting diode or neon light) to activate upon a single break, open, or ground fault condition which prevents the required normal operation of the system. The trouble signal shall also operate upon loss of primary power (ac) supply, low battery voltage, removal of alarm zone module (card, PC board), and disconnection of the circuit used for transmitting alarm signals off-premises. A trouble alarm silence switch shall be provided which will silence the trouble buzzer, but will not extinguish the trouble indicator lamp. After the system returns to normal operating conditions, the trouble buzzer shall again sound until the silencing switch returns to normal position, unless automatic trouble reset is provided.
4. Evacuation alarm silencing switch or switches which, when activated, will silence audible notification appliances, but will not affect the display of the address and status of the alarmed initiating device nor the operation of the transmitter. This switch shall be overridden upon activation of a subsequent alarm from an unalarmed initiating device and the audible notification appliances should be re-activated.
5. All addressable devices shall have the capability of individually being disabled or enabled from the panel.
6. Confirmation or verification capability provided for circuits with smoke detection devices which shall interrupt the transmission of an alarm signal to the system control panel for a factory set period. This interruption period shall be adjustable from 1 to 60 seconds and be factory set at 20 seconds. Immediately following the interruption period, a confirmation period shall be in effect during which time an alarm signal if present will be sent immediately to the FACP. All fire alarm devices other than smoke detectors shall be prohibited on circuits which implement confirmation or verification capability.
7. Transmitter disconnect switch to allow testing and maintenance of the system without activating the transmitter but shall provide a trouble signal when disconnected and a restoration signal when reconnected.
1.07 SITE CONDITIONS

A. Ambient Conditions: Provide fire alarm and detection systems complete and fully functional suitable for use and operating continuously at the specified site conditions with all necessary associated and ancillary equipment tested and demonstrated.
   1. Installed Equipment Elevation: 5280 feet above sea level.
   2. Indoor Conditions: 40 degrees F to 95 degrees F; 0 to 95% relative humidity, noncondensing.
   3. Exterior Conditions: -20 degrees F to 98 degrees F, 0 to 100% relative humidity, condensing.
   4. Seismic Zone: Zone 1.

B. All equipment shall be rated for continuous operation under the ambient vibration conditions encountered for the installed location.

C. Components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust or ignitable fibers or flyings, shall be rated and installed in accordance with Chapter 5 of NFPA 70 and as shown.

1.08 ELECTRICAL REQUIREMENTS

A. The equipment shall operate from a voltage source as shown, plus or minus 10 percent. Where not shown, voltage source shall be 115 VAC, single-phase.

B. Surge Protection.
   1. All equipment connected to ac circuits shall be protected from power line surges.
   2. All cables and conductors which serve as communication circuits shall have surge protection installed at each end.
   3. Equipment shall withstand surge test waveforms described in IEEE C62.41.
   4. Fuses shall not be used for surge protection.

C. Communications Circuit Surge Protection. All communications equipment shall be protected against surges induced on any communications circuit. All cables and conductors which serve as communications circuit between the local processor and the central processor shall have surge protection devices installed at each end. Protection shall be provided at the equipment and on each wireline circuit within 3 feet of the building cable entrance. The inputs and outputs shall be tested in both normal mode and common mode using the following two waveforms:
   1. A waveform with a 10 microsecond rise time, a 1000 microsecond width, a peak voltage of 1500 volts, and a peak current of 60 amperes.
   2. A waveform with an 8 microsecond rise time, a 20 microsecond waveform, a peak voltage of 1000 volts, and a peak current of 500 amperes.

1.09 WARRANTY

A. Warranty all materials, installation and workmanship for one year from the date of Notice of Acceptance, minimum, and greater warranty period as otherwise specified.
B. Provide a certified original of the manufacturers’ warranty with close-out documentation and included with the operation and maintenance manuals.

1.10 REQUESTS FOR UTILITY INTERRUPTIONS OR OUTAGES

A. The Contractor’s on-site superintendent shall forecast and submit for approval 30 days in advance their need to schedule any and all interruptions or outages required on any FADS utility system, communications lines, etc. An interruption is defined to mean any work event which will disable a portion of redundant system. An outage is defined to mean any work event which will disable both the primary and backup systems. This forecast shall be submitted in writing on a weekly basis to the Owner. The forecast shall identify a work week "window" 30 days in advance and shall contain as a minimum the following:

1. A brief description of the tasks required to accomplish the interruption or outage and of the actual work to be accomplished.
2. Building and site locations where the work will be performed and portions of the building (floor level, wing, room numbers) which during the work will have less than fully functioning FADS.
3. The estimated number of workmen or crews involved.
4. The estimated duration of the interruption or outage to the nearest whole hour.
5. The estimated recovery to restore the interrupted service to the nearest 15 minutes.
6. The work week "window" not later than which this event must be accomplished in order to keep the project on schedule.

B. Upon review of the forecast the Owner shall reply in writing to the Contractor not less than 5 days prior to the day on which the interruption or outage will occur. It may be impossible to use the work week "window" proposed by the Contractor. Therefore, the Owner reserves the right to select an alternate work week "window" and will notify the Contractor as soon as possible and under most circumstances at least 2 weeks in advance. Once the work week "window" has been established, the Owner will identify primary and alternate dates on which the interruption or outage shall be scheduled. The primary date for an interruption or outage may be canceled even after it has been approved and scheduled. Therefore, the alternate date is provided. If both primary and alternate dates must be canceled, the Owner will provide the Contractor with new primary and alternate dates as quickly as an accelerated approval can be obtained. The Owner will reply to the Contractor with the following information:

1. Descriptive Event Name and Task Number
2. Approved primary date and start/finish times.
3. Approved alternate date and start/finish times.
4. Any special instructions concerning on-site control and recovery procedures. The Contractor shall provide sufficient allowance in the project bid to cover canceled dates and canceled alternate dates whether for interruptions or outages. Such cancellations shall not be a basis for delay claims or requests for extensions.

C. No interruptions of the fire sprinkler or fire suppression systems in a building are permitted while the building FADS are interrupted.
D. The interruptions of the FADS in any buildings shall be limited to 4.0 hours when the building is occupied and 8.0 hours when the building is not occupied. The FADS may not remain interrupted unless fire watchers are present.

1.11 REQUIREMENTS FOR FADS INTERRUPTION

A. Announcements and Notification. Prior to initiating work, repair, or replacement procedures on any portion of the FADS which will cause the FADS to not be fully functional, the following announcements and notifications shall be made:

1. Building Owner or Manager: Notify 10 working days prior to work.
2. Building Occupants: Notify 24 hours prior to work.
3. Responding Fire Department: Notify 24 hours prior to work and 1 hour prior to actual start of work.
4. Posted Announcement: Post temporary signs at each entrance to each building, each stairwell entrance, and each elevator entrance. Signs shall be posted one hour, minimum, prior to occupant entry on the day during which the work will be performed. Signs shall be a minimum 8-1/2" x 11" dimension with block letter printing using black lettering on a light red or pink background. Provide with secure attachment and means of protecting from weather damage. Sign shall state substantially:


5. Immediately prior to initiating work, fire watchers shall announce to all building occupants that fire alarm system work is in progress. All personnel entering the buildings after these announcements shall be similarly advised of work in progress. When the fire alarm system work is no longer in progress and the FADS is again fully functional, an announcement to all building occupants shall be made that the fire alarm system work is no longer in progress and the FADS has been restored to normal operation.

B. Fire Watch. Provide Fire Prevention Precautions, Preplanned Impairment Programs, and mobile fire watch and fire patrol including escorts, as a minimum, equal to those stated in NFPA 1 Chapter 13 and NFPA 25 Chapter 14, and as specified herein. The fire watchers shall:

1. Have portable or semi-portable fire extinguishing equipment readily available and shall be trained in its use, including practice on test fires. Fire extinguishing equipment shall be verified ready for use in accordance with NFPA 10.
2. Be familiar with the facilities and procedures functional at the time for sounding an alarm in the event of a fire; normal procedures and equipment that is not functional.

3. Watch for and detect incipient fires in all exposed areas.

4. Sound the alarm immediately in all cases when fire is observed. Sounding the alarm shall not be delayed for any reason, including any attempts to extinguish or control the fire.

5. Only attempt to extinguish fires when obviously within the capacity of the equipment available.

6. Continue to perform fire watcher duties for at least one-half hour after re-activation of the FADS systems.

7. Have dedicated, continuous voice communication means to a constantly monitored location, including the building fire alarm control panel (FACP). Voice communication by use of two-way radios, minimum, shall be used.

8. Be instructed as to the fire hazards anticipated.


10. Assure that existing automatic suppression systems, such as sprinkler systems, water supplies, fire pumps, and hand hoses, are in service during the fire watch.

11. Be assigned to no other duties.

12. Perform fire watch in one building only during a fire watch. Fire watchers shall not perform fire watch services in more than one building during any fire watch.

13. Be trained and familiar with egress routes from each location in the buildings.

14. Tour the building continually during FADS work. Tour shall include all floors and levels of the buildings. Tour shall include each room for which the FADS is not fully functional.

15. Ensure that fire doors and fire shutters are closed and not blocked open.

16. Generally, the quantity of roving fire watchers shall be adequate such that each floor, level, and room of the fire watch area is visited by a fire watch each 60 minutes during the fire watch. Specifically, provide adequate quantity of fire watchers as specified below.

   a. One fire watcher for each floor when floor area exceeds 20,000 square feet.

   b. One fire watcher for every two floors when floor areas are between 10,000 and 20,000 square feet.

   c. One fire watcher for every three floors when floor areas are less than 10,000 square feet.

   d. One fire watcher for each building when the building gross square footage of all floors is less than 10,000 square feet.

   e. For fully sprinklered buildings, the quantity of fire watchers specified in paragraphs 16.a through 16.d above may be reduced during normal building occupied hours by not more than 50%. This reduction shall only be permitted in those buildings and instances for which the sprinkler system remains fully operational. Reductions will not be permitted for preaction sprinkler systems unless it is possible for the preaction sprinkler system sprinkler water discharge to be manually initiated.
PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Fire Alarm and Detection System: All fire alarm and detection system equipment shall be supplied by one representative and shall be by the same fire alarm equipment manufacturer. All systems, system equipment, components and wiring configurations shall be submitted for review and approval regardless whether listed herein. Equipment shall be by:
   1. Siemens

B. Standard Products. Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall be items that have been in satisfactory use for at least 2 years prior to bid opening.

2.02 FIRE ALARM CONTROL PANELS

A. Unless otherwise noted or shown, provide FACPs which contain the following components and which will provide the following characteristics:
   1. Steel cabinet construction, with hinged front and lock on front of door frame, keyed as directed. Factory primed and painted red. Designed for transmitting signals to the fire signal receiving facility.
   2. FACPs shall be addressable. Provide non-addressable circuits as shown.
   3. FACPs shall be modular and expandable.
   4. FACP Spare Capacity: Provide spare capacity within each FACP for all equipment, signaling line circuits, initiating device circuits, supervisory circuits, and notification appliance circuits, as follows:
      a. Except as specified for spare signaling line circuit (SLC) cards, the quantity of addresses assigned to each SLC shall be no greater than 80% of the SLC card address capacity for the specified style. The available unused address capacity per installed SLC card shall exceed 20%.
      b. Provide one, minimum, spare signaling line circuit (SLC) card in each FACP which has zero assigned point addresses. Spare SLC card shall be energized and monitored by the FACP and fully ready to accept SLC with assigned point addresses.
      c. The FACP cabinet shall not be filled to over 80% capacity, leaving an additional 20% for future expansion and 20% combined horn, speaker, and strobe capacity.
      d. Provide spare FACP battery capacity and power supply capacity as specified in paragraph POWER SUPPLY.
   5. Digital Alarm Communicator Transmitter (DACT), as specified.
   6. Local Control and Display Annunciators, as specified.
   7. Annunciators, as specified.
   8. FACP Features:
      a. Annunciator panel.
      b. TROUBLE SILENCE switch and TROUBLE SILENCE visible indicator.
c. Provide a suitable means for testing the FACP visual indicating devices (meters and lamps). Meters and lamps shall be plainly visible when the cabinet door is closed.

d. Provide system RESET and ACKNOWLEDGE switches.

e. ALARM SILENCE switch and ALARM SILENCED visible indicator. Activation of switch shall silence audible notification appliances, but all strobes shall continue to operate.

f. Independent manual bypass switches for deactivation of elevator recalls, central system signal disconnects, preaction systems, air handling equipment shut down, door releases, suppression systems, and signal silences. Auxiliary controls shall be provided with an individual override switch at the FACP for each system/control with a trouble indication when the switch is in the manual override position.

g. Minimum of four alternate alarm notification appliance circuits (2 visible and 2 audible), alternating every other floor per fire division building separations.

h. The FACP shall directly shut down heating, ventilating, and air-conditioning (HVAC) fans through supervised circuits (not through contacts in the duct detector unless the contacts can be individually controlled by the FACP). A fire alarm signal shall also be sent to the Building Automation System (BAS) control panel so it can shut dampers, de-energize pump motors, etc. Re-energization of BAS shall only take place upon resetting of FACP or overriding the alarm signal sent to the BAS control panel and the shut down signal sent to the unit in alarm to allow operation of the BAS systems from the BAS control panel.

i. Ring back alarm on all switches.

j. Power supply as specified.

k. Loss of power, including any or all batteries, shall not require the reloading of a program. Upon restoration of power, startup shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or secondary power shall not affect the transmission of alarm, supervisory or trouble signals.

l. Provide capability to bypass multiple, individual addressable devices by field programming changes.

m. The FACP shall have prominent rigid plastic, phenolic or metal identification plates for all lamps, zones, controls, meters, fuses, and switches. Nameplates for fuses shall also include fuse type and ampere rating.

n. Incorporate alarm verification feature and provide a switch for easily defeating the system for testing purposes.

9. Provide system supervision as follows:

a. A break or ground on a signaling line circuit, initiating device circuit, notification appliance circuit, or supervisory circuit or operation of a bypass switch shall put the FACP in TROUBLE, energize a TROUBLE audible indication and shall illuminate a TROUBLE light. The TROUBLE SILENCE switch shall silence the local TROUBLE audible signal but the TROUBLE light shall remain on. Upon restoration of the system, all
trouble signals remain energized until all switches are restored to their normal positions and troubles cleared. Upon loss of AC power, the TROUBLE audible indication shall operate and illuminate an emergency power supervisory pilot lamp. Upon restoration of normal power, the TROUBLE indication shall remain energized until all switches are restored to their normal position.

B. Provide smoke detector at each FACP location regardless whether shown, to provide notification of fire at the FACP location. Where ambient conditions at the FACP prohibit installation of automatic smoke detection, automatic heat detection will be permitted.

C. Network Peer-to-Peer Communication:
   1. Provide FACP capable of supporting full communication with UL listed Style 7 as specified for signaling line circuits between local FACP and other FACPs connected in a peer-to-peer network configuration, and between the local FACP and the System head-end station.
   2. Provide components to enable future installation of network communication cards without requiring future modifications to FACP. Network cards shall be capable of rated communication speeds using both unshielded twisted pair copper cable media and multi-mode fiber optic cable media.

2.03 MANUAL FIRE ALARM STATIONS (PULL STATIONS)

A. Manual, noncoded, single action and shall provide indication of operation until physically reset.

B. Mounting: Unless otherwise noted, shall be as follows:
   1. New manual fire alarm stations that replace existing manual fire alarm stations in the same location shall be provided with the same mounting configuration (flush, semi-flush, or surface) as the mounting configuration of the existing.
   3. Provide manual fire alarm boxes located such that the highest operable part (e.g., operating handle) shall not be less than 42 inches nor greater than 48 inches above finished floor. Preferred height to centerline of operating handle is 48 inches above finished floor unless otherwise noted.

C. In spaces which may be subject to vandalism or unnecessary (e.g., false) alarm activation, such as spaces for theatrical, sporting or seminar events, dormitories, and the like, provide dual action type. In dormitories and other such areas susceptible to nuisance alarms provide a shielded enclosure with a battery operated horn (Stopper II or equal).

D. Stations shall be finished in red, with raised letter operating instructions of contrasting color.

E. Stations requiring the breaking of glass or plastic panels or rods for operation are not acceptable.
F. The use of a key or wrench shall be required to reset the station.

G. Stations shall have a separate screw terminal for each conductor.

H. Surface mounted boxes shall be painted the same color as the fire alarm manual stations.

I. Addressable pull stations shall be capable of being programmed, shall latch upon operation, and remain latched until manually reset.

2.04 DETECTORS

A. General: All new detectors, including all new replacement detectors, shall be addressable.

B. Heat Detector: Unless otherwise noted, heat detectors shall be as follows.
   1. Fixed temperature type, nonself-restoring. Temperature rating of 135 degrees F for office and general use areas, 190 degrees F for high ambient temperature areas, mechanical rooms, and the like. Provide rate-compensation type, in areas that are not environmentally controlled, such as attic areas and the like. 190 degrees F heat detectors shall be dual contact models.
   2. Rate-of-rise nonself-restoring type containing a lighted indicator lamp. Manual reset shall be required to restore to normal.

C. Smoke Detectors.
   1. General: All smoke detectors shall be analog initiating devices (sensors) meeting NFPA 72 definition of same.
   2. Area detectors shall be in compliance with NFPA 72 requirements and manufacturer recommended type for the installation and shall be capable of being provided with optional auxiliary contacts. Provide such auxiliary contacts when required for the function and control as specified and as indicated. Detectors in high air velocity areas shall be listed for that application. Detectors shall be unaffected by changes in environmental temperature, humidity, vibration, and pressure. Detectors shall meet UL specifications concerning sensitivity measurements and shall be adjustable, surface or flush mounted with indicator lamps and provisions for remote indication.
   3. Photoelectric detectors shall be UL 268 listed, have a pulsing power-on LED indicator which shall lock “ON” in event of alarm.
   4. Ionization detectors shall be UL 268 listed, dual chamber with pulsing power-on LED which shall lock “ON” in the event of an alarm.
   5. Projected Beam Smoke Detectors: Detectors shall consist of separate transmitter and receiver units. The transmitter unit shall emit an infrared beam to the receiver unit. When the signal at the receiver falls below a preset sensitivity, the detector shall initiate an alarm. The receiver shall contain an LED which is powered “ON” in the event of an alarm. Long-term changes to the received signal caused by environmental variations shall be automatically compensated. Detectors shall incorporate features to assure that they are operational; a trouble signal shall be initiated if the beam is obstructed for more than three seconds, the limits of the compensation circuit are reached, or the
housing cover is removed. Detectors shall have multiple sensitivity settings in order to meet UL listings for the different distances covered by the beam.

D. Provide duct smoke detectors UL 268A listed complete with duct sampling tubes, remote indicator, and test switch.
1. Duct smoke detectors shall be able to be reset at the FACP.
2. Duct smoke detectors shall be photoelectric, supervised 24 VDC four-wire (2 power, 2 signal) type (power and signal shall originate from FACP).
3. Provide remote indicating lamps and mount at the nearest corridor access location with engraved labels clearly identifying the duct smoke detector and the air handling unit with which the duct smoke detector is associated in accordance with NFPA 5.14.5.9.
4. Provide auxiliary contacts on each duct smoke detector which shall change state upon detection of smoke. Auxiliary contacts shall be used by others to annunciate detection of smoke at the building automation system.
5. Detection of smoke by each duct smoke detector shall annunciate a signal at the FACP and remote annunciators, and shall de-energize associated air-handling unit supply fans, return fans, and exhaust fans where the exhaust fans do not serve smoke-control system or function.

2.05 NOTIFICATION APPLIANCES (SIGNALING DEVICES)

A. Notification Appliances shall have separate screw terminal for each conductor. Provide matching mounting back box; recess mount unless otherwise noted. Painted surfaces shall be primed and factory painted red.

B. Indoor Audible Notification Appliances: Provide synchronized between areas on each floor and between floors. Each horn or speaker shall provide an audible level not less than 90 dBA at 10 feet. Alarm notification audibility in the area shall be a minimum 15 dBA above the average ambient sound level and clearly heard in all areas. All devices shall comply with ADA requirements. Unless otherwise shown, specified, or approved, speakers shall be provided tapped at 1 watts with the speaker circuit designed for loading of all installed speakers set at 2 watt tap. Unless otherwise shown, speakers shall be suitable for use on 25V audible notification appliance circuits. Provide grill unless single or double projector required or shown.

C. Outdoor Notification Appliances: UL listed, weatherproof vibrating horns not less than 90 dBA at 10 feet with integral weatherproof 75-candela-rated visual strobe, located at Fire Department entrance to building. The horn shall sound until reset from the FACP.

D. Indoor Visible Notification Appliances: Unless otherwise shown or noted, strobes shall be ADA compliant and candela-rated. Provide strobes multiple-candela rated with field-selectable candela ratings of 15, 30, 75, or 110 candela (cd). Design notification appliance circuit for loading with all circuit-installed strobes, horn-strobes, and speaker-strobes set at 110 candela. Strobes rated other than candela values shown but no less than 15 candela may be used where calculations showing compliance with ADA equivalent facilitation are submitted with shop drawings and are approved. Strobes shall have the following characteristics:
1. Xenon strobe type lamp.
2. Lens color: Clear.
3. Maximum pulse duration of 0.2 seconds with maximum duty cycle of 40 percent.
4. Flash rate of 1 to 2 Hz; 1 Hz preferred.
5. Listed in accordance with UL 1971.

E. Combination notification appliances which combine an audible notification appliance and a visible notification appliance shall be factory-combined audible and visible notification appliance in a single mounting assembly.

F. Provide means to silence audible notification appliances while visible notification appliances remain energized.

2.06 ANNUNCIATORS

A. Unless otherwise noted or shown, provide annunciators in each new FACP, and as shown, with the following characteristics:
   1. Liquid crystal display (LCD) type back-lit, 80 alphanumeric characters, minimum include dedicated visible indicators to indicate Alarm, Trouble, Supervisory conditions.
   2. The annunciators shall indicate all initiating devices, supervisory devices, signaling devices, alarms, and individual trouble by address, and when a fault occurs on the system (trouble).
   3. The annunciator, at the minimum, shall be a fully functioning control panel which duplicates the FACP front panel functions.

2.07 FIRE ALARM ANNUNCIATOR PANELS (REMOTE)

A. Provide key-enabled Fire Alarm Annunciator Panels (FAAP) remote from local FACP enclosure and interfaced to local FACP, as follows:
   1. With integral membrane-style tactile pushbutton control switches for ACKNOWLEDGE, RESET, and SILENCE.
   2. LCD display, features, and capabilities identical to paragraph ANNUNCIATORS.
   3. Location: As shown, unless otherwise directed.
   4. Mounting: Flush, semi-flush, or surface as shown or as directed.
   5. Enclosure: NEMA 1, unless otherwise shown.
   6. Enable Key switch to preclude unauthorized use. Provide minimum 2 keys, keyed as directed by Owner as also approved by the local AHJ.
   7. Supervised by, and energized from FACP.

2.08 POWER SUPPLY

A. Transfer from primary to secondary power supply or restoration from secondary to primary power supply shall be fully automatic and not cause transmission of a false alarm. Loss of ac power shall not prevent transmission of a signal via the fire reporting system upon operation of any SLC, IDC, or NAC.
B. Provide battery charger complete with automatic operation, with high/low charging rate, capable of restoring the batteries from full discharge to full charge within 12 hours. A separate ammeter shall be provided for indicating rate of charge. A separate voltmeter shall be provided to indicate the state of the battery charge. A pilot light indicating when batteries are manually placed on a high rate of charge shall be provided as part of the unit assembly if a high rate switch is provided. Charger shall be located in FACP.

C. Provide storage batteries of the sealed, lead-calcium type requiring no additional water. The batteries shall have ample capacity, with primary power disconnected, to operate the fire alarm system for a period of 48 hours. Following this period of operation using batteries, the batteries shall have ample capacity to operate all components of the system, including all notification appliances in the total alarm mode for a minimum period of 15 minutes. Battery cabinet shall be a separate compartment within the FACP. Provide batteries located at the bottom of the FACP or in separate battery enclosure. Provide batteries with overcurrent protection in accordance with NFPA 72.

2.09 REMOTE SYSTEM TROUBLE AUDIBLE AND VISIBLE APPLIANCES

A. Audible appliance shall have a minimum sound level output rating of 85 dbA at 10 feet and operate in conjunction with the panel's integral trouble signal. The audible device shall be silenced by the system trouble silence switch. A rigid plastic, phenolic or metal identification sign which reads "Fire Alarm System Trouble" shall be provided at the audible appliance. The visual appliance located with the audible appliance shall not be extinguished until the trouble has been cleared.

2.10 TAMPER AND FLOW SWITCHES

A. Tamper Switches: Interference with a tamper switch shall indicate a supervisory off-normal condition at the fire alarm control panel. Interference with a tamper switch shall include, but not be limited to, movement of a firewater sprinkler control valve from its normal position. Tamper switch supervisory points shall be individually addressed with each tamper switch connected to an individual addressable monitor module.

B. Flow switches shall be individually addressed with each flow switch connected to an individual addressable monitor module. The main sprinkler flow shall be annunciated separately as MAIN FLOW. Flow switches shall be adjustable between 0 - 90 seconds time delay and set at 20 to 30 seconds.

C. Conduit and boxes within 6 feet of tamper and flow switches shall be sealed tight, and all junction boxes shall be watertight.
2.11 CONTROL AND MONITOR MODULES

A. Provide control modules and monitor modules as shown, and as required for the monitoring functions and control functions required regardless whether shown, and as follows:

1. Addressable, interfaced to and powered from FACP.
2. Provide status monitoring and supervision for integrity for non-addressable circuit or device for which connected.
3. Signal and Control modules: Provide adequate quantity for controlling quantity of notification appliances and controlled devices to which connected. Provide voltage and current originating from FACP to operate connected components when such voltage and current is not otherwise available.
4. Provide installation complete with outlet or back box or enclosure, terminal strip wiring, terminations, enclosure cover, testing, and demonstration.

2.12 DOOR RELEASING DEVICES

A. Magnetic door holders. Provide for wall or floor mounting as indicated complete with matching plate provided and installed on door. Obtain operating voltage and current from the FACP. Holding force shall be approximately 25 pounds, minimum and greater as required to hold door open.

B. Door closer devices. Devices integral to door closers will be considered subject to demonstration of acceptable functions.

2.13 LOW TEMPERATURE SWITCHES

A. Provide low temperature switches which shall provide a supervisory signal indication upon decrease in space temperature to 40 degrees F and also upon restoration of space temperature to above 40 degrees F.

B. Low temperature switches shall be addressable. Providing an addressable monitor module which reports a supervisory signal indication in combination with a low temperature switch will be considered to meet the addressable requirement.

2.14 DIGITAL ALARM COMMUNICATOR TRANSMITTER (DACT)

A. Provide DACT, UL-Listed compatible with FACP and with Owner-selected 24-hour monitoring service company receiver, complete with pre-test, testing, demonstration, and instruction. DACT shall be located interior to, and be powered from within, FACP enclosure and shall incorporate and provide features and accessories including, but not limited to, the following:

1. Dual phone lines, primary and secondary.
2. Dual telephone line voltage detect.
4. Built-in, four-character, red seven-segment LED display.
7. Communicates vital system status including:
   a. Independent point alarm or Point-Group alarm.
   b. Independent point trouble.
   c. Independent point supervisory.
   d. AC (mains) Power Loss (programmable).
   e. Low Battery and Earth Fault.
   f. System Off Normal.
   g. 12- or 24-hour Test Signal (selectable).
   h. Abnormal Test Signal per UL requirements.
   i. Communication Bus Failure.
8. Annunciation of DACT trouble signals including loss of phone lines,
   communication failure with either central station; total communications failure.
9. Individual LEDs for Power Loss of FACP-to-DACT Communication; Manual Test;
   Kissoff; Comm Fail; Primary Line Seize; Secondary Line Seize; and Modem
   Communications.
10. Open collector relay driver for total communications failure, phone line fault, and
    DACT troubles.
11. Real-time clock.
12. Phone line transient protection.
13. Auxiliary DPDT Form C relays, 2 minimum.
14. Communications bus interface to FACP.

B. The installation must meet the approval of the local AHJ and fire response agency (e.g.,
    fire department). Coordinate witnessing of Final Test by Owner, local fire response
    agency, and Engineer. Submit written test results and written approval from local fire
    response agency.

2.15 LOCAL CONTROL AND DISPLAY ANNUNCIATORS (LCDAs)

A. Provide LCDAs, integral to FACP enclosure, with integral membrane-style tactile
   pushbutton control switches for the control of system functions and LED-type lamps to
   annunciate 12 minimum, point groups (PG) specified hereafter. Assignment of single, or
   multiple, peripheral device addresses or system events and controls to Point Groups
   shall be adjustable, or programmable. Provide Point-Group identification by use of
   slide-in typewritten labels placed adjacent to corresponding LED lamp.

B. LED lamp and corresponding labels shall be readily visible when FACP enclosure door is
   closed and locked.

C. Point Groups shall have assigned identifications PG1, PG2, and the like.

D. Provide initial programming and Point-Group assignments as follows:
   1. PG 1: Pull Stations—First Floor.
   2. PG 2: Pull Stations—Second Floor.
   3. PG 3: Pull Stations—Third Floor.
   4. PG 4: Pull Stations—Fourth Floor.
   5. PG 5: Pull Stations—Attic Floor.
2.16 FIRE ALARM ANNUNCIATOR PANELS (FAAPs)

A. Provide Fire Alarm Annunciator Panels with integral membrane style, tactile push-button control switches for the control of system functions, and LEDs with programmable (software-controlled) flash rates and slide-in labels for annunciation of system events.

B. Provide each FAAP with integral annunciator with features and capabilities specified in paragraph ANNUNCIATORS.

C. The FAAPs shall provide:
   1. Point-Group alarm, trouble, or supervisory signal annunciation for each Point-Group specified for corresponding Local Control and Display Annunciators (LCDAs).
   2. Individual Point Group and device disable shall equal Point Group and device disable specified for LCDAs.

2.17 REMOTE FIRE ALARM ANNUNCIATOR PANELS

A. Provide remote FAAPs with integral membrane style, tactile push-button control switches for the control of system functions, and LEDs with programmable (software-controlled) flash rates and slide-in labels for annunciation of system events.

B. Provide each remote FAAP with integral annunciator feature and capabilities in paragraph ANNUNCIATORS.
2.18 VOICE EVACUATION

A. Provide emergency communication systems including central voice message announcement system components complete with microphones, pre-amplifiers, amplifiers, and tone generators. Features and components shall include:

1. Dual channel type to permit simultaneous paging to selected speaker zones while fire alarm evacuation signal is being transmitted to other speaker zones.
2. The fire alarm evacuation signal shall be an alarm tone or pre-recorded message as required by the Fire Department. Failure of the primary tone generator shall result in a trouble signal and automatic switchover to a backup tone generator.

3. Amplifiers: Integral with the FACP, listed per UL 1711, 25 volt RMS output, frequency response 120 Hz to 12,000 Hz. For each voice evacuation, provide quantity of amplifiers adequate for speaker wattage connected plus 20%, plus one additional amplifier.

4. Two, minimum, message announcement channels and greater quantity as shown. System shall permit simultaneous transmission of different announcements to different zones or floors automatically or by use of the central control microphone. All announcements shall be made using dedicated, supervised communication lines.

5. Speakers:
   a. Multi-watt tap setting unless otherwise shown. Lettering “FIRE”. Provide complete with line matching transformer, back box, housing, and labeled terminations.
   b. Wall-mounted lettering “FIRE” oriented top-to-bottom, or left-to-right. Suitable for use on specified amplifier output.
   c. Rooms and spaces with average ambient sound pressure level greater than 85 dB: tap setting 8 watts maximum.
   d. Wall Mounting: Flush, unless otherwise noted.
   e. Ceiling Mounting: Flush, unless otherwise noted.

   a. The audio alert signal shall be announced for a maximum of three seconds followed by an automatic announcement of a prerecorded digital voice message. At the end of the voice message, the audio alert tone shall resume. The audio alert tone and digital voice message shall be announced alternately until the SILENCE switch has been operated.
   b. Audio alert signal tone shall be BEEP a 500 Hz tone with a time duration of 0.7 seconds on and 0.7 seconds off unless otherwise directed.
   c. Unless otherwise directed, prerecorded digital voice message shall be standard evacuation message substantially as follows:
      "Attention...Attention...Attention. An emergency has been reported. All occupants walk to the nearest stairway exit and walk down to your assigned reentry floor or main lobby. Do not use the elevator. WALK to the nearest stairway. Do not use the elevator. WALK to the nearest..."
stairway."

d. Operation of audible circuits shall be configured and controlled by the system software so that any future changes can be programmed by authorized personnel without any component rewiring or hardware revisions.

   a. The system shall support and provide live voice announcement. Upon activation of any speaker manual control switch, the audio alert tone shall be sounded over all speakers in that group.
   b. If any speaker manual control switch is activated, the operator shall be able to make announcements via the press-to-talk button on the voice announcement microphone over the preselected speakers. When the microphone button is released, the audio alert tone shall resume.
   c. Provide "All speaker circuits" master switch which shall activate all speaker circuits and provide same operation as specified for activation of any speaker manual control switch.

8. Alarm Silencing. Provide silence button or switch which upon activation will cause audible alarm signals to cease operation.

9. System Reset. The System Reset button shall be used to return the system to its normal state after an alarm condition has been eliminated.

2.19 GRAPHIC MAP

A. Silk-screened image on white polycarbonate background with clear acrylic cover. Provide wood frame to match wood type and color found throughout rest of building subject to owner's approval prior to installation. Door shall be hinged with concealed hinges. Provide lock keyed per owner direction.

B. Indicate the building floor plan for each building floor including basement and attic and provide a "You Are Here" designation. Floor plan lines are ¼” wide black, room designation letters are ¼ inch high black, and addressable fire alarm point location letters are ¼ inch high red.

C. Indicated location of all electrical distribution equipment on building floor plan, including but not limited to, switchboard and main disconnect switch, panelboards, and central battery inverter. Include location of sprinkler control valves, fire department connection, and fire water entry.

2.20 FIRE ALARM TERMINAL CABINET (FATC)

A. Steel enclosure in standard finish, hinged locking door, fire retardant plywood backboard, and coded terminal blocks.

B. Provide appropriate permanent identification labeling of control and indicating functions.
2.21 FIREFIGHTER’S TELEPHONE SYSTEM

A. Solid state, microprocessor based, modular design, fully supervised. Steel enclosure in standard finish, with hinged, locking door. Integral power supply, standby batteries, and battery charger. Wall mount in FCC.

B. Two way voice communication between the FCC and firefighter’s phone jacks and emergency telephones. Selective zone paging to all or any combination of telephone zones. Sound powered type systems are not permitted.

C. Each telephone zone shall have a manual selection switch, red LED to indicate active zone, and yellow LED to indicate zone trouble.

D. Acknowledge switch, system trouble, reset, and lamp test switch.

E. Red telephone handset.

F. Auxiliary Devices:
   1. Firefighter’s phone jack: Recessed wall mounted telephone jack, stainless steel faceplate engraved FIRE EMERGENCY PHONE.
   2. Emergency telephone: Recessed wall mounted cabinet, hinged locking door engraved LOCAL FIRE EMERGENCY PHONE, permanent handset with armored cable, and break rod glass.
   3. Telephone handset cabinet: Surface mount cabinet in FCC. Provide plug in type phones with coil cord and jack, quantity as required by the Fire Department.

2.22 FIREFIGHTER’S FAN AND DAMPER CONTROL PANEL (FFDCP)

A. Provide an FCIP for manual control and override of automatic control of smoke control systems. The FCIP shall graphically depict the building arrangement and smoke control system zones served by the systems. The status of each smoke control zone shall be indicated by lamps and appropriate legends.

B. Fans, major ducts and dampers within the building that are portions of the smoke control systems shall be shown on the FCIP and shall be shown connected to their respective ducts with a clear indication of air flow. For purposes of smoke control, the FCIP response time shall be the same for automatic or manual smoke control action initiated from any other building control point.

C. Provide override control and status indication of the following smoke control systems:
   1. Stairwell pressurization fan systems
   2. Elevator Shaft pressurization fan systems
   3. Smoke exhaust systems:
   4. Damper Systems:

D. Two-position switch for unlocking stairwell door electric locking devices: NORMAL-UNLOCK.
E. Two-position switch for unlocking interior door electric locking devices: NORMAL-UNLOCK.

F. LED test button.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide all fire alarm wiring in raceways unless otherwise specified and approved. See Division 260533 for additional raceway requirements.
   1. Use galvanized rigid steel or intermediate metal conduit where subject to mechanical damage, installed in concrete floors and walls, installed exposed to weather, or installed 7 feet or less above floor. Electrical metallic tubing may be used elsewhere, when connecting electrical equipment 2 feet or less apart, and when entering top of electrical equipment 5 feet minimum above floor.
   2. Comply with NEC for proper raceway fill requirements.
   3. Multiplex wiring may be “T-Tapped” only with prior written permission of Owner and when such does not violate fire alarm equipment manufacturer’s recommendations and style of wiring and separation requirements specified.
   4. Wiring for the FADS shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting, power, or other systems.
   5. Visible notification appliance circuit conductors are not permitted to be installed in a raceway in common with other circuit conductors unless placing such circuit conductors with other circuit conductors in a common raceway is shown (by submitting FACP manufacturer’s printed literature) to not violate FACP manufacturer’s recommendations.
   6. Audible notification appliance circuit conductors are not permitted to be installed in a raceway in common with other circuit conductors unless placing such circuit conductors with other circuit conductors in a common raceway is shown (by submitting FACP manufacturer’s printed literature) to not violate FACP manufacturer’s recommendations.

B. Raceways shall be concealed in all areas except as listed below, unless otherwise noted:
   1. Mechanical equipment rooms and electrical equipment rooms.
   2. Connections to surface mounted electrical cabinets or enclosures.
   3. When new raceways are routed parallel and adjacent to existing exposed utilities, such as raceways, ductwork and piping. The underside (i.e., bottom) of raceways and the underside of associated raceway supports shall not be lower than the underside of existing exposed utilities.
   4. As otherwise noted.

C. General Fire Alarm Circuit Conductor Requirements.
   1. Annunciator and Notification Appliance Circuits: Provide in accordance with FACP manufacturer’s written recommendations. #14 AWG copper, minimum, solid conductor, not stranded.
2. Conduit shall be 1/2 inch, minimum, for all horizontal floor/device runs. All risers/distribution conduits shall be a 3/4 inch minimum to junction boxes.

3. Do not pull wires through conduits with live circuits.

D. Fire Alarm Circuit Conductor Terminations.
   1. Conductors in control panels and annunciator panels shall be landed on numbered terminal strips with one conductor per screw terminal. Arrange wiring neatly using clips and harnesses as required. Identify conductors and the terminal landed upon per Section IDENTIFICATION. Include wiring diagram on inside cover of panels and in operation and maintenance manuals.
   2. Provide junction and splice boxes with numbered terminal strips with all wires numbered and landed on corresponding terminal strip (one conductor per terminal strip terminal). Twist-on type connectors not permitted. Include wiring diagram on inside cover of boxes and in operation and maintenance manuals.

E. Provide 120 VAC dedicated circuits for primary power supply to each FACP. Provide one FACP maximum per dedicated circuit. Provide dedicated circuit disconnecting devices with mechanism for locking in ON position and identified “FIRE ALARM CIRCUIT” and identified with red color.

F. Provide one 1/2 inch conduit with four, minimum, #14 AWG wires for a signal connection to the elevator controller, 1 set of wires for primary floor, 1 set for alternate floor. Extend wire and conduit to elevator control panel and label wires. Coordinate installation with elevator contractor/supplier and Owner.
G. Color coding and American wire gage (AWG) sizes for fire alarm and detection system shall be as follows, unless otherwise shown or specified. For existing buildings, determine the existing Circuit Type wiring colors by inspecting several typical component wire terminations for each Circuit Type. Match existing wire colors if they differ from the following. Provide all wire new, solid copper unless otherwise noted.

<table>
<thead>
<tr>
<th>Circuit Type</th>
<th>Colors</th>
<th>Size (AWG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiating Device Circuits</td>
<td>Red+ \ Black-</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Supervisory-Signal Initiating Device</td>
<td>Red+ \ Black-</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Signaling Line Circuits</td>
<td>Red+ \ Black-</td>
<td>18 twisted shielded</td>
</tr>
<tr>
<td>Communications lines</td>
<td>White/Red+ \ Black-</td>
<td>18 twisted shielded</td>
</tr>
<tr>
<td>Audio Risers (panel to floor terminal cabinet / or floor-to-floor riser)</td>
<td>Red+ \ Black-</td>
<td>12 twisted shielded</td>
</tr>
<tr>
<td>Notification Appliances:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horns</td>
<td>Yellow+ \ Brown-</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Strobes</td>
<td>Yellow+ \ Brown-</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Speakers (floor wiring, riser-to-device)</td>
<td>Red+ \ Black-</td>
<td>14 twisted shielded</td>
</tr>
<tr>
<td>Annunciators; Communications</td>
<td>White/Red+ \ Black-</td>
<td>18 twisted shielded</td>
</tr>
<tr>
<td>24 VDC power or 120 V for door holders from FACP</td>
<td>White+ \ Black-</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Door Holders (24 VDC) and Auxiliary</td>
<td>Blue+ \ White-</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Remote Test Switches</td>
<td>White\White</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Remote Lights</td>
<td>Red+ \ Black-</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Fan Controls</td>
<td>Gray (NC) \ Pink (NO) \ Orange (Common)</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Damper Controls</td>
<td>same as fans</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Remote Fire Fighter’s Reset</td>
<td>Blue\Blue</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Remote Fire Fighter’s Signal Silence</td>
<td>White\White</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Remote Fire Fighter’s Trouble Light</td>
<td>Yellow</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Remote Fire Fighter’s Alarm Light</td>
<td>Red</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Remote Fire Fighter’s Lamp Common</td>
<td>Black</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Dorado Alarm</td>
<td>Blue and Black</td>
<td>14 THHN twisted</td>
</tr>
<tr>
<td>Dorado Trouble</td>
<td>Purple and Yellow</td>
<td>14 THHN twisted</td>
</tr>
<tr>
<td>Elevator Recall Primary</td>
<td>Purple\Purple</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Elevator Recall Alternate</td>
<td>Silver\Silver</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Shunt Trip</td>
<td>White\Black</td>
<td>14 THHN</td>
</tr>
</tbody>
</table>
H. In accordance with NFPA, detectors shall not be installed until all dirt and dust creating construction activities are complete unless otherwise specified or as shown.

I. Provide detectors installed in accordance with NFPA 72 and detector manufacturer’s recommendations. Detectors shall be at least 12 inches from any part of any lighting fixture. Locate detectors at least 3 feet from diffusers of air handling systems. Provide each detector complete with appropriate mounting hardware as required by its mounting location. Detectors which mount in free space shall be mounted directly to the end of the stubbed down rigid conduit drop. Conduit drops shall be firmly secured to minimize detector sway. Where length of conduit drop from support to detector exceeds 3 feet, provide sway bracing.

J. Audible, visible, and combination audible and visible notification appliance spacing shall be in compliance with ADA requirements.

K. Audible Notification Appliances. Provide as shown. Unless otherwise noted or shown:
   1. Audible NA shall produce a sound that exceeds the prevailing equivalent sound level in the room or space by at least 15 dbA or exceeds any maximum sound level with a duration of 60 seconds by 5 dbA, whichever is louder. Locate audible notification appliances such that they will be audible in all parts of the buildings.
   2. Sound levels generated by audible NA for alarm signals shall not exceed 120 dbA at the minimum hearing distance.
   3. Where ceiling heights allow, wall-mounted audible NA shall have their tops above the finished floors at heights not less than 90 inches and below the finished ceilings of not less than 6 inches.
   4. Where combination audible and visible NA are installed, the location of the installed appliance shall be determined by the requirements specified for visible NA.
   5. The average ambient sound level used for determining placement and quantities and ratings of audible NA shall not be less than average ambient sound levels shown and the following:
<table>
<thead>
<tr>
<th>Location</th>
<th>Average Ambient Sound Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business occupancies</td>
<td>55 dbA</td>
</tr>
<tr>
<td>Educational occupancies</td>
<td>45 dbA</td>
</tr>
<tr>
<td>Industrial occupancies</td>
<td>80 dbA</td>
</tr>
<tr>
<td>Places of assembly</td>
<td>55 dbA</td>
</tr>
<tr>
<td>Storage occupancies</td>
<td>30 dbA</td>
</tr>
<tr>
<td>Mechanical equipment rooms and similar spaces</td>
<td>85 dbA</td>
</tr>
<tr>
<td>Institutional occupancies</td>
<td>50 dbA</td>
</tr>
<tr>
<td>Mercantile occupancies</td>
<td>40 dbA</td>
</tr>
<tr>
<td>Piers and water-surrounded structures</td>
<td>40 dbA</td>
</tr>
<tr>
<td>Residential occupancies</td>
<td>35 dbA</td>
</tr>
<tr>
<td>Thoroughfares, high density urban</td>
<td>70 dbA</td>
</tr>
<tr>
<td>Thoroughfares, medium density urban</td>
<td>55 dbA</td>
</tr>
<tr>
<td>Thoroughfares, rural and suburban</td>
<td>40 dbA</td>
</tr>
<tr>
<td>Tower occupancies</td>
<td>40 dbA</td>
</tr>
<tr>
<td>Underground structures and windowless buildings</td>
<td>35 dbA</td>
</tr>
<tr>
<td>Vehicles and vessels</td>
<td>40 dbA</td>
</tr>
</tbody>
</table>

L. Visible Notification Appliances. Provide as shown. Unless otherwise noted or shown:
   1. Visible NA shall be provided with candela ratings, and shall be so located such that the visible NA provides effective illuminance equal or greater than 0.0375 lumens per square foot at every point in the room.
   2. Wall-mounted visible NA shall be mounted such that the entire lens is not less than 80 inches and not greater than 96 inches above the highest finished floor level within the space.
   3. Visible NA in corridors shall be located no more than 15 feet from each end of the corridor.

M. Separation of Circuits. Provide separation of fire alarm circuits and data transmission media (DTM) as follows:
   1. All Styles of Class A and all fault-tolerant circuits which use physical conductors (e.g., metallic, optical fibers) shall be provided such that the outgoing and return conductors, exiting from and returning to the equipment item (e.g., FACP), respectively, are routed separately. The outgoing and return Class A and fault-tolerant physical circuit conductors shall not be run in the same cable assembly (i.e., multiconductor cable), enclosure, or raceway unless identified as an Exception below.
      a. Exception No. 1: For a distance not to exceed 10 feet where the outgoing and return conductors enter or exit the initiating device, notification appliance, or FACP enclosures.
      b. Exception No. 2: Where the vertically run conductors are contained in a 2-hour rated cable assembly or enclosed (installed) in a 2-hour rated enclosure.
c. Exception No. 3: Where looped conduit and raceway systems are provided, single conduit and raceway drops to individual equipment items, such as initiating devices, notification appliances, or FACP enclosures, shall be permitted.

d. Exception No. 4: Where looped conduit and raceway systems are provided, single conduit and raceway drops to multiple devices or appliances installed within a single room not exceeding 1000 square feet area shall be permitted.

2. For Class A circuits interior to buildings, provide separated conduits with one Class A or fault-tolerant cable in each conduit. When circuits route vertically, provide a minimum of 12 inches separation between conduits which contain corresponding Class A or fault-tolerant cables. When circuits route horizontally, provide a minimum of 48 inches separation between conduits which contain corresponding Class A or fault-tolerant cables.

3.02 FIELD QUALITY CONTROL

A. Perform all wiring by experienced personnel under supervision of manufacturer’s representative. The fire alarm equipment supplier shall make a thorough inspection and test of the completed fire alarm system prior to final acceptance testing and prior to interconnection to the fire signal receiving facility.

B. Installation Documentation for Final Acceptance.

1. Operating and maintenance (O&M) manuals and as-built record drawing sets shall be furnished as specified herein. For each building fire alarm and detection system, provide two O&M manuals and three sets of drawings. One copy of drawings shall be encased in envelope and placed interior to each FACP. All other copies shall be delivered with the final indexed copies of approved shop drawings and catalog data in a hardback cover 3-ring binder which is clearly labeled to designate the building for which it is intended. Manuals shall be as approved. Submit the working field set with workman’s notes. All technical information shall include the manufacturers logos. Include terminal strip wiring diagrams for each junction box.

2. As-built Drawings.
   a. Contractor shall prepare corrected AutoCAD computer files to indicate As-built record conditions. Provide complete, reproducible original drawing size as-built plans. Include four sets of drawings and AutoCAD disks showing conduit routing and number of conductors per conduit. Show all devices including known future devices and indicate as such.
   b. As-built point-to-point wiring depicting every device, complete with room numbers. Revised schematic, wiring, and interconnection diagrams of all circuits, internal and external, for all equipment installed and exact locations for all devices. Provide manufacturer’s technical information drawings. These schematics shall include the conductor color coding and terminal number identification system, location of all terminal boxes complete with numbering and each device address.
c. Complete, as-installed, riser diagrams indicating the wiring sequence of all alarm initiating devices, supervisory devices, and all signaling appliances on all signaling circuits.

d. A complete description of the system operation, including a schedule of relay abbreviations used on the drawings, list of relay functions, and the sequence of relay operation during supervisory, trouble, and alarm conditions.

e. Complete wiring and control diagrams for control and shut down of circuits for fan systems.

f. Completed certificate of compliance and testing.

g. The Owner’s representative will walk through the building and spot check 5 to 10% of all device locations against the as-builts. If all devices are not accurately shown, the drawings shall be rejected. Prepare corrected drawings and resubmit. Upon resubmittal, another spot check will be done. If deficiencies are still found, an independent audit of the system by the system manufacturer will be required. The cost of the audit, labor, materials, and management costs incurred by the Owner, shall be reimbursed by Contractor to Owner.

3. Parts Lists. Include recommended spare parts list with the as-built drawings, including:
   a. Complete parts catalog of installed parts (include quantities).
   b. Complete parts price list.
   c. Recommended spare parts list.

3.03 SYSTEM TESTING

A. Preliminary Tests. Perform a complete system check with the manufacturer’s technician present. This testing shall be completed without the involvement of the Owner and prior to scheduling the Acceptance Test. This testing shall include setting every detector into alarm individually, operating each pull station, operating all audible and visible notification appliance systems, operating all functions in the FACP, demonstrating operating sequences function properly, and the like. The purpose of this test is to ensure that all system components, functions, and sequences are functioning properly prior to the Acceptance Test. The Preliminary Test written report shall document what was tested, the testing procedures used, and all detector sensitivities. Submit this test documentation and a completed Inspection and Testing Form from NFPA 72, Chapter 10, Figure 10.6.2.3, for review prior to scheduling the Acceptance Test.

1. The Contractor and a manufacturer’s technician shall demonstrate to the Owner’s representative that the FADS is in full operational status. This demonstration shall include testing 100% of the devices and systems and functions. Acceptance test will be witnessed by Owner’s representative. Provide all test equipment necessary to set the detectors into an alarm condition. Record all test results. For each building and each protected premises, prepare and submit a separate Fire Alarm System Record of Completion per NFPA 72 Section 4.5.2 and Section 10.6. In cases where a FADS is modified, a Reacceptance Test, as specified, may be substituted for Acceptance Test.
2. Acceptance Test and Certification. Provide satisfactory Acceptance Test in presence of Authority Having Jurisdiction (AHJ), provide Certification, and provide instructions to comply with the 2003 International Fire Code (IFC) Sections 106 and 107.

B. Reacceptance Test. For existing FADS, after any modification, repair, or adjustment of system hardware or wiring; or after any change to software, perform Reacceptance Testing in accordance with NFPA 72 Section 10.4.1.2 minimum, and as specified. All components, circuits, systems operations, or site-specific software functions known to be affected by the change, or identified by a means that indicates the system operational changes, shall be 100 percent tested. In addition, 10 percent, minimum, of initiating devices that are not directly affected by the change, and greater quantity as directed, shall also be tested and proper system operation verified. Prepare a dated, revised Fire Alarm System Record of Completion in accordance with NFPA 72 Section 4.5.2.2 to document and record all changes.

C. Provide testing in accordance with NFPA 72. Test methods shall be in accordance with NFPA 72, Section 10.4.2 and Table 10.4.2.2. The recommended tests in NFPA 72 are mandatory and shall verify that all previous deficiencies have been corrected. The tests shall additionally include the following although not stated in NFPA 72, minimum:
   1. Test of each function of the FACP.
   2. Test of each circuit in both trouble and normal modes.
   3. Tests of alarm initiating devices in both normal and trouble conditions.
   4. Tests of each control circuit and device.
   5. Tests of each alarm notification appliance.
   6. Tests of the battery chargers and batteries.
   7. Complete operational tests under secondary power supply.
   8. Visual inspection of all wiring connections.
   9. Opening the circuit at each alarm initiating device and notification appliance to test the wiring supervisory feature.
   10. Ground fault.
   11. Short circuit faults.
   12. Stray voltage.
   13. Loop resistance.

D. Failure to comply with all contractual obligations resulting in costs incurred by Owner shall result in those costs being transferred to the Contractor for payment.

E. Contractor shall be financially responsible and shall reimburse Owner for all fees assessed to Owner by responding Fire Department due to false alarms that occur between the Notice To Proceed and the date of Notice of Acceptance.

3.04 SPARE PARTS

A. Furnish spare part types and quantities as specified and shown for each building and each FACP.

B. Furnish two spare fuses of each type and size required and five spare lamps and LEDs of each type. Fuses and lamps shall be mounted in the fire alarm panel.
C. Furnish two percent of the total number of each different type of detector, but no less than two each.

D. Furnish special tools necessary for the maintenance of the equipment.

3.05 TRAINING

A. Provide a training course for the facility operations and maintenance staff. The course shall be conducted in the building where the system is installed or as directed. The training shall start after the system is functionally completed but prior to final acceptance tests. The instructions shall cover all of the items contained in the operating and maintenance instructions. Instruction shall include all normal maintenance and trouble-shooting procedures down to circuit board level of equipment.

B. Duration of training shall be as follows:
   1. 8 hours, minimum, per new system.
   2. 1 to 4 hours as required for remodeled system.

C. Provide complete factory training (component and programming) for one technician. Include transportation, lodging, and 1 meal per day of training.

3.06 IDENTIFICATION

A. Paint all FADS junction and outlet boxes red. Provide identification on box cover plates with lettering “FIRE ALARM” in one inch white block letters on red background.

B. Identify conduits enclosing fire alarm conductors at 50 foot intervals for both exposed locations and in accessible ceiling locations. Provide lettering similar to box cover plates.

3.07 ENCLOSURES

A. Provide FACP and component enclosures suitable for the location installed and rated as shown. Enclosures shall be rated, weatherproof, minimum, when located exterior.

B. Mount FACP with top of enclosure 72 inches maximum above finished floor unless other height is shown.
C. Abbreviations:

1. The following abbreviations shall be used on all programming and descriptive labels.

   **Directions:**
   - N - North
   - S - South
   - E - East
   - W - West

   **Floor Designation:**
   Floor abbreviations are to be consistent with building method of floor designation.
   - FLR - Floor
   - SUB-B - Subbasement
   - BSMT - Basement
   - GRD - Ground
   - MEZZ - Mezzanine
   - FLR1 - Floor one
   - FLR2 - Floor two, etc.
   - LVL00 - Level 00 or subbasement
   - LVL1 - Level one
   - LVL2 - Level two, etc.

   **Sprinkler Systems:**
   - TS - Tamper Switch
   - WFS - Water Flow Switch
   - APS - Alarm Pressure Switch (water flow)
   - LOWAIR - Low Air Pressure Switch
   - LT - Low Temperature
   - PA - Preaction Sprinkler System
   - DRY - Dry Pipe Sprinkler System
   - SOLENOID - no abbreviation
   - WATER FLOW BELL - no abbreviation

   **General:**
   - CORR - Corridor
   - ELEV - Elevator
   - RM - Room
   - STAIR - Stairway
   - MACH - Machine
   - MECH - Mechanical
   - HIGHVOLT - High Voltage Room
D. Address Labeling:

1. General Procedures.
   a. Include address identifier, e.g., M4-10.
   b. Locations within buildings shall be readily distinguishable to emergency response personnel. Wings or areas of buildings shall be identified by direction, e.g., N, S, or SW.
   c. Even if there is room available to indicate a more descriptive label, standardized abbreviations shall be used to maintain consistency.
   d. Specific devices do not need to be indicated if "Point Type" is normally indicated in a separate line on the readout. Exception to this is water flow switches and all sprinkler supervisory devices, e.g., tamper switches and low air pressure switches.
   e. Fire alarm shop drawings shall include device addresses as they will be shown in the fire alarm control panel.
   f. Originally submitted addresses shall be as close as possible to the actual installation and shall be based on the above guidelines.
   g. Owner personnel will review submitted addresses. Minor changes will be indicated in review report. However, if considerable revision is required, the submittal will be returned to the Contractor for complete revision.
   h. Field revision shall be maintained to an absolute minimum and is to be reviewed and accepted in writing by Owner personnel.

   a. Primary information to be indicated is area of sprinkler control, e.g., FLR1 or SUB-B N END.
   b. Secondary information is to indicate system type, e.g., preaction (PA) or dry system (DRY).
   c. Additional information includes location of device itself. Examples:
      1) M2-45 FLR2 E WING RM 256 WFS, i.e., floor two east wing, room 256, water flow.
      2) M1-23 BSMT HIGHVOLT PA 2B-23 APS, i.e., basement high voltage room preaction, room 2B-23, alarm pressure switch (water flow).
      3) M5-10 SUB-B WFS W CORR, i.e., subbasement water flow switch with the device located in the west corridor.

3. Tamper Switches.
   a. Primary information to be indicated is location of device, e.g., RM 367.
      1) M7-42 FLR1 W WING RM 109 TS, i.e., floor one, west wing room 109, tamper switch.
      2) M1-15 BSMT W CORR TS, i.e., basement, west corridor, tamper switch.
4. Spot Type Device.
   a. Primary information to be indicated is location of devices, e.g., CORR CR3-45 E END. Example:
      1) M2-12 RM 1-45, i.e., detector in room 1-45.

END OF SECTION
SECTION 28 32 00

2-WAY COMMUNICATION SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Furnish, install, and wire all equipment associated with the installation of a 2-Way Communication System to comply with ADA requirements. This work shall include, but not be limited to, a main annunciator panel, remote call stations, normal and standby power supplies, outlet boxes, cables and wiring as shown on the drawings and as specified herein.

1.02 SUBMITTALS

A. General: Data sheets on all equipment being provided as well as cable types. Internal control cabinet drawings showing internal block diagram connections shall be provided. Wiring diagrams showing typical field wiring connections as well as single line floor plan indicating equipment locations as well as cable routings and quantities.

B. Product Data: Submit product data, including manufacturer’s (Spec-Data) product sheets, for specified products.

C. Shop Drawings: Submit shop drawings showing layout, profiles and product components, including anchorage and accessories. Include cabling diagrams, wiring diagrams, station installation details, and equipment cabinet details.

D. Quality Assurance Submittals: Submit the following:
   1. Test Reports: Certified test reports showing compliance with specified performance characteristics.
   2. Manufacturer’s Instructions: Manufacturer’s installation instructions.
   3. Manufacturer’s Field Reports: Manufacturer’s field reports specified herein.

E. Closeout Submittals: Submit the following:
   1. Operation and Maintenance Data: Operation and maintenance data for installed products in accordance with Division 1 Closeout Submittals (Maintenance Data and Operation Data) Section. Include methods for maintaining installed products and precautions against cleaning materials and methods detrimental to finishes and performance. Include troubleshooting guide, wiring terminal identification and equipment parts list.
   2. Warranty: Warranty documents specified herein.

F. Project Closeout
   1. A one-year maintenance contract offering continued factory authorized service of this system shall be provided as part of this contract. Built drawings that include changes to wiring, wiring designations, junction box labeling and other pertinent information shall be supplied upon completion of the project.
2. The contractor shall furnish manufacturer’s manuals of the completed system including individual specifications sheets, schematics, inter-panel and intra-panel wiring diagrams.
   a. All information necessary for the proper maintenance and operation of the system must be included.
   b. Provide four copies.

3. As built drawings that include changes to wiring, wiring designations, junction box labeling, and other pertinent information shall be supplied upon completion of the project.

4. Provide a minimum of two (2) hours of in-service training with the system.
   a. These sessions shall be broken into segments that will facilitate the training of the system users in operating station equipment.
   b. Operating manuals and user’s guides shall be provided at the time of training.

1.03 WARRANTY

A. Project Warranty: Refer to Conditions of the Contract for project warranty provisions.

B. Manufacturer’s Warranty: Submit, for Owner’s acceptance, manufacturer’s standard warranty document executed by authorized company official. Manufacturer’s warranty is in addition to, and not a limitation of, other rights Owner may have under Contract Documents.
   1. Warranty Period: 1 years commencing on the Date of Substantial Completion.
   2. All materials and installation shall be guaranteed to be free of defects in material and workmanship for one year after final acceptance of installation and tests.

1.04 INSTALLATION STANDARDS

A. The system shall be installed in accordance with NEC and ADA requirements.

B. The completed system shall be in compliance with state and local electrical codes including city of Pueblo IFC Amendments (IFCA).

C. All wiring shall test free from grounds and shorts.

1.05 SYSTEM OPERATIONS

A. Furnish, install and place into operation a 2-Way Communication System for this building as indicated on the drawings and as specified herein.

B. A common annunciator shall be provided at the main building entrance where shown on the drawings to indicate light and tone signals from multiple remote call stations.
   1. When the call station switch is activated, a red LED button illuminates and a one shot tone sounds.
   2. When the alarm signal is acknowledged, the remote call station is signaled with a flashing light and tone.
3. Voice communication with the remote call can then be initiated from the annunciator.

PART 2 PRODUCTS

2.01 2-WAY COMMUNICATION SYSTEM EQUIPMENT

A. Manufacturer: Cornell Communications, Inc.

2.02 PRODUCT SUBSTITUTIONS

A. Substitutions: Housing Devices Inc. No other substitutions permitted.

2.03 CORNELL 4200 RESCUE ASSISTANCE-AUDIO/VISUAL SYSTEM AND COMPONENTS

A. Equipment
   1. This system shall consist of multiple remote call stations, which will share a common annunciator panel.

B. Annunciator
   1. The annunciator panel shall be a CORNELL Model A4208, with capacity for (8) zones, surface mounted at the Main Fire Department Entrance to the building.
      a. Verify location with the Local Fire Marshal and the Architect.
   2. An alternate action switch with internal LED indicator shall be included for each zone.
      a. A yellow LED light on the zone switch shall illuminate and the alarm shall emit a repeating sound if the supervised wiring is faulted.
   3. An audible alarm shall be mounted on the annunciator panel, which will emit a minimum sound level of 90 db at 30 cm when a remote station calls.
      a. Depressing the zone switch will answer a zone and open the intercom line to the zone.
   4. The front panel shall have silk-screened zone designations and operating directions as well as zone designation strips.
   5. The power supply shall be a 120 volt emergency battery backup, CORNELL model B-5243A or P-512243A.
      a. Provide batteries and regulated battery charging means with automatic transfer to battery power source upon loss of normal power input voltage.
      b. Provide battery enclosure with contained batteries.
      c. Provide battery capacity adequate for 4.0 hours of full-load operation without requiring recharge per IFCA 1007.6.3.
      d. Provide durable label on each battery case listing date of battery manufacture.
C. Remote Call Stations:
1. The remote call station shall be CORNELL Model 4201B, with one momentary switch with LED and loudspeaker.
2. The station shall have hands free voice communication with the annunciator.
3. The station shall have silk-screened operating instructions.
4. The station shall be flush wall mounted on a 2-gang stainless steel plate with a 48" maximum mounting height for forward reach, and a 54 maximum for side reach.
5. The Vandal Proof Call Station shall be Cornell Model 4201/V. The standard two gang mounting plate can be flush mounted or wall mounted and incorporate heavy duty switches and speakers along with stainless steel plates and tamper-proof screws. The 4201/V shall contain water resistant switch and speaker for exterior applications.

2.04 SOURCE QUALITY
A. Source Quality: Obtain 2-Way Communication System equipment and system from a single manufacturer.

PART 3 EXECUTION

3.01 MANUFACTURER’S INSTRUCTIONS
A. Compliance: Comply with manufacturer’s product data, including product technical bulletins, product catalog installation instructions, and product carton instructions for installation.

3.02 EXAMINATION
A. Site Verification of Conditions: Verify substrate conditions, which have been previously installed under other sections, are acceptable for product installation in accordance with manufacturer’s instructions.

3.03 INSTALLATION
A. Cabling Requirements
1. Wiring from the annunciator to the call station shall be 22-gauge, 2 conductor shielded audio pair + 3 conductor unshielded.
2. Wiring from the annunciator to the power supply shall be 18-gauge, 2 conductor.
3. Verify cable types with the 2-Way Communication System Manufacturer.
B. 2-Way Communication System Installation
1. Complete system shall be installed in strict accordance with manufacturer’s recommendations.
2. Wiring shall be installed in raceways throughout the building.
   a. Conduit shall be 1/2" minimum.
3.04 FIELD QUALITY REQUIREMENTS

A. Site Tests (Post Installation Testing): Checkout final connections to the system shall be made by a factory technician authorized by the manufacturer of the products installed.
   1. Factory authorized technicians shall demonstrate operation of the complete system and each major component to the staff.

B. System field wiring diagrams shall be provided by the factory to prior to construction.

C. Inspection: Perform a complete functional test of the system upon completion of the installation and instruct the staff in the operation and maintenance of the system.

3.05 CLEANING

A. Cleaning: Repair or replace damaged installed products. Clean installed products in accordance with manufacturer’s instructions prior to Owner’s acceptance. Remove construction debris from project site and legally dispose of debris.

END OF SECTION
SECTION 31 10 00
SITE CLEARING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following:
   1. Protecting existing trees, shrubs, groundcovers, plants, grass, and other vegetation to remain or as designated by Owner in pre-construction conference.
   2. Removing existing trees, shrubs, groundcovers, plants, grass, and other vegetation.
   3. Clearing and grubbing.
   4. Stripping and stockpiling topsoil.
   5. Removing above and below-grade site improvements.

B. Related Sections include the following:
   1. Division 01 Section “LEED” or “Sustainable Design” requirements for product data and manufacturing documentation.
   2. Division 01 Section “Construction Waste Management and Disposal” for recycling and disposal of waste.
   3. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
   4. Division 31 Section “Temporary Erosion and Sedimentation Control” for storm water erosion and sediment mitigation.

1.02 DEFINITIONS

A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches (50 mm) in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.

B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.03 MATERIAL OWNERSHIP

A. Except for stripped topsoil or other materials indicated to be stockpiled or to remain on Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.04 SUBMITTALS

A. Photographs or videotape, sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.
B. Record drawings, identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions. Information required may also be included in Division 1 Section "Project Record Documents".

C. LEED Submittals
1. Product Data for Credit MR 4.1 and Credit MR 4.2: Include manufacturer’s product data indicating separate percentages, by weight, of post-consumer and pre-consumer recycled content for projects having recycled content. Include statement indicating material costs for products.
2. Product Data for Credit MR 5.1 and Credit MR 5.2: Indicate location of manufacturing facility including name, address and distance between manufacturing facility and the proposed site. Provide manufacturer’s documentation indicating location where the base materials were extracted, mined, quarried, harvested, etc. and the distance between this location and the project site. Also include material costs, excluding cost of installation.

1.05 QUALITY ASSURANCE

A. Preconstruction Conference: Conduct conference at Project site as directed by Owner’s Representative prior to start of construction. Contractor to comply with requirements, which may also be included in Division 01 Section "Project Management and Coordination."

1.06 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

B. Protect improvements on Owner’s property.

C. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner’s premises as directed.

D. Utility Locator Service: Notify Owner of limits of work for locates prior to site clearing.

E. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

F. Restore damaged improvements to their original condition, as acceptable to parties having jurisdiction.
PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 31 Section "Earth Moving", (PART 2 - PRODUCTS).

2.02 LEED REQUIREMENTS

A. Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity.

B. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

PART 3 - EXECUTION

3.01 PREPARATION

A. Protect and maintain benchmarks, survey control points, monuments, property line pins and other reference points from disturbance during construction. If disturbed or destroyed, restore or replace at no cost to Owner.

B. Provide erosion control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust from leaving project site.

C. Locate and clearly flag trees and vegetation to remain or to be relocated.

D. Protect existing site improvements to remain from damage during construction.
   1. Restore or replace damaged improvements to their original condition, as acceptable to Owner.

E. Provide temporary erosion and sedimentation control measures in accordance with Division 31 Section "Temporary Erosion and Sedimentation Control" to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation control drawings and requirements of authorities having jurisdiction.

3.02 TREE PROTECTION

A. Erect and maintain temporary fencing around drip line of individual trees or around perimeter drip line of groups of trees to remain before starting site clearing. Remove fence when construction is complete.
   1. Do not store construction materials, debris, or excavated material within fenced area.
   2. Do not permit vehicles, equipment, or foot traffic within fenced area.
   3. Maintain fenced area free of weeds and trash.

B. Do not excavate within tree protection zones, unless otherwise indicated.
C. Where excavation for new construction is required within drip line of trees, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
   1. Cover exposed roots with burlap and water regularly.
   2. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
   3. Coat cut faces of roots more than 1-1/2 inches (38 mm) in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
   4. Cover exposed roots with wet burlap to prevent roots from drying and backfill with soil as soon as possible.

D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Owner’s Representative.
   1. Employ a qualified arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
   2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the qualified arborist.

3.03 UTILITIES

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Owner’s Representative not less than two days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Owner’s Representative’s written permission.

3.04 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out stumps and obstructions and grubbing roots.
   1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
   3. Grind stumps and completely remove roots, obstructions, and debris extending to a depth of 18 inches (450 mm) below exposed subgrade.
   4. Use only hand methods for grubbing within drip line of remaining trees.
   5. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earth moving is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.
3.05 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered or as determined by Geotechnical Engineer in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Remove subsoil and nonsoil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
   1. Limit height of topsoil stockpiles to 72 inches (1800 mm) unless authorized by Owner's Representative.
   2. Do not stockpile topsoil within drip line of remaining trees.
   3. Dispose of excess topsoil as specified for waste material disposal.
   4. Stockpile surplus topsoil to allow for resprading a thicker layer of topsoil.

3.06 SITE IMPROVEMENTS

A. Remove existing above and below grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated on plans.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
   2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

C. Remove existing fill. Refer to Geotechnical Investigation and/or drawings for information regarding suitability for re-use and estimates of location/extent of existing fill.

3.07 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
   1. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.
   2. Maintain records of weight or volume of all recycled material.
   3. Manage construction waste in accordance with provisions of Division 01 Section "Construction Waste Management and Disposal" for recycling and disposal of waste. Submit documentation to satisfy the requirements of that section.

END OF SECTION
SECTION 31 20 00

EARTH MOVING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Additional information concerning earth moving may be found on the civil drawings, in the project geotechnical report and agency having jurisdiction construction standards. In case of conflict between the drawings, jurisdictional criteria and the information specified herein, the more stringent requirements shall govern.

B. Additional information concerning earth moving may be found in the geotechnical investigation report by CTL Thompson dated December 8, 2008. All requirements of this report shall be followed. The information shown in this report is for information and it shall be the contractors responsibility to field verify conditions indicated.

1.02 SUMMARY

A. This Section includes the following:
   1. Preparing and grading subgrades for walks, pavements, lawns and grasses, and exterior plants.
   2. Excavating and backfilling for buildings and structures including overexcavation of existing unsatisfactory on-site soil materials and replacement with structural fill.

B. Related Sections include the following:
   1. Division 01 Section “LEED” or “Sustainable Design” requirements for product data and manufacturing documentation.
   2. Division 01 Section “Construction Waste Management and Disposal” for recycling and disposal of waste.
   3. Division 31 Section “Site Clearing” site stripping, grubbing, stripping and stockpiling topsoil, and removal of above and below grade improvements and utilities.
   4. Division 31 Section “Trenching and Backfilling” for excavating and backfilling of utilities.
   5. Division 31 Section “Temporary Erosion and Sedimentation Control” for erosion and sedimentation control measures.

C. Permits and Fees: Obtain and pay for all permits and fees required for the work of this section, including erosion and sediment control and water quality permits required by the agency having jurisdiction and the Colorado Department of Public Health and Environment, Water Quality Control Division.

1.03 DEFINITIONS

A. Backfill: Soil material used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.
B. **Base Course:** Course placed between the subbase course and hot-mix asphalt paving.

C. **Bedding Course:** Course placed over the excavated subgrade in a trench before laying pipe.

D. **Borrow Soil:** Satisfactory soil imported from off-site for use as fill or backfill approved by Geotechnical Engineer.

E. **Drainage Course:** Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. **Excavation:** Removal of all material of whatever character required for the work encountered above subgrade elevations and to lines and dimensions indicated, including boulders. See Section 3.4 for definition of unclassified and classified excavation.

G. **Authorized Additional Excavation:** Excavation below subgrade elevations or beyond indicated lines and dimensions as directed or approved by Owners Representative and the testing and inspections agency to correct unsatisfactory conditions. Authorized additional excavation and replacement material will be paid for according to Contract Provisions for changes in the Work.

H. **Bulk Excavation:** Excavation more than 10 feet (3 m) in width and more than 30 feet (9 m) in length.

I. **Unauthorized Excavation:** Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Owners Representative. Unauthorized excavation including disposition of overexcavated materials and other work resulting from slides, cave-ins, swelling, upheaval, or remedial work, as well as remedial work directed by Owners Representative, shall be without additional compensation.

J. **Fill:** Fill is all material placed to raise the grade of the site or to backfill excavation, upon which the Geotechnical Engineer has made sufficient tests and observations to enable him to issue a written statement that, in his opinion, the fill has been placed and compacted in accordance with the requirements of these specifications.

K. **Structural Fill:** Select granular material for use below floor slabs and to 5'-0" beyond building lines. On-site material may be used if approved by the Geotechnical Engineer.

L. **Underslab Gravel:** Imported Class 6 road base per Colorado Department of Transportation Standard Specifications for Road and Bridge Construction (2005) or material approved by Geotechnical Engineer.
M. Rock Excavation: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. (0.76 cu. m) for Bulk Excavation or 3/4 cu. yd. (0.57 cu. m) for footing, trench, and pit excavation which in the Geotechnical Engineer’s opinion cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
   1. Excavation of Footings, Trenches, and Pits: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch (1065-mm-) wide, maximum, short-tip-radius rock bucket; rated at not less than 138-hp (103-kW) flywheel power with bucket-curling force of not less than 28,090 lbf (125 kN) and stick-crowd force of not less than 18,650 lbf (83 kN); measured according to SAE J-1179.
   2. Bulk Excavation: Late-model, track-mounted loader; rated at not less than 210-hp (157-kW) flywheel power and developing a minimum of 48,510-lbf (216-kN) breakout force with a general-purpose bare bucket; measured according to SAE J-732.

N. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

O. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

P. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

Q. Utilities: Include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.04 SUBMITTALS

A. Material Test Reports: Provided by Owner from a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
   1. Classification according to ASTM D 2487 of each on-site or borrow soil material proposed for fill and backfill.
   2. Laboratory compaction curve according to ASTM D 698 for each on-site or borrow soil material proposed for fill and backfill.

B. Preexcavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

C. LEED Submittals
   1. Product Data for Credit MR 4.1 and Credit MR 4.2: Include manufacture’s product data indicating separate percentages, by weight, of post-consumer and pre-consumer recycled content for projects having recycled content. Include statement indicating material costs for products.
2. **Product Data for Credit MR 5.1 and Credit MR 5.2:** Indicate location of manufacturing facility including name, address and distance between manufacturing facility and the proposed site. Provide manufacture's documentation indicating location where the base materials were extracted, mined, quarried, harvested, etc. and the distance between this location and the project site. Also include material costs, excluding cost of installation.

### 1.05 QUALITY ASSURANCE

**A.** Comply with applicable codes, ordinances, regulations, references and standards in effect at bid date:
3. State and local codes.

**B.** In case of conflict between the above codes, regulations, references and standards and these specifications, the more stringent requirements shall govern.

**C.** Testing Agency: The Owner will employ a qualified independent Geotechnical testing agency. Contractor shall furnish testing agency access to work, facilities and incidental labor required for testing. Notify the testing and inspection agency not less than 48 hours in advance of all work requiring testing.

**D.** Geotechnical Engineer: All materials and operations under this section of the specifications shall be executed under the supervision of a Geotechnical Engineer who will place qualified personnel on the site during earth moving operations as necessary.

The Geotechnical Engineer shall approve all foundation excavations and give written approval of the completed foundations to the Owner’s Representative at the following times:
1. When excavations are first open.
2. Just prior to placing of concrete, shall test and control the fill compaction, approve the materials and method of placing and compacting and give written approval to the Owner's Representative that all bearing surfaces and fill requirements have been inspected.
3. The Contractor shall be responsible to notify the Geotechnical Engineer when tests are to be made.

**E.** For approval of imported or on-site fill material, notify the Geotechnical Engineer at least four (4) working days in advance of intention to import material, designate the proposed borrow area and permit the Geotechnical Engineer to sample as necessary from the borrow area for the purpose of making acceptance tests to prove the quality of the material. The Geotechnical Engineer report on the acceptability shall be final and binding.

**F.** Reference Standards:


**G.** Preconstruction Conference: Conduct conference at Project site as directed by Owner’s Representative prior to start of construction. Contractor to comply with requirements, which may also be included in Division 01 Section "Project Management and Coordination."
1.06  PROJECT CONDITIONS

A. Existing Utilities: Locations, sizes and depths or invert elevations of existing utilities as shown on the drawings are based on information provided by others, and believed to be correct, but may not be absolutely so. Such information is therefore presented only as approximations, and should be verified prior to construction. Protect from damage any sewer, water, gas, electric, phone or other pipe lines or conduits uncovered during the work until they have been examined by the Owner’s Representative. If such lines are found to be abandoned and not in use, remove affected sections without extra cost. If such lines are found to be in use, carefully protect and carry on work around them. If Owner’s Representative deems it advisable to move such lines, Owner will pay cost of moving. Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Owner’s Representative and then only after arranging to provide temporary utility services according to requirements indicated.
   1. Contact utility-locator service for area where project is located before excavating.
   2. Notify Owner’s Representative not less than two (2) days in advance of proposed utility interruptions.
   3. Do not proceed with utility interruptions without Owner’s Representative’s written permission.

B. Remove all existing fill deemed by Geotechnical Engineer to be unsatisfactorily placed.

C. Existing Contours and Elevations: Contours and spot elevations of existing ground elevations at the site, and approximate elevations of finish grade cuts, fills, and excavations for the Work are shown on Drawings. Contours and elevations for existing ground lines are based on information provided by others, and are believed to be correct, but may not be absolutely so. Existing contours and elevations should therefore be considered approximate, and should be verified at the site prior to construction.

D. Verification of Existing Conditions: Visit the site prior to submission of bids. Verify existing conditions, elevations, and contours. In the event of discrepancies between existing conditions and those indicated on the Contract Documents or survey, contact the Owner’s Representative for clarification.

E. Existing Benchmarks: Carefully preserve and maintain existing benchmarks, monuments, property line pins, and other reference points. If disturbed or destroyed, restore or replace by a Professional Land Surveyor at no additional cost to Owner.

F. Frost Protection: When freezing temperatures may be expected, do not excavate to the full depth indicated unless the footing or slabs are to be poured immediately after the excavation has been completed. If placing of concrete is delayed, protect the bottoms of excavations from frost until concrete is placed.

1.07  WARRANTY

A. Settlement in backfill, fill or in structures built over backfill or fill, which may occur within the specified project warranty period, shall be corrected at no cost to the Owner. Any structures damaged by settlement shall be restored to their original condition by the Contractor, at no cost to the Owner.
PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Shall meet approval of Geotechnical Engineer and shall be free of rock or gravel larger than 3 inches (75 mm) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter. Clean, on-site, natural soils, or imported materials, as approved by the Geotechnical Engineer.

C. Unsatisfactory Soils: Soil Classification Groups GP, SP, CH, MH, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups, as identified by the Geotechnical Engineer.
   1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Backfill and Fill: Approved by Geotechnical Engineer.

E. Structural Fill: Approved by Geotechnical Engineer.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1 ½-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.

G. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.

H. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.02 GEOTEXTILES

A. Subsurface Drainage and Separation Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288. Utilize Mirafi 140N or as recommended by Geotechnical Engineer.

2.03 LEED REQUIREMENTS

A. Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity.

B. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.
PART 3 - EXECUTION

3.01 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

B. Preparation of subgrade for earth moving operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Division 31 Section "Site Clearing."

C. Protect and maintain erosion and sedimentation controls, which are specified in Division 31 Section "Temporary Erosion and Sediment Control," during earth moving operations. Provide erosion control measures to prevent erosion or displacement of soils and discharge of soil bearing water runoff or airborne dust to adjacent properties and rights-of-way.

D. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.

E. Cold Weather Work: Prevent frost from entering bearing stratus upon which construction will take place or in areas where fill will be placed in that season.

F. Provide temporary erosion and sedimentation control measures in accordance with Division 31 Section "Temporary Erosion and Sedimentation Control" to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation control drawings and requirements of authorities having jurisdiction.

3.02 DEWATERING

A. Prevent surface water and subsurface ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
   1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
   2. Install a dewatering system to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.
   3. Obtain and comply with all provisions of the Colorado Department of Public Health and Environment, Water Quality Control Division, Construction Dewatering Permit.
C. Protection of Persons and Property:
   1. Provide all necessary measures to protect workmen and passersby. Barricade open excavations occurring as part of the Work, as required by municipal or other authorities having jurisdiction.
   2. Protect adjacent streets, roadways, and properties throughout the entire operation. Protect newly graded areas from destruction by weather or runoff. Protect structures, utilities, sidewalks, pavements, and other improvements from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

3.03 EXPLOSIVES
   A. Explosives: Do not use explosives.

3.04 EXCAVATION, GENERAL
   A. Unclassified Excavation: All excavation (other than rock excavation) is considered as unclassified and is defined as removal of all material encountered, regardless of soil type. Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include soil materials, and obstructions. Unclassified excavation is considered normal excavation and no extra costs will be allowed.
      1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
      2. Remove material of every nature or description encountered in obtaining required lines and grades. Excavate and/or place and compact fill to provide for building pad elevation(s) required by drawings.
      3. Excavate wide enough at foundations and retaining walls to permit erection and removal of forms, application of dampproofing or waterproofing.
      4. Pitch grading around excavations to prevent water from running into excavated areas.
      5. Pre-rip hardpan and soft bedrock with single-tooth ripper or other suitable equipment to facilitate excavation with conventional earth-moving equipment.
      6. Bearing soils disturbed by excavating equipment must be recompacted to 95 percent of maximum Standard Proctor Density (ASTM D698) prior to placing concrete.
      7. Exposed areas which will receive fill once properly cleaned, shall be scarified to a minimum depth of 8”, conditioned to near optimum moisture content, and compacted.

   B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth excavation and rock excavation. Do not excavate rock until it has been classified and cross sectioned by Owner’s Representative.
      1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.
         a. Intermittent drilling; ram hammering; or ripping of material not classified as rock excavation is earth excavation.
C. Stability:
   1. Slope sides of excavations in compliance with OSHA requirements and local codes or ordinances. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated.
   2. Continuously monitor cut slopes for distress. Take all necessary precautions to safeguard workers, structures, and utilities.
   3. Provide all necessary shoring, sheeting, or bracing of sides of excavations required to prevent caving, erosion, and gullying. Provide underpinning of existing structures or other improvements adjacent to excavations which are subject to damage.

D. Unanticipated Conditions: Notify the Owner’s Representative immediately upon finding evidence of previous structures or filled materials which penetrate below designated excavation levels, groundwater or water-bearing strata, or other conditions which are not shown or which cannot be reasonably assumed from existing surveys and geotechnical reports. Secure the Owner’s Representative instruction before proceeding with further work in such areas.

E. Rock Excavation: Includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction. Rock excavation in unconfined areas is defined as removal and disposal of material which in the Geotechnical Engineer’s opinion, cannot be excavated without continuous and systematic drilling and blasting, or continuous use of a suitable ripper or other special equipment.
   1. Unanticipated Rock Excavation: Rock excavation that is not indicated on existing surveys or which cannot be reasonably assumed from geotechnical studies of the site and which could not have been anticipated without extensive investigations. Unanticipated rock excavation shall be subject to change order procedures or previously agreed upon unit prices.

3.05 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 0.10-foot. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
   1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
   2. Pile Foundations: Stop excavations 6 to 12 inches (150 to 300 mm) above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
   3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.
3.06 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

B. Scarify subgrade soils beneath exterior slabs, sidewalks and pavements to a minimum depth of 8-inches, moisture condition and recompact as specified.

C. Existing man-made fill shall be removed under walks and pavements as required by the Geotechnical Engineer.

3.07 EXCAVATION FOR UTILITY TRENCHES

A. Refer to Division 31 Section “Trenching and Backfilling,” for excavating and backfilling of utilities.

3.08 SUBGRADE INSPECTION

A. Notify Geotechnical Engineer when excavations have reached required subgrade.

B. If Owner's Representative and Geotechnical Consultant determine that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below the building slabs and pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Remove and replace soft areas. Do not proof-roll wet or saturated subgrades.
   1. Completely proof-roll subgrade in one direction. Limit vehicle speed to 3 mph (5 km/h).
   2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
   3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Owner's Representative, and replace with compacted backfill or fill as directed.

D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Owner's Representative, without additional compensation.
3.09 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi (17.2 MPa), may be used when approved by Geotechnical Engineer. If approved by Geotechnical Engineer, structural fill placed at 100 percent ASTM D698, 2 percent below to 1 percent above optimum moisture may be used.

1. Fill unauthorized excavations under other construction or utility pipe as directed by Owner's Representative.

3.10 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials in approved locations without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
8. Acceptance of subgrade by Geotechnical Engineer.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

A. Refer to Division 31 Section "Trenching and Backfilling," for excavating and backfilling of utilities.

3.13 SOIL FILL

A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface before placing fills.

1. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
2. In areas of fill, scarify natural soil following removal of unsatisfactory material, to a depth of 8".
B. Place and compact fill material in layers to required elevations per the geotechnical report and as follows:
   1. Under grass and planted areas, use satisfactory soil material.
   2. Under walks and pavements, use satisfactory soil material.
   3. Under steps and ramps, use engineered fill or structural fill as approved by Geotechnical Engineer.
   4. Under building slabs, use engineered fill or reconditioned on-site soils or imported fills of native soils as approved by Geotechnical Engineer.
   5. Under footings and foundations, use engineered fill or reconditioned on-site soils or imported fills of native soils as approved by Geotechnical Engineer.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to optimum or to 3 percent over optimum moisture content for clay soils, or within 2 percent of optimum moisture content for granular soils. Refer to geotechnical study for additional recommendations.
   1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
   2. Remove and replace, or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content beyond the tolerances described above and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698:
   1. Under exterior flatwork, slabs, steps, and pavements, scarify and recompact top 8 inches (300 mm) of existing subgrade and each layer of backfill or fill soil material at 95 percent.
   2. Underfootings and interior floor slabs, excavate to approved natural soils, in fill condition, compact to 95 percent.
   3. Under lawn or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 90 percent.
   4. Compact foundation wall backfill to 95 percent.
   5. Compact scarified subgrade soils to 95 percent.
   6. Compact retaining wall backfill to 95 percent.
3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
   1. Provide a smooth transition between adjacent existing grades and new grades.
   2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
   1. Lawn or Unpaved Areas: Plus or minus 0.10 feet.
   2. Walks: Plus or minus 0.10 feet.
   3. Pavements: Plus or minus 0.10 feet.
   4. Grading inside Building Lines: Finish subgrade to a tolerance of ½-inch (13 mm) when tested with a 10-foot (3-m) straightedge.

3.17 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Owner’s Representative.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Perform field moisture tests in accordance with ASTM D3017. Tests will be performed at the following locations and frequencies at a minimum:
   1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least 1 test for every 2000 sq. ft. (186 sq. m) or less of paved area or building slab, but in no case fewer than 3 tests.
   2. Foundation Wall Backfill: At each compacted backfill layer, at least 1 test for each 100 feet (30 m) or less of wall length, but no fewer than 2 tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.
3.18 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
   1. Scarify or remove and replace soil material to depth as directed by Owner’s Representative; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
   1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.19 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Transport surplus satisfactory soil to designated storage areas on Owner’s property. Stockpile or spread soil as directed by Owner’s Representative.
   1. Remove waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner’s property.
   2. Maintain records of weight or volume of all recycled material.
   3. Manage construction waste in accordance with provisions of Division 1 Section "Construction Waste Management and Disposal" for recycling and disposal of waste. Submit documentation to satisfy the requirements of that section.

END OF SECTION
SECTION 31 23 33
TRENCHING AND BACKFILLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Additional information concerning trenching and backfilling may be found on the civil drawings, in the project geotechnical study/report and agency having jurisdiction construction standards. In case of conflict between the drawings, jurisdictional criteria and the information specified herein, the more stringent requirements shall govern.

B. Additional information concerning earthwork may be found in the geotechnical investigation report by CTL Thompson dated December 8, 2008. All requirements of this report shall be followed unless noted otherwise. The information shown in this report is for information and it shall be the contractors responsibility to field verify conditions indicated.

1.02 SUMMARY

A. This Section includes the following:
1. Subsurface drainage backfill for walls and trenches.
2. Excavating and backfilling for utility trenches.
3. Excavating and backfilling trenches for buried mechanical and electrical utilities and pits for buried utility structures.

B. Related Sections include the following:
1. Division 1 Section "LEED" or "Sustainable Design" requirements for product data and manufacturing documentation.
2. Division 1 Section "Construction Waste Management and Disposal" for recycling and disposal of waste.
3. Division 31 Section "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above and below grade improvements and utilities.
4. Division 31 Section "Earth Moving" for soil materials, site excavating, filling and grading.
5. Division 31 Section “Temporary Erosion and Sedimentation Control" for erosion and sediment control.
6. Divisions 22, and 26 Sections for installing underground mechanical and electrical utilities and buried mechanical and electrical structures, if available.

C. Shoring Design: Provide the services of a professional engineer to design all shoring, bracing, and underpinning required to protect the safety of workers and integrity of adjacent existing structures or other improvements.

1.03 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.
B. **Base Course:** Course placed between the subbase course and hot-mix asphalt paving.

C. **Bedding Course:** Course placed over the excavated subgrade in a trench before laying pipe.

D. **Borrow Soil:** Satisfactory soil imported from off-site for use as backfill approved by Geotechnical Engineer.

E. **Unclassified Excavation:** Removal of all material of whatever-character required for the work encountered above subgrade elevations and to lines and dimensions indicated, including boulders.

F. **Authorized Additional Excavation:** Excavation below subgrade elevations or beyond indicated lines and dimensions as directed or approved by Owner’s Representative and the testing and inspections agency to correct unsatisfactory conditions. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

G. **Bulk Excavation:** Excavation more than 10 feet (3 m) in width and more than 30 feet (9 m) in length.

H. **Unauthorized Excavation:** Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Owner’s Representative. Unauthorized excavation including disposition of overexcavated materials and other work resulting from slides, cave-ins, swelling, upheaval, or remedial work, as well as remedial work directed by Owner’s Representative, shall be without additional compensation.

I. **Rock Excavation:** Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. (0.76 cu. m) for bulk excavation or 3/4 cu. yd. (0.57 cu. m) for footing, trench, and pit excavation that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
   1. **Excavation of Footings, Trenches, and Pits:** Late-model, track-mounted hydraulic excavator; equipped with a 42-inch (1065-mm-) wide, maximum, short-tip-radius rock bucket; rated at not less than 138-hp (103-kW) flywheel power with bucket-curling force of not less than 28,090 lbf (125 kN) and stick-crowd force of not less than 18,650 lbf (83 kN); measured according to SAE J-1179.
   2. **Bulk Excavation:** Late-model, track-mounted loader; rated at not less than 210-hp (157-kW) flywheel power and developing a minimum of 48,510-lbf (216-kN) breakout force with a general-purpose bare bucket; measured according to SAE J-732.

J. **Subbase Course:** Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

K. **Subgrade:** Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

L. **Utilities:** Includes on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

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**TRENCHING AND BACKFILLING**

31 23 33 - 2
1.04 SUBMITTALS

A. Product Data: For the following:
   1. Each type of plastic warning tape.

B. Samples: Contractor to submit representative samples of all materials proposed for use in bedding and trench backfilling operations to the testing and inspections agency for analysis and determination of compliance with the requirements specified herein.

C. Material Test Reports: Provided by Owner from a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
   1. Classification according to ASTM D 2487 of each on-site or borrow soil material proposed for fill and backfill.
   2. Laboratory compaction curve according to ASTM D 698 for each on-site or borrow soil material proposed for fill and backfill.

D. Pre-Excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins.

E. LEED Submittals
   1. Product Data for Credit MR 4.1 and Credit MR 4.2: Include manufacturer’s product data indicating separate percentages, by weight, of post-consumer and pre-consumer recycled content for projects having recycled content. Include statement indicating material costs for products.
   2. Product data for Credit MR 5.1 and Credit MR 5.2: Indicate location of manufacturing facility including name, address and distance between manufacturing facility and the proposed site. Provide manufacturer’s documentation indicating location where the base materials were extracted, mined, quarried, harvested, etc. and the distance between this location and the project site. Also include material costs, excluding cost of installation.

1.05 QUALITY ASSURANCE

A. Testing Agency:
   1. All testing and inspections required herein will be performed by an independent testing and inspection agency employed by the Owner.
   2. Notify the testing and inspection agency not less than 48 hours in advance of all work requiring testing or inspection services.

B. Regulatory Requirements: Comply with all applicable requirements of the Occupational Safety and Health Administration and local and State rules, regulations, and ordinances concerning shoring, bracing, or sloping of excavations and safety of workers. Safety of workers is the responsibility of the Contractor.

C. Coordination: Coordinate scheduling and procedures for trench excavation, bedding, and backfilling with other Sections whose work relates to or is affected by this work.
D. Pre-Construction Conference: Conduct conference at Project site as directed by Owner’s Representative prior to start of construction. Contractor to comply with requirements, which also may be included in Division 1 Section "Project Management and Coordination."

1.06 PROJECT CONDITIONS

A. Existing Utilities: Locations, sizes and depths or invert elevations of existing utilities as shown on the drawings are based on information provided by others, and are believed to be correct, but may not be absolutely so. Such information is therefore presumed only as approximations and should be verified prior to construction. Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Owner’s Representative and then only after arranging to provide temporary utility services according to requirements indicated.
   1. Notify Owner’s Representative not less than two (2) days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Owner’s Representative's written permission.
   3. Contact utility-locator service for area where Project is located before excavating.

B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

C. Existing Bench Marks: Carefully preserve and maintain existing bench marks, monuments, property line pins, and other reference points. If disturbed or destroyed, restore or replace them at no additional cost to the Owner.

D. Verification of Existing Conditions: Visit the site prior to submission of bids. Verify existing conditions, elevations, and utility locations. In the event of discrepancies between existing conditions and those indicated on the Contract Documents or survey, contact the Owner’s Representative for clarification.

1.07 WARRANTY

Settlement in backfill, fill or in structures built over backfill or fill, which may occur within the specified project warranty period, shall be corrected at no cost to the Owner. Any structures damaged by settlement shall be restored to their original condition by the Contractor, at no cost to the Owner.
PART 2 - PRODUCTS

2.01 MATERIALS

A. Utility Trench Bedding Materials:
   1. Granular Bedding: Well graded mixture of sound mineral aggregate complying with
      Class 67 (Modified) gradation in accordance with the following table:

      | Nominal Size | Percent Passing by Weight |
      |--------------|---------------------------|
      | ¾"           | 90-100                    |
      | 3/8"         | 20-55                     |
      | No. 4        | 5-10                      |
      | No. 8        | 5-10                      |

      In the event the excavation or overexcavation for bedding is below the water table, the
      sub-bedding material shall consist of ¾” to 1-1/2” rock (or larger if approved), placed in
      accordance with the Agency having authority.

   2. Sand Bedding: Clean, well-graded sand, not more than 5% by weight passing a No. 200
      sieve.

   3. Agency Requirements: Bedding requirements shall be in accordance with jurisdiction
      having control over utility.

B. Utility Trench Backfill Materials:
   1. Existing soils obtained from trench excavations, including granular or aggregate base
      course from removed pavements, broken and pulverized claystone or claystone-
      sandstone bedrock may be used for backfilling trenches, provided it meets any special
      requirements of the Utility Agency and Geotechnical Engineer. Bedrock must be
      processed and broken or pulverized so that the maximum particle or fragment size does
      not exceed three-inches (3”).

C. Unsuitable Utility Trench Materials: Materials unsuitable for bedding and backfilling include
   highly organic soils, ASTM D2487 Group PT topsoil, and soils containing roots, vegetable mat-
   ter, trash, and debris.

2.02 ACCESSORIES

A. Shoring and Bracing: Provide all materials for shoring and bracing, such as sheet piling,
   uprights, stringers, and cross-braces, in good and serviceable condition, as required for safety
   and by governing authorities.
B. Warning Tape: Acid and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored as follows:
   2. Yellow: Gas, oil, steam, and dangerous materials.
   3. Orange: Telephone and other communications.
   4. Blue: Water systems.
   5. Green: Sewer systems.

2.03 LEED REQUIREMENTS

A. Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity.

B. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the work of this Section will be performed. Do not proceed with the work until unsatisfactory conditions have been corrected. Commencement of work implies acceptance of all areas and conditions.

3.02 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Division 31 Section "Site Clearing."

C. Protect and maintain erosion and sedimentation controls, which are specified in Division 31 Section "Temporary Erosion and Sediment Control," during earthwork operations.

D. Existing Utilities:
   1. General: Location of existing utilities shown on the plans are approximate only. The Contractor shall be responsible to locate all existing underground utilities in areas of the work. If utilities are to remain in place, provide protection during excavation and backfilling operations. Should uncharted or incorrectly charted piping or other utilities be encountered during excavations, consult the Owner’s Representative immediately for direction. Cooperate with the Utility Agency in keeping respective services and facilities in operation. Repair damaged utilities to the satisfaction of the Utility Agency.
2. **Active Utilities:** Do not interrupt existing utilities serving facilities occupied and used by the Owner or by adjacent properties, except when permitted in writing by the Owner’s Representative, and then only after acceptable temporary utility services have been provided. Remove or relocate utilities only as indicated or specified.

3. **Inactive Utilities:** Report inactive or abandoned utilities encountered in excavating or grading operations, and remove, plug, or cap as required. In the absence of specific requirements, plug or cap such utility lines at least 5'-0" outside new building walls, or as required by local requirements.

4. **Removal:** Demolish and completely remove from the project site all existing underground utilities indicated to be removed. Coordinate with Utility Agencies for discontinuance of services if lines are active.

**E. Protection of Persons and Property:**

1. Provide all necessary measures to protect workmen and passersby. Barricade open excavations occurring as part of the work, as required by municipal or other authorities having jurisdiction.

2. Protect adjacent streets, structures, and other improvements from damage caused by settlement, undermining, washout, and other hazards created by trench excavations.

**F. Protect subgrades and trench bottoms soils against freezing temperatures or frost. Provide protective insulating materials as necessary.**

**G. Cold Weather Work:** Prevent frost from entering bearing strata upon which construction will take place or in areas where fill will be placed in that season.

**H. Provide temporary erosion and sedimentation control measures in accordance with Division 31 Section "Temporary Erosion and Sedimentation Control" to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation control drawings and requirements of authorities having jurisdiction.**

3.03 **DEWATERING**

A. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations and to collection or runoff areas. Establish and maintain temporary drainage ditches and diversions away from trench excavations. Do not use trench excavations as temporary drainage ditches.

C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

2. Install a dewatering system to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.
3. Obtain and comply with all provisions of the Colorado Department of Public Health and Environment, Water Quality Control Division, Construction Dewatering Permit.

3.04 SHORING AND BRACING

A. Provide shoring and bracing of excavations as required for safety and by governing authorities. Carry down shoring and bracing as excavation progresses. Maintain shoring and bracing in excavations regardless of time period excavations will be open.

3.05 PAVEMENT REMOVAL AND REPLACEMENT

A. Where trenches or other utility excavations are made in existing paved areas, saw-cut pavement surface to create a clean break line. Cut pavement a minimum of 12” beyond trench width on each side of trench; remove and dispose of existing surface course and aggregate base course, leaving a 12” wide undisturbed subgrade lip on each side of trench.

B. After trench has been backfilled and compacted, place new pavement in accordance with applicable requirements of Division 32 Sections as applicable, for Asphaltic or Portland cement concrete pavement and in accordance with Authorities having jurisdiction.

3.06 EXPLOSIVES

A. Explosives: Do not use explosives.

3.07 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.
   1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit, unless otherwise indicated on the drawings.

C. Clearance: 12 inches (300 mm) each side of pipe or conduit.
   1. Slope sides of trenches or provide shoulders in accordance with OSHA requirements and as required by Utility Agency standards.
   2. Continuously monitor cut slopes and trenches for distress or movement. Provide all necessary shoring and bracing required to protect the life and safety of workmen performing excavation or installing piping or conduit.

D. Trench Bottoms: Excavate trenches a minimum of 3 inches (75 mm) deeper than bottom of pipe elevation to allow for bedding course. Hand excavate for bell of pipe.
   1. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course and backfill with a 6” layer of crushed stone or gravel prior to installing pipe.
3.08 BEDDING OF PIPES:

A. After completion of trench excavation and before installation of piping, install not less than 3” of approved bedding material in trench bottom for support of pipe. Dig bell holes in bedding deep enough to provide a minimum of 2” clearance between the bell and bedding material. Fully support pipe on bedding material for the full length of the pipe barrel.

B. After pipe is adjusted for line and grade, and all jointing is complete, carefully place and tamp bedding material under the haunches of the pipe and in the previously dug bell holes.

C. Install bedding to a minimum depth of 12” above top of pipe prior to starting placement of compacted backfill. Lightly compact or tamp bedding material in a manner to avoid displacement of or damage to the pipe.

3.09 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials in approved locations without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
   1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.10 UTILITY TRENCH BACKFILL

A. After installation of utility piping or lines have been completed, locations recorded, trash or other debris removed from excavations, and bedding placed and approved, backfill promptly as work and weather conditions permit. Do not backfill trenches until all required pipe system tests and inspections have been made, unless partial backfilling is required to restrain pipe under test pressures. Use care in backfilling to avoid damage or displacement of pipe systems.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

C. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

D. Place backfill materials in layers not more than 8” in loose depth for material compacted by heavy compaction equipment, and not more than 4” in loose depth for material compacted by hand operated tampers. Use hand held tools or compacting devices for trench backfill, until a minimum compacted thickness of 3'-0" above top of pipe is achieved. Mechanical or power compactors may be used thereafter.

E. Before compaction, moisten or aerate each layer of backfill to specifications.

F. Compact each layer to not less than 95% of maximum standard Proctor density (ASTM D698). Thoroughly compact by means of mechanical tampers areas which cannot be properly compacted by means of rolling equipment.

G. Backfill to subgrade elevation shown for finish grading, topsoil placement, or paving.
H. Place and compact initial backfill of satisfactory soil, free of particles larger than 1 inch (25 mm) in any dimension, to a height of 12 inches (300 mm) over the utility pipe or conduit.
   1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

I. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

J. Place and compact final backfill of satisfactory soil to final subgrade elevation.

K. Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, and 6 inches (150 mm) below subgrade under pavements and slabs.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

C. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Perform field moisture tests in accordance with ASTM D3017. Tests will be performed at the following locations and frequencies at a minimum:
   1. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for each 150 feet (46 m) or less of trench length, but no fewer than 2 tests. At a minimum, test intervals and quantities shall meet or exceed the requirements of the local utility agency.

D. When testing agency reports that backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.12 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
   1. Scarify or remove and replace soil material to depth as directed by Owner’s Representative; reshape and recompact.
C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
   1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.13 CLEANING AND ADJUSTMENT:

A. Reconditioning Compacted Areas: When completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and recompact to required density prior to further construction.

B. Cleanup: Remove excess materials not required for backfilling purposes, including excess spoil material, accumulated debris, and rubbish from site. Burning of waste material is prohibited.

3.14 RESTORATION:

A. Adjacent Improvements: Restore all fences, irrigation ditches, yards, lawns, and other structures or surfaces to condition equal to or better than before work began.

3.15 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Owner's Representative.
   1. Remove waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.
   2. Maintain records of weight or volume of all recycled material.
   3. Manage construction waste in accordance with provisions of Division 1 Section "Construction Waste Management and Disposal" for recycling and disposal of waste. Submit documentation to satisfy the requirements of that section.
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TEMPORARY EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.01 RELATED WORK

A. Additional information concerning temporary erosion and sedimentation control may be found on the civil drawings and agency having jurisdiction construction standards. In case of conflict between the drawings, jurisdictional criteria and the information specified herein, the more stringent requirements shall govern.

B. Additional information concerning erosion may be found in the geotechnical investigation report by CTL Thompson dated December 8, 2008. All requirements of this report shall be followed unless stated otherwise.

C. All work shall meet or exceed the requirements of the EPA’s National Pollution Discharge Elimination System (NPDES) Construction General Permit.

1.02 SUMMARY

A. Work Included. Furnish, install, maintain, and remove temporary erosion and sedimentation controls as shown on the drawings or specified herein, or as required to complete the work.

B. Related Sections include the following:
   1. Division 1 Section “LEED” or "Sustainable Design” requirements for product data and manufacturing documentation.
   2. Division 1 Section "Construction Waste Management and Disposal" for recycling and disposal of waste.
   3. Division 31 Section "Site Clearing" site stripping, grubbing, stripping and stockpiling topsoil, and removal of above and below grade improvements and utilities.
   4. Division 31 Section "Earth Moving" for soil materials, site excavating, filling and grading.
   5. Division 31 Section “Trenching and Backfilling” for excavating and backfilling of utilities.

C. Permits and Fees: Obtain and pay for all permits and fees required for the work of this section, including erosion and sediment control and water quality permits required by the authority having jurisdiction and the Colorado Department of Public Health and Environment, Water Quality Control Division.

D. Erosion Control: Provide erosion and sedimentation control as necessary to meet applicable local and State criteria.
1.03 DEFINITIONS

A. **Backfill**: Soil material used to fill an excavation.
   1. **Initial Backfill**: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. **Final Backfill**: Backfill placed over initial backfill to fill a trench.

B. **Unclassified Excavation**: Removal of all material of whatever character required for the work encountered above subgrade elevations and to lines and dimensions indicated, including boulders.

C. **Fill**: Fill is all material placed to raise the grade of the site or to backfill excavation, upon which the Soils Engineer has made sufficient tests and observations to enable him to issue a written statement that, in his opinion, the fill has been placed and compacted in accordance with the requirements of these specifications.

D. **BMP**: Best Management Practice. Erosion and sediment control devices, which may consist of silt fence, crates, filter fabric, riprap, etc.

E. **SWMP**: Storm Water Management Plan. Identifies BMPs, which are erosion and sediment control measures for the project.

F. **Structures**: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

G. **Subgrade**: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

H. **Utilities**: Include on-site underground pipes, conduits, ducts, and cables, as well as underground services to buildings.

1.04 SUBMITTALS

A. **Submittal Procedures**: All submittals are to be made to the Owner’s Representative. If provided refer to Division 01 Section “Submittal Procedures.”

B. **Product Data**: Submit manufacturer’s published descriptive literature and complete specifications for manufactured products specified herein and utilized on the project.
   1. Geotextiles.
   2. Erosion Control Fabric.

C. **Storm Water Management Plan**: The Engineer may provide a Storm Water Management Plan (SWMP) and report addressing erosion and sediment control measures for all sites with over one acre of disturbed ground. The Engineer will also assist in preparation of the General Permit application.
2. The Contractor is responsible for obtaining all required permits including a General Permit application for Storm Water Discharges associated with construction activities at least ten (10) days prior to start of construction. Permits are to be filed with the Colorado Department of Public Health and Environment, Water Quality Control Division.

3. Contractor shall have the Storm Water Management Plan (SWMP) and report available on-site at all times.

D. LEED Submittals:
   1. Product Data for Credit MR 4.1 and Credit MR 4.2: Include manufacturer’s product data indicating separate percentages, by weight, of post-consumer and pre-consumer recycled content for projects having recycled content. Include statement indicating material costs for products.
   2. Product data for Credit MR 5.1 and Credit MR 5.2: Indicate location of manufacturing facility including name, address and distance between manufacturing facility and the proposed site. Provide manufacturer’s documentation indicating location where the base materials were extracted, mined, quarried, harvested, etc. and the distance between this location and the project site. Also include material costs, excluding cost of installation.
   3. Include photos or videotape of erosion and sedimentation control measures in place.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with applicable local, State and Federal ordinances, rules and regulations concerning sedimentation control and storm water runoff.

B. In case of conflict between the above codes, regulations, references and standards and these specifications, the more stringent requirements shall govern.

C. Preconstruction Conference: Conduct conference at Project site as directed by Owner’s Representative prior to start of construction. Contractor to comply with requirements, which may also be included in Division 01 Section "Project Management and Coordination."

1.06 PROJECT/SITE CONDITIONS

A. Existing Conditions: Verify all existing conditions affecting the work of this section prior to submitting bids or proposals. Additional compensation will not be allowed for revisions or modification of work resulting from failure to verify existing conditions.

1.07 WARRANTY

A. Temporary Erosion and Sediment Control measures shall be maintained until permanent measures are in place. All damaged, disturbed or devices filled with sediment, which may occur within the specified project warranty period, shall be corrected at no cost to the Owner. Any devices damaged by erosion or sediment shall be restored to their original condition by the Contractor, at no cost to the Owner.
1.08 LEED REQUIREMENTS

A. Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity.

B. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Erosion and Sedimentation Control Materials: Provide one or more of the following materials, as shown on the plans or as applicable for site conditions:
  1. Sand bags.
  2. Silt fences.
  3. Rock riprap.
  4. Temporary seeding.
  5. Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh.
  6. Biodegradable twisted jute or spun-coir mesh, 0.92 lb/sy minimum, with 50 to 65 percent open area.
  7. Drainage geotextile.
  8. Impervious fill.
  9. Other materials proposed for use on-site.

PART 3 - EXECUTION

3.01 PREPARATION

A. General:
  1. Determine the existing ground elevations, drainage patterns, and changes to such patterns during excavation in order to satisfactorily plan and provide materials for adequate erosion and sediment control devices.
  2. Provide temporary erosion and sedimentation control measures in accordance with Division 31 Section "Temporary Erosion and Sedimentation Control" to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation control drawings and requirements of authorities having jurisdiction.

3.02 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and rights-of-way according to requirements of authorities having jurisdiction.
B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

C. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

D. Secure grading permit from agency have jurisdiction prior to commencing grading operations.

3.03 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the work of this section will be performed. Do not proceed with the work until unsatisfactory conditions have been corrected. Commencement of work implies acceptance of all areas and conditions.

3.04 INSTALLATION

A. Erosion and Sedimentation Control Devices. Erosion and sedimentation control measures to be taken during construction include, but are not necessarily limited to the following:

1. Apply soil stabilization within 14 days to all disturbed areas that are to be dormant for a period longer than 30 calendar days after reaching grade. Stabilize soil with mulch anchored per criteria of authorities having jurisdiction. Temporarily revegetate areas that will remain in an interim condition for more than three (3) months.

2. Roads and parking areas indicated to be paved may be covered with an appropriate aggregate base course in lieu of mulch. Temporary mulching or aggregate base course is not required if final pavement construction will take place within 30 days after grading to final contours.

3. Soils that will be stockpiled for more than 30 days must be mulched and seeded within 14 days after stockpile construction.

4. Prevent sediment from leaving the project site by installing a silt fence or other BMPs as indicated on the plans. Protect existing storm inlets adjacent to the site by an approved gravel filter.

5. Excavate the future detention/water quality pond and construct the outlet structure/storm sewer such that the pond may function as a temporary sediment basin during development of the site. Construct the sediment basin in accordance with authority having jurisdiction’s criteria. Provide temporary swales to convey site runoff to the pond.

6. Locate stone stabilization pads at all points of vehicular ingress and egress to the construction site.

7. Provide temporary erosion controls consisting of berms at the top of slopes and interceptor ditches at ends of berms and at those locations which will eliminate or minimize erosion during construction, along with temporary seeding, temporary diversion, chutes, and down pipes and lining of water courses.

8. Temporary sedimentation controls shall consist of silt dams, traps, silt fence, barriers, and appurtenances at the top of spoil and borrow area slopes and where runoff water exits the site.
9. Maintain the available silt holding capacity of silt dams, fence traps and barriers until no longer needed. The sediment capacity of sediment retainage areas shall be at a minimum, the capacity shown on the plans in conformance with Urban Drainage Criteria Manual, Volume 3. Prior to removal, obtain concurrence of the Owner and Engineer.

10. Remove accumulated sediment and debris from a BMP when the sediment level reaches one-half the height of the BMP, or at any time the sediment or debris adversely impacts the functioning of the BMP.

11. Remove hay bales which have deteriorated and filter stone or cloth which has become dislodged. Place new hay bales and new filter and fence.

12. The erosion/sediment control plan shows the minimum required for the project. If it becomes apparent that additional controls are necessary, the Engineer shall be notified and with approval of the Owner’s Representative additional controls shall be installed.

B. Chemicals and Pollutants:
1. Store construction materials and chemicals that could contribute pollutants to the runoff within an enclosure, container, or dike located around the perimeter of the storage area, to prevent discharge of these materials into runoff from the construction site.

2. Locate areas used for collection and temporary storage of solid and liquid waste away from the storm drainage system. Provide covering or fencing as required to prevent windblown materials; construct perimeter dike to contain liquid runoff. These measures may not be necessary if materials are immediately placed in covered waste containers.

3. Perform equipment maintenance in designated areas using measures such as drip pans to control petroleum products spillage.

4. Immediately clean up and properly dispose of spills of construction related materials such as paints, solvents, or other chemicals.

C. Final Stabilization and Long-Term Management:
1. Final stabilization shall be achieved through permanent vegetation and landscaping after construction of all buildings and paved surfaces.

2. With approval of authorities having jurisdiction, temporary erosion and sediment control measures may be removed within 30 days after final site stabilization is achieved or after temporary measures are no longer needed.

D. Inspection and Maintenance: Inspect erosion and sediment control measures weekly during construction. In addition, inspect all facilities immediately after any significant runoff or snowmelt which results in runoff. Repair or otherwise mitigate any damage to the erosion and sediment control facilities at no additional cost to the Owner.
3.05 CLEANING

A. Removal of Controls: Remove controls upon completion of that portion of the work for which controls were furnished. Leave the site and work area in a clean condition.

B. Maintain records of weight or volume of all recycled material.

C. Manage construction waste in accordance with provisions of Division 1 Section “Construction Waste Management and Disposal” for recycling and disposal of waste. Submit documentation to satisfy the requirements of that section.

END OF SECTION
SECTION 31 63 33

DRILLED MICROPILES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This section specifies performance requirements, design, drilling, installation, testing and inspection, and all other work necessary for a complete installed system of drilled micropiles consisting of threaded steel reinforcement bars grouted in place.

1.03 PERFORMANCE REQUIREMENTS

A. Structural Performance: Required service load capacity in compression, tension, and lateral loads as indicated on drawings. Required settlement performance under working loads as follows: maximum total settlement = 1/2”, maximum differential settlement = 1/4”, maximum horizontal and vertical movement of battered micropiles = 1/2”. Maximum lateral movement under working downward load = 1/2”. Required design life = 100 years without repair or maintenance.

B. Engineering design of drilled micropiles by Contractor. Micropiles are a performance specified item that requires a stamped engineered submittal.

C. Design shall indicate minimum length of time after micropile construction before contractor can build on top of micropile foundations.

D. Micropile Testing: Contractor shall determine bottom elevations, load carrying capacities, diameter, casing, and reinforcement of micropiles from available soil data and structural loading. Actual elevations and embedment lengths will be verified by testing and by actual soil conditions encountered and drilling method as determined in the field. Contractor shall create a safety plan for testing of micropiles. Testing shall not induce stresses, movement, or damage to existing structure or utilities.

1.04 UNIT PRICES

A. Basis of Bids: Bids shall be based on the number and location of micropiles shown on the drawings and on diameters and lengths determined by the Contractor’s design. Do not base bids solely on the minimum lengths and embedments listed herein.

B. Basis for Payment: Payment for micropiles will be made on length, size, type, and number of micropiles in place and approved. Actual length and size/type of micropile may vary to coincide with elevations where satisfactory bearing strata are encountered, and with actual
strength of bearing strata determined by the testing with Owner’s geotechnical engineering review and approval. Adjustments will be made on net variation of total quantities.

1. Unit prices shall include labor, materials, tools, equipment, and incidentals required for drilling, casings, reinforcement, grout, hardware, and other items for complete micropile installation.

2. See Division 00 Form “Basis for Bids – Drilled Micropile Construction”.

1.05 SUBMITTALS

A. Proposed Means and Methods
   1. Submit a narrative with proposed method of construction, drilling equipment, area of disturbance, and extent of disturbance for Owner’s review and approval. Submit proposed methods to minimize dust, debris, noise, and drilling spatter.
   2. Submit methods statement describing all load testing of micropiles. Include a drawing describing the setup, method of applying the test loads, and method of measuring movements. A submittal is required for compression tests, tension tests, and lateral tests.

B. Stamped and Signed engineering calculations by a qualified engineer registered in the state of the project. Calculations shall include design of complete micropile foundation system, including calculations substantiating required design life. Designs shall consider slenderness of micropiles for unbraced lengths at top of micropiles, particularly for micropiles extending through geo-foam fill at existing crawl spaces.

C. Product Data: For each type of product indicated including:
   1. Grout materials, grouting admixtures, grout mix design, and grout cube breaks indicating proposed material conforms to the contract documents.
   2. Rebar, threaded and deformed
   3. Steel plates, bolts, weld metal, etc. including grade and finish
   4. Centralizers
   5. Finishes on rebar

D. Shop Drawings: Submit shop drawings for all fabricated steel elements including plates, washers, etc. indicating dimensions, material specification, and finishes.

E. Grout mix design and grout test results from previous testing.

F. Verification and Proof Load Test Equipment: Submit hydraulic pump and pressure gauge calibration curve to Architect prior to performing any tests.

G. Verification and Proof Load Test Data: Contractor shall submit data for all verification and proof load tests performed to the Owner’s Testing and Inspection Agency and Architect.

1.06 QUALITY ASSURANCE

A. Design Standard: IBC 2006 Section 1810.8 “Micropiles”, “Micropile Design and Construction Guidelines” Published by the Federal Highway Administration; Publication Number FHWA-SA-97-070, and “Micropile Design and Construction, FHWA NHI-05-039”. Maximum allowable stresses used for micropile design shall not exceed those found in the IBC 2006.

C. Contractor Qualifications: The Contractor performing the work described in this specification shall have installed micropiles for a minimum of five years. At the time of bid, the Contractor shall submit a list containing at least five projects of similar size and complexity on which the Contractor has installed micropiles. A brief description of each project and a reference shall be included for each project listed. As a minimum, the reference shall include an individual’s name and current phone number.


E. Survey Work: Engage a qualified land surveyor to perform surveys, layouts, and measurements for micropiles. After installation, record actual measurements of each micropile location, diameter, bottom and top elevations, depth to bearing strata, and deviations from specified tolerances, and other specified data.
1. Record and maintain information pertinent to each micropile and submit to Owner within 2 weeks of installation.

F. Verification Tests: Prior to constructing production micropiles, install and test one tension verification micropile and one compression verification micropile for each installation method used. Construct within the footprint of the new additions. Location of verification micropile shall be located at least ten feet clear of permanent micropiles and existing foundations and utilities. Verification tests are to verify the design and demonstrate Installer's construction methods, equipment, standards of workmanship, and tolerances.
1. If the Architect determines that verification test does not comply with requirements, install another until it is accepted.

G. Preinstallation Conference: Conduct conference at Project site. Notify the Owner and Architect at least two weeks prior to the meeting.
1. Require representatives of each entity directly concerned with this work to attend, including the following:
   a. Contractor's superintendent.
   b. Testing agency and geotechnical engineer.
   c. Micropile engineer of record, Foreman
   d. Owner’s representative
   e. Building engineer of record
2. Review geotechnical engineering work, verification and proof tests, drilling, grouting, special inspection and testing and inspecting agency procedures for field quality control, cold- and hot-weather grouting, micropile installation tolerances, steel reinforcement installation, location and plumbness measurements, and protection during subsequent work.
3. Minutes of the meeting shall be recorded, typed, and printed by the Contractor and distributed by him to all parties concerned within 5 days of the meeting.
H. Record of Work: Maintain a record listing the time and date of drilling and grouting of all micropiles. Such record shall be kept until the completion of the project and shall be available to the Architect for examination at any time.

1.07 PROJECT CONDITIONS

A. Existing Utilities or Structure: Locate existing underground utilities and structure before installing micropiles. If utilities or structure are to remain in place, provide protection from damage during drilling operations.
   1. Should uncharted or incorrectly charted piping, other utilities or structure be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities or structure. Cooperate with Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities or structure to satisfaction of the Owner.

B. Site Information: A geotechnical report has been prepared for this Project and is included elsewhere in the Project Manual for information only.
   1. The drilling log and accompanying report are believed to be accurate; however, neither the Owner nor Architect guarantees the information contained nor do they guarantee the conditions indicated to exist at the location of the test holes will prevail at other locations on the site.

1.08 DELIVERY STORAGE AND HANDLING

A. Store cement to prevent moisture degradation and partial hydration. Do not use cement that has become caked or lumpy. Store aggregates so that segregation and inclusion of foreign materials are prevented. Do not use the bottom six inches of aggregate piles in contact with the ground.

B. Store steel casings and reinforcement on supports to keep the steel from contacting the ground. Damage to the bar steel as a result of abrasion, cuts, nicks, welds and weld splatter shall be cause for rejection. Do not ground welding leads to bars. Protect steel from dirt, rust and other deleterious substances prior to installation.
PART 2 - PRODUCTS

2.01 STEEL REINFORCEMENT

A. Deformed Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

B. Threaded Reinforcing Bars: ASTM A 615/A 615M, Grade 75 minimum, ASTM A722/A722M, Grade 150 minimum, or per German Certificates of Approval Z-1.5-76, Z1.5-149, or Z1.5-2, 72.5ksi (500 N/mm²) minimum yield strength. Actual yield strength may need to be greater than these minimums as required by the contractor’s design to satisfy the performance requirements herein. Continuously threaded.
1. Subject to all requirements herein, the following products are acceptable:
   a. Williams All-thread Rebar by the Williams Form Company
   b. GEWI Threadbar by Dywidag-Systems International

C. Hollow Threaded Reinforcing Bars: ASTM A 519/A 519M, Grade 85 minimum. Continuously threaded.
1. Subject to all requirements herein, the following products are acceptable:
   a. Williams Geo-Drill Injection Bar by the Williams Form Company

D. Couplings:
1. Couplings for Grade 75 Threaded Reinforcing Bar: ASTM A108, Stop-Type.
2. Couplings for Grade 150 Threaded Reinforcing Bar: ASTM A29, Grade C1045, Stop-Type.
3. Couplings for Hollow Threaded Reinforcing Bar: ASTM A29, Stop-Type.
4. All couplings shall be stop-type, and shall develop 100 percent of the ultimate tensile strength of the coupled reinforcing bars without evidence of any failure.

E. Nuts:
1. Nuts for Grade 75 Threaded Reinforcing Bar: ASTM A108.

F. Washers: ASTM F436.

G. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication. Mechanically clean bars prior to galvanization. Galvanize top 15 feet of all reinforcing bars in micropile construction.


2.02 REINFORCEMENT ACCESSORIES

A. Bar Supports: spacers, and other devices for spacing, supporting, and fastening reinforcing bars in place. Manufacture bar supports according to CRSI’s "Manual of Standard Practice," as follows:
1. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.
2.03 GROUT MATERIALS

A. Grout shall be nonshrink grout conforming to ASTM C1107, Grades B or C and shall achieve 4000 psi compressive strength at 28 days.

B. Alternatively grout may be neat Portland Cement or Portland Cement with fine aggregate. The Portland Cement grout shall conform to the following:
   1. Portland Cement: ASTM C150, Type I, II, or Type III.
   2. Water: Potable, complying with ASTM C 94/C 94M requirements, and shall be free from substances that may be detrimental to cement and steel
   3. Fine Aggregate: Fine Aggregate, if used, shall conform to AASHTO M6/ASTM C33. Free of materials with deleterious reactivity to alkali in cement
   4. Admixtures: Admixtures shall conform to AASHTO M194/ASTM C494. Admixtures which control bleeding, improve flowability, reduce water content and retard setting may be used. Accelerators are not permitted. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer’s recommendations.
   5. Grout Mix: Cement shall be fresh and shall not contain lumps or other indications of hydration. Resin, epoxy or other non-cementitious grouts shall not be used. Chloride-containing grouts or other grouts, which in the opinion of the Architect may be detrimental to the micropile, are not permitted. The grout shall be capable of reaching cube strength (AASHTO T 106/ASTM C109) of 2500 psi in 3 days and 4000 psi in 28 days. The grout shall have a maximum water-cement ratio of 0.45. The grout shall be free of lumps and un-dispersed cement.

C. Grout Materials:
   3. Admixtures: Subject to Manufacturer’s recommendations and Architect’s Approval.

2.04 STRUCTURAL STEEL MATERIALS

A. Plate and Bar: ASTM A 36/A 36M

B. Centralizers. Centralizers are to be manufactured from Schedule 40 PVC pipe or tube, ASTM D-1785, steel or other material not detrimental to the steel (wood shall not be used); and are to be securely attached to the bar and pipe. Centralizers shall be sized to position the bar/pipe within the center of the drill hole, sized to allow grout tube insertion to the bottom of the drill hole, and sized to allow grout to freely flow up the drill hole.

C. Welding Electrodes: Comply with AWS D1.1 requirements, 70 Series.

D. Headed Anchor Rods: ASTM A449, weldable, straight, Heavy Hex headed.
   4. Select one finish from options in subparagraph below.
E. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B, structural tubing.


PART 3 - EXECUTION

3.01 PREPARATION

A. Protect existing and new structures, utilities, sidewalks, pavements, and other facilities from damage caused by drilling, equipment use, stored materials, and other hazards created by these operations.

3.02 DRILLING

1. By personnel experienced and properly equipped to construct micropiles of indicated diameter and length.

2. Drilling may be by any method the Contractor chooses for the particular ground conditions including core drilling, rotary drilling, percussion drilling, and auger drilling; however site constraints will dictate the size and accessibility of the drilling equipment. Drill with penetration into competent bearing material per contractor’s design or deeper if required by on-site testing. Driven casing is not allowed.

3. Micropile reinforcing may be installed in the hole after drilling or advanced by the drill.

4. Use of drilling muds such as bentonite slurry to assist in drill cutting removal is not allowed. Provide a written plan for controlling dust and drill splatter if air is used. Existing construction shall be cleaned to the satisfaction of the owner after drilling operations are complete. The Contractor shall control and properly dispose of drill flush and construction-related waste, including excess grout, in accordance with the specifications and all applicable local codes and regulations. The Contractor shall control the dust and drill spatter during the drilling operations to limit the impacts to the environment, public traffic, and pedestrians.

5. If water is used in the drilling operation, the Contractor shall be responsible for controlling and disposing of the water in such a manner that is not harmful to the site or existing structures. Any damage by drilling water shall be repaired by the Contractor at no cost to the Owner. Holes shall be thoroughly cleaned of all dust, rock chips, grease or other deleterious material.

B. Prevent surface water from entering excavated holes. Do not leave holes open overnight.

C. Drill holes to proper depths. Clean sides of hole and remove loose material from bottom.

D. Owner’s Geotechnical Engineer shall inspect each hole. If unsuitable material is encountered, contractor shall stop drilling operations and shall submit alternate procedures for Architect’s review. Holes may not be made smaller or shallower than specified.

1. Do not excavate holes deeper than elevations indicated, unless approved by the Geotechnical Engineer.
2. Additional authorized excavation will be paid according to Contract provisions for changes in the Work.

E. Excavate closely spaced holes only after adjacent holes are filled with grout and allowed to set to prevent holes from interfering or weakening each other. Set shall be achieved when the grout achieves 500 psi.

F. Tolerances: Construct micropiles within the following tolerances.
   1. Plan location: steel projecting from ground shall be located within 1 1/2" from specified position.
   2. Plumbness: Hole and steel projecting from ground shall be plumb to within 1 percent.
   3. Elevation: Top of threaded rebar and bearing plate elevations shall with within 1" of specified elevation. Top of grout and permanent steel casing shall be within 1" of specified elevation.
   4. Subparagraph below is based on ACI 336.1 requirements. Revise scope, design responsibility, or corrective procedure if required.
   5. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit design and construction proposals to Architect for review and approval before proceeding.

G. Inspection: Each micropile must be inspected by the Owner’s Geotechnical Engineer before placing grout, unless a hollow bar simultaneous drilling and grouting procedure is used.

3.03 GROUTING AND EMBEDING REBAR AND CASING

A. Reinforcing bars and permanent steel casing shall be placed prior to grouting, unless a hollow bar simultaneous drilling and grouting procedure is used, and shall be free of deleterious substances that might contaminate the grout or impair bond.

B. The Contractor shall have means and methods of measuring the grout quantity and pumping pressure (if pressure grouting is used) during the grouting operations. The grout mixture shall be kept in agitation prior to placement and shall be placed in one continuous operation

C. The Contractor shall prepare and submit to the Architect full installation records for each micropile installed. The records shall be submitted within one week. The date shall be recorded on the installation log. A separate log shall be completed for each micropile.

D. Grout equipment shall produce a uniformly mixed grout free of lumps and undispersed cement, and be capable of continuously agitating the grout. Size the grouting equipment to enable the entire micropile to be grouted in one continuous operation. Place the grout within 60 minutes after mixing, or within the time recommended by the admixture manufacturer, if admixtures are used. Grout not placed in the allowed time limit will be rejected.

E. Install the grout after installation of the steel bar and permanent steel casing, if any, unless a hollow bar simultaneous drilling and grouting procedure is used. Accurately position, support, and secure reinforcement against displacement during grouting. Place spacers at 9 feet on center maximum, and within 4 feet of top and bottom of micropile. Maintain minimum 3/4" cover to reinforcement.
F. Bar couplings shall be installed tight with jamb nuts.

G. Each hole will be grouted the same day of drilling, unless otherwise approved by the Owner’s geotechnical engineer. Inject the grout at the lowest point of each hole through a grout tube. Keep the outlet end of the grout tube at the bottom of the borehole to prevent the creation of voids. Completely fill the hole in one continuous operation. Cold joints in the grout column are not allowed. At the Contractor’s option, the grout tube may remain in the hole provided it is filled with grout. Grouting before insertion of the bar will not be allowed, but simultaneous grouting is acceptable if a hollow bar system is used. The quantity of the grout placed in each hole shall be recorded on the installation records.

H. Prior to placing the grout, the bar and casing shall be at a temperature of at least 40 degrees F but not more than 90 degrees F. At the time of placing the grout, the grout shall have a temperature of at least 50 degrees F but not more than 90 degrees F. The mixing water shall be a minimum temperature of 50 degrees F. If the air temperature is below 35 degrees F, exposed portions of the bar shall be protected against freezing immediately after the grout is placed until the grout achieves 1,000 psi unconfined compressive strength. These requirements shall be met any time the outside air temperature is expected to drop below 35 degrees F.

I. Maintain the grout level in the hole to the top of the hole until the grout achieves initial set. The borehole will require “topping off” to the surface after the set of the initially installed grout.

J. Completed installation of reinforcement, spacers, grout tube, etc. must be approved by the Owner’s Testing Agency before placing grout.

3.04 STEEL REINFORCEMENT ABOVE GROUND

A. Comply with recommendations in CRSI’s “Manual of Standard Practice” for fabricating, placing, and supporting reinforcement.
   1. Reinforcing: Exact location of dowels extending into work above shall be verified by the Contractor. Deviations in location of such reinforcing in excess of specified placing tolerances shall be reported to the Architect within 1 week after grout is placed.

B. Clean reinforcement of earth, and other materials that reduce or destroy bond.

C. Zinc-Coated Reinforcement: Repair cut and damaged zinc coatings with zinc repair material according to ASTM A 780. Use galvanized steel wire ties to fasten zinc-coated steel reinforcement.

D. Protect exposed ends of extended reinforcement, grout, and casing damage and exposure to weather.

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified Geotechnical Engineer to perform geotechnical field services and an independent testing and inspecting agency to sample materials, perform tests, and submit reports for drilling, grouting, and reinforcing. Geotechnical Engineer shall
review initial engineering submittal, and return to Architect and Engineer within five business days.

B. An installation report shall be prepared by the Owner’s Geotechnical Engineer for each micropile as follows:
   1. Identification Mark.
   2. Hole diameter.
   3. Actual top and bottom elevations and design top and bottom elevations.
   4. Top of ground surface elevation and top of competent bedrock elevation.
   5. Description of soil materials.
   6. Description, location, and dimensions of obstructions/voids during drilling.
   7. Final top centerline location and deviations from requirements.
   8. Variation from plumb.
   9. Verification that drilling and installation method matches those used in approved verification test(s).
   10. Cleanliness of hole.
   11. Ground-water conditions and water-infiltration rate and depth.
   12. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
   13. Date and time of starting and completing hole excavation and hole grouting.
   14. Type, size, and length of reinforcing steel and casing.
   15. Grout placing method, including delays.
   16. Remarks, unusual conditions encountered, and deviations from requirements.
   17. Grout testing results.
   18. Overrun or underrun.

C. Verification Testing:
   1. Verification tests shall be completed prior to the beginning of production micropiles. Verification Testing consists of one tension test and one compression test.
   2. The tests shall be completed and the Contractor shall allow a minimum of 10 working days for the review of the test data prior to the installation of production micropiles. Submit the details of the verification testing arrangement for approval.
   3. Construct verification test micropiles using the same equipment, installation methods, inclination and hole diameter as planned for the production micropiles. Changes in the Contractor’s drilling or installation method may require additional verification testing as determined by the Architect and shall be provided at no additional cost to the Owner.
   4. Verification test micropiles shall be built as described for the proof load tests. Verification test micropiles shall be incrementally loaded to a maximum test load based on a percentage of the Design Test Load (DTL) in accordance with the following loading schedule. The Design Test Load shall be equal to the specified service load on the drawings. Verification tests shall be as proof testing with the exception the verification will be tested to 2 times the DTL. The micropile movements shall be recorded at each load increment.
5. The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed five percent of the Design Test Load.

**Verification Test Loading Schedule**

<table>
<thead>
<tr>
<th>LOAD</th>
<th>HOLD TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL (.05 DTL max.)</td>
<td>1 minute</td>
</tr>
<tr>
<td>0.25 DTL</td>
<td>2.5 minutes</td>
</tr>
<tr>
<td>0.50 DTL</td>
<td>2.5 minutes</td>
</tr>
<tr>
<td>0.75 DTL</td>
<td>2.5 minutes</td>
</tr>
<tr>
<td>1.00 DTL</td>
<td>2.5 minutes</td>
</tr>
<tr>
<td>1.25 DTL</td>
<td>2.5 minutes</td>
</tr>
<tr>
<td>1.50 DTL (Creep Test)</td>
<td>60 minutes</td>
</tr>
<tr>
<td>1.75 DTL</td>
<td>2.5 minutes</td>
</tr>
<tr>
<td>2.00 DTL (MTL for bar)</td>
<td>2.5 minutes</td>
</tr>
</tbody>
</table>

6. Micropile movements during the creep portion of the test shall be measured and recorded at 1 minute, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. The load during the creep test shall be maintained within two percent of the specified load by use of the load cell.

7. Verification tests will be accepted if the vertical movements of the tension and compression bars tested bar satisfy the creep requirements listed for the Proof Testing, and if the total vertical movement is less than 1/2”.

**D. ProofTesting:**

1. Test and acceptance per ASTM D 11438-81 and IBC 2006 Section 1808.2.8.3
2. Perform a tension proof test on a minimum of 5 percent of the production micropiles at locations selected at random by the Owner’s Geotechnical Engineer. Perform a minimum of one lateral load tension test on a battered micropile.
3. Required test data shall be recorded by the Contractor. Do not perform testing until the grout has attained the specified 3-day compressive strength.
4. Testing Equipment. Testing equipment shall include all necessary items to satisfactorily apply a tension load and monitor the bar movement. This may include, but may not be limited to: hydraulic ram, hydraulic pump (hand or electric operated) with pressure gauge, dial gauge indicator, tripod (reference point), dial gauges, dial gauge support, and miscellaneous small tools. Provide a description of the test setup and jack, and pressure gauge calibration curves in accordance with Submittals section
5. The hydraulic ram (jack), pump, and pressure gauge shall be calibrated as a unit and used in that fashion. Any acceptable combination of a ram, pump, and gauge may be used together as long as a calibration curve exists for those particular items. The calibration shall have been performed within 30 days of initial testing and every 6 months thereafter.
6. The hydraulic ram must be capable of efficiently achieving and maintaining a load range to effectively sustain the maximum anticipated test loads. The displacement capacity, or throw of the ram cylinder, shall have sufficient travel to complete the test without resetting.
7. Hydraulic Pump:
   a. The hydraulic pump shall be capable of applying each load increment in less than 60 seconds, and shall be equipped with a gauge that is divided into 100 psi or less intervals. The gauge shall be mounted to read output line pressure to the pump.
   b. A dial gauge and independent reference point shall also be used to measure elongation of the bar at the stressing end. The dial gauge shall have sufficient travel to complete the test without resetting. The dial gauge shall be capable of recording bar movement at each load increment to the nearest 0.001 inches. The dial gauge shall be supported on a fixed reference independent to movement of the structure.
   c. Align the jack, bearing plates, and reaction frame with the bar such that unloading and repositioning of the equipment will not be required during the test. Visually align the gauges to be parallel with the axis of the bar and support the gauges independently of the jack, wall or reaction frame.

8. The stressing equipment shall be placed over the bar in such a manner that the jack, bearing plates, and stressing anchorage are axially aligned with the bar/pipe and the bar is centered within the equipment.

9. Proof Test:
   a. The Design Test Load (DTL) during proof testing shall be the same as that used for the verification tests.
   b. The proof tests shall be performed by incrementally loading the proof test bar to a maximum test load of 150% of the design test load.
   c. The bar movement at each load shall be measured and recorded. At load increments other than maximum test load, the load shall be held long enough to obtain a stable reading. Incremental loading for proof tests shall be in accordance with the following loading schedule. The bar movements shall be recorded at each load increment.
   d. The DTL for the laterally loaded micropile is 1 times the specified service load on the drawings, and the Maximum Test Load (MTL) for the laterally loaded micropile is 2 times the specified service load.
   e. The alignment load (AL) should be the minimum load required to align the testing apparatus and should not exceed five percent of the Design Test Load.

**Proof Test Loading Schedule:**

1) | LOAD | HOLD TIME |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AL (0.5 DTL max.)</td>
<td>Until Stable</td>
</tr>
<tr>
<td>0.25 DTL</td>
<td>Until Stable</td>
</tr>
<tr>
<td>0.50 DTL</td>
<td>Until Stable</td>
</tr>
<tr>
<td>0.75 DTL</td>
<td>Until Stable</td>
</tr>
<tr>
<td>1.00 DTL</td>
<td>Until Stable</td>
</tr>
<tr>
<td>1.25 DTL</td>
<td>Until Stable</td>
</tr>
<tr>
<td>1.50 DTL (Max. Test Load)</td>
<td>See Below</td>
</tr>
</tbody>
</table>

2) Depending on performance, either 10 minute or 60 minute creep tests shall be performed at the maximum test load. The creep period shall start as soon as the maximum test load is applied and the bar movement shall be measured and recorded at 1, 2, 3, 5, 6 and 10 minutes. Where the bar
movement between 1 minute and 10 minutes exceeds 0.04 inches based on the average of the two dial gauges, the maximum test load shall be maintained an additional 50 minutes and movements shall be recorded at 20, 30, 50 and 60 minutes.

f. Proof Test Acceptance: Proof test results shall be submitted to the Architect and Owner’s Geotechnical Engineer for review. The acceptance criteria for bar support proof tests shall be:
   1) For vertically loaded proof tests, a total creep movement of less than 0.04 inches is measured between the 1 and 10 minute readings, or a total creep movement of less than 0.08 inches is measured between the 6 and 60 minute readings, and the creep rate is linear or decreasing when plotted on a log scale throughout the creep test.
   2) For vertically loaded proof tests, the total vertical movement is less than 1/2".
   3) The lateral loaded micropile proof test will be accepted if there is no failure of the soil and pile, if the lateral deflection at 1.0 DTL is less than 1/2", and if the lateral deflection at the MTL is less than 2”.
   4) A pullout failure does not occur at any test load. Pullout failure is defined as the load at which attempts to further increase the test load simply result in continued pullout movement of the test bar. The pullout failure load shall be recorded as part of the test data.

g. Proof Test Rejection:
   1) If the Architect determines that the failure was caused by the installation methods or materials, the Architect may require the Contractor to replace some or all of the installed production pipe supports between a failed proof test location and the adjacent passing proof test location. Alternatively, the Architect may require the installation and testing of additional proof test of bar supports. Installation and testing of additional proof test locations or installation of additional or modified pipe supports as a result of proof test failure(s) will be at no additional cost to the Owner.

E. Grout: Owner’s Testing and Inspection Agency shall sample and test grout as follows:
   1. Grout Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.
   2. Compression Test Specimens: ASTM C 31/C 31M; one set of four cubes for each compressive-strength test, unless otherwise indicated. Mold and store cubes for laboratory-cured test specimens.
   3. Compressive-Strength Tests: ASTM C 39; one set for each micropile. One specimen will be tested at 3 days, one specimen will be tested at 7 days, and 2 specimens will be tested at 28 days.
   4. Include time water was added to cement when making the grout batch and time when placement of grout was finished.

F. Inspections: the following shall be inspected/tested by the Owner’s Geotechnical Engineer:
   1. Grout placement:
a. Inspect all grout placement, including mixing, conveying and placing

2. Steel reinforcement placement:
   a. Inspect all reinforcing, verifying type of reinforcing, bar sizes, spacings, grout cover to bar, bar locations, splices including splice location and mechanical connector, in place condition of coated bars, and method of support of reinforcing.
   b. Inspect partially embedded reinforcement, which is field bent, or field straightened. Verify that procedures specified in ACI-301-05 Section 3.3.2.8 – “Field Bending or Straightening” are followed. Inspect all field bent using visual and magnetic particle methods after bending is complete.

3. Structural Steel:
   a. Inspect plates, nuts, washers at the top of micropile reinforcing. Verify that sizes and embedment are as specified.
   b. Welds: All (100%) shop and all field welds shall be visually inspected and 10% of all welds shall be magnetic particle tested.

4. Verification and Proof Testing:
   a. Review Contractor’s proposed means and methods for verification and proof tests.
   b. Observe and review all data for all verification and proof tests.
   c. Return reviewed copies of above information to the Architect and Structural Engineer within five business days.

3.06 DISPOSAL OF MATERIALS

A. Material removed during micropile construction shall be disposed of offsite.

3.07 CONSTRUCTION WASTE MANAGEMENT: (CREDIT MR2)

A. Manage construction waste in accordance with provisions of Division 01 Section “Construction Waste Management and Disposal”. Submit documentation to satisfy the requirements of that section.

END OF SECTION
SECTION 32 12 16

ASPHALT PAVING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Additional information concerning asphalt paving may be found on the civil drawings, in the project geotechnical report and agency having jurisdiction construction standards. In case of conflict between the drawings, jurisdictional criteria and the information specified herein, the more stringent requirements shall govern.

B. Additional information concerning asphalt paving may be found in the geotechnical investigation report by CTL Thompson dated December 8, 2008. All requirements of this report shall be followed unless noted otherwise. The information shown in this report is for information and it shall be the contractors responsibility to field verify conditions indicated.

1.02 SUMMARY

A. This Section includes the following:
   1. Hot-mix asphalt paving.
   2. Hot-mix asphalt patching.
   3. Hot-mix asphalt paving overlay.
   4. Asphalt surface treatments.
   5. Cold milling of existing hot-mix asphalt pavement.

B. Related Sections include the following:
   1. Division 01 Section “LEED” or “Sustainable Design” requirements for product data and manufacturing documentation.
   2. Division 01 Section “Construction Waste Management and Disposal” for recycling and disposal of waste.
   3. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling and site grading.
   4. Division 31 Section “Temporary Erosion and Sedimentation Control” for storm water erosion and sediment mitigation.

C. References:
   2. Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, current edition and all appropriate standard special provisions.

1.03 DEFINITIONS

A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

B. CDOT: State of Colorado Department of Transportation.

ASPHALT PAVING

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C. CDOT Specifications: Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, current edition and all appropriate standard special provisions.

1.04 SYSTEM DESCRIPTION

A. Provide hot-mix asphalt paving in accordance with Section 401 of the CDOT Specifications.
   2. Measurement and payment provisions and safety program submittals included in CDOT Specifications do not apply to this Project.

1.05 SUBMITTALS

A. Product Data: For each type of product indicated, include technical data and tested physical and performance properties.

B. Job-Mix Designs: For each job mix proposed for the Work.

C. Material Test Reports: For each paving material.

D. Material Certificates: For each paving material, signed by providers.

E. LEED Submittals
   1. Product Data for Credit MR 4.1 and Credit MR 4.2: Include manufacturer’s product data indicating separate percentages, by weight, of post-consumer and pre-consumer recycled content for projects having recycled content. Include statement indicating material costs for products.
   2. Product data for Credit MR 5.1 and Credit MR 5.2: Indicate location of manufacturing facility including name, address and distance between manufacturing facility and the proposed site. Provide manufacturer’s documentation indicating location where the base materials were extracted, mined, quarried, harvested, etc. and the distance between this location and the project site. Also include material costs, excluding cost of installation.

1.06 QUALITY ASSURANCE

A. Manufacturer and Installer Qualifications:
   1. Manufacturer Qualifications: Engage a firm experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-service performance.
   2. Installer Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

B. Testing Agency:
   1. All testing and inspections required herein will be performed by an independent testing and inspection agency employed by the Owner.
   2. Notify the testing and inspection agency not less than 48 hours in advance of all work requiring testing or inspection services.
C. Testing Requirements: Asphalt Paving shall be tested for gradation, asphalt content and inplace density in accordance with CDOT Specifications, the current edition of CDOT Field Materials Manual, and local Regulatory Agency requirements, whichever are the most stringent.

D. Preconstruction Conference: Conduct conference at Project site as directed by Owner’s Representative. Contractor to comply with requirements, which may also be included in Division 01 Section "Project Management and Coordination."

1.07 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp or if the following conditions are not met:
   1. Tack Coats: Minimum surface or air temperature in the shade of 60 deg F (15 deg C).
   2. Slurry Coat: Comply with weather limitations of ASTM D 3910.
   3. Asphalt Base Course: Minimum surface or air temperature in the shade of 40 deg F and rising at time of placement.
   4. Asphalt Surface Course: Minimum surface or air temperature in the shade of 50 deg F and rising at time of placement.

B. Coordination and Scheduling:
   1. Cooperate with other trades and arrange scheduling to avoid damage to other work, including grading, site utilities and piping, exterior concrete, landscaping and irrigation systems.
   2. Before commencing pavement operations, ascertain that utility lines, site lighting and wiring, piping, curb and gutter work, general grading and heavy trucking is complete so that such operations will not damage paving work.
   3. Mask off and protect exposed building surfaces and abutting concrete from damage or staining by tack coat and paving operations.

PART 2 - PRODUCTS

2.01 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations meeting the requirements of the CDOT Specifications.

B. Asphalt Concrete Aggregate: Clean, hard, durable particles of crushed stone, crushed slag, crushed gravel, or natural gravel conforming to the requirements of Subsection 703.04 of the CDOT Specifications and Grading SX and S (Table 703-4).

C. Mineral Filler: Rock dust, slag dust, hydrated lime, hydraulic cement, or other suitable mineral material conforming to the requirements of Subsection 703.06 of the CDOT Specifications.

2.02 ASPHALT MATERIALS

A. Asphalt Cement: The asphalt cement to be used on this project shall be PG 64-22 conforming to the requirements of Subsection 702.01 of the CDOT Specifications.
B. Tack Coat: AASHTO M 140, emulsified asphalt or AASHTO M 208, cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

C. Fog Seal: AASHTO M 140, emulsified asphalt or AASHTO M 208, cationic emulsified asphalt, slow setting, diluted at the factory in water, of suitable grade and consistency for application.

D. Water: Potable.

2.03 MIXES

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes. Furnish job-mix formulas for each pavement type, conforming to the requirements of Subsection 401.02 of the CDOT Specifications. Mix aggregates and bituminous materials in accordance with the requirements of Subsection 401.15 of the CDOT Specifications. Use approved job mix formulas. Mix to comply with the following requirements:
   1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
   2. Base Course: Grading S.
   3. Surface Course: Grading SX.

B. Emulsified-Asphalt: Shall conform to AASHTO M140 or M208 in accordance with Subsection 702.03 of the CDOT Specifications.

2.04 LEED REQUIREMENTS

A. Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity.

B. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that subgrade is unfrozen, free of water, snow, and ice otherwise in suitable condition to support paving and imposed loads.

B. Proof-roll subbase using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction. Scarify, regrade and recompact surface of subgrade that is pumping or deforming as required to provide true levels, uniform slopes and proper total thickness of paving as required in Division 31 Section "Earth Moving."

C. Proceed with paving only after unsatisfactory conditions have been corrected.
3.02 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.
   1. Mill to a depth of a minimum 1 ½-inches or as indicated on the plans.
   2. Mill to a uniform finished surface free of gouges, grooves, and ridges.
   3. Control rate of milling to prevent tearing of existing asphalt course.
   4. Repair or replace curbs, manholes, and other construction damaged during cold milling.
   5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
   6. Transport milled hot-mix asphalt to asphalt recycling facility.
   7. Keep milled pavement surface free of loose material and dust.

3.03 PATCHING

A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches (300 mm) into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.2 gal./sq. yd. (0.2 to 0.8 L/sq. m).
   1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

C. Patching: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.04 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch (25 mm) in existing pavements.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 inch (6 mm).
   1. Clean cracks and joints in existing hot-mix asphalt pavement.
   2. Use emulsified-asphalt slurry to seal cracks and joints less than ¼ inch (6 mm) wide. Fill flush with surface of existing pavement and remove excess.
   3. Use hot-applied joint sealant to seal cracks and joints more than ¼ inch (6 mm) wide. Fill flush with surface of existing pavement and remove excess.
C. Hot-applied joint sealant being a single-component formulation complying with ASTM D 3405 or D1190.
   1. Refer to CDOT Standard Specification, Section 702.06 for joint and crack sealant material requirements.
   2. Refer to CDOT Standard Specification, Section 408.01 and 408.03 for joint and crack sealant installation requirements.

3.05 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
   1. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.

B. Herbicide Treatment: Apply herbicide according to manufacturer’s recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.20 gal./sq. yd. (0.2 to 0.8 L/sq. m).
   1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.06 PAVING GEOTEXTILE INSTALLATION

A. Apply asphalt binder uniformly to existing pavement surfaces at a rate of 0.25 gal./sq. yd. (1.0 L/sq. m) per in accordance with Subsection 420.04 of the CDOT Specifications.

B. Place paving geotextile promptly according to manufacturer’s written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints 4 inches (100 mm) and transverse joints 6 inches (150 mm).
   1. Protect paving geotextile from traffic and other damage and place hot-mix asphalt paving overlay the same day.

3.07 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
   1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated on the plans or as directed by Geotechnical Report. Maximum lift thickness shall be 3-inches. Minimum lift thickness shall be 1½-inches for Grading SX and 2-inches for Grading S.
   2. Place hot-mix asphalt surface course in single lift. Maximum lift thickness shall be 2-inches.
   3. Spread mix at minimum temperature of 235 deg F (113 deg C) per in accordance with Subsection 401.15 of the CDOT Specifications, Table 401-5.
   4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes, unless otherwise indicated.
5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet (3 m) wide unless infill edge strips of a lesser width are required.
   1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.08 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions with same texture and smoothness as other sections of hot-mix asphalt course.
   1. Clean contact surfaces and apply tack coat to joints.
   2. Offset longitudinal joints, in successive courses, a minimum of 6 inches (150mm).
   3. Offset transverse joints, in successive courses, 6 to 12 inches (150-300 mm).
   4. Construct transverse joints as described in AI MS-22, "Construction of Hot Mix Asphalt Pavements."
   5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
   6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.09 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or vibratory-plate compactors in areas inaccessible to rollers.
   1. When paving surface temperature falls below 185 deg F (85 deg C) no further compaction effort will be permitted unless approved.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density in accordance with Subsection 401.17 of the CDOT Specifications.
   1. Pavement shall be compacted to a density of 92% to 96% of the maximum theoretical density, determined according to Colorado procedure 51. Field density determination will be in accordance with Colorado Procedure 44 or 81.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.10 INSTALLATION TOLERANCES

A. Thickness: Compact each course to produce the thickness indicated within the following tolerances:
   1. Base Course: Plus or minus ¼ inch (6 mm).
   2. Surface Course: Plus ¼ inch (6 mm), no minus.

B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:
   1. Base Course: ¼-inch (6 mm).
   2. Surface Course: \( \frac{3}{16} \) inch (5 mm).
   3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is ¼-inch (6 mm).

3.11 MANHOLE FRAME ADJUSTMENTS

A. Set frames for manholes and other such units within areas to be paved to ¼-inch minimum to ½-inch maximum below final grade as part of this work. Include existing frames or new frames furnished under other sections of these specifications.

B. Set cover frames to ¼-inch minimum and ½-inch maximum below surface of adjacent pavement. Surround frames set to grade with a ring of compacted asphaltic concrete base prior to paving. Place asphaltic concrete mixture up to 1-inch below top of frame, slope to grade, and compact with hand tamping. Adjust frames as required for paving.

C. Provide temporary closures over openings until completion of rolling operations. Remove closures at completion of work.

3.12 ASPHALT CURBS

A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of 250 deg F (121 deg C).
   1. Asphalt Mix: Same as pavement surface-course mix.
B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.13 SURFACE TREATMENTS

A. Fog Seals: Apply fog seal at a rate of 0.10 to 0.15 gal./sq. yd. (0.45 to 0.7 L/sq. m) to existing asphalt pavement and allow to cure. With a fine sand, lightly dust areas receiving excess fog seal.

B. Slurry Seals: Apply slurry coat in a uniform thickness according to ASTM D 3910 and allow to cure.
   1. Roll slurry seal to remove ridges and provide a uniform, smooth surface.

3.14 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and to prepare test reports.
   1. Testing agency will conduct and interpret tests and state in each report whether tested work complies with or deviates from specified requirements.

B. Additional testing and inspecting, at Contractor’s expense, will be performed to determine compliance of replaced or additional work with specified requirements.

C. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

D. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.
   1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
   2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
      a. One core sample will be taken for every 350 sq. yd. or less of installed pavement, with no fewer than 3 cores taken.
      b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

F. Asphalt Content and Gradation. Testing agency will take sample of uncompacted paving mixtures at a minimum frequency of every 1,000 tons according to Colorado Procedure – Laboratory CPL-5120 and Colorado Procedure CP-31.
G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements. Conforming to the specified requirements will be in accordance with Subsection 105.03 of the CDOT Specifications.

H. Provide temporary erosion and sedimentation control measures in accordance with Division 31 Section "Temporary Erosion and Sedimentation Control" to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation control drawings and requirements of authorities having jurisdiction.

3.15 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from project site and legally dispose of them in an EPA-approved landfill.
   1. Do not allow excavated materials to accumulate on-site.
   2. Maintain records of weight or volume of all recycled material.
   3. Manage construction waste in accordance with provisions of Division 1 Section “Construction Waste Management and Disposal” for recycling and disposal of waste. Submit documentation to satisfy the requirements of that section.

END OF SECTION
SECTION 32 13 13

CONCRETE PAVING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes constructing exterior concrete paving on prepared subgrade or base course in accordance with these specifications. This work shall be in conformity with the lines, grades, thicknesses and typical cross-sections shown on the plans for the following:
1. Driveways and roadways.
2. Sidewalks, steps, ramps.
3. Dumpster and loading dock pads.
4. As detailed on the plans.

B. Related Sections include the following:
1. Division 01 Section “LEED” or “Sustainable Design” requirements for product data and manufacturing documentation.
2. Division 01 Section “Construction Waste Management and Disposal” for recycling and disposal of waste.
3. Divisions 31 Section "Earth Moving" for subgrade preparation, grading, and subbase course.
4. Division 31 Section "Temporary Erosion and Sedimentation Control" for storm water erosion and sediment mitigation.

1.02 REFERENCES


B. Colorado Department of Transportation Standard Specifications for Road and Bridge Construction, current edition.

1.03 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, expansive hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume.

B. CDOT: State of Colorado Department of Transportation.


F. Refer to ACI 301: (American Concrete Institute – Standard Specifications for Structural Concrete), for additional definitions.

1.04 SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated.

B. Design Mixes: For each concrete pavement mix, and includes alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

C. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:
   1. Aggregates.
   2. Cement.
   3. Admixtures.

D. Material Certificates: Signed by manufacturers certifying that each of the following materials used in the project complies with requirements:
   1. Cementitious materials and aggregates.
   2. Steel reinforcement and reinforcement accessories.
   3. Fiber reinforcement.
   4. Admixtures.
   5. Curing compounds.
   7. Bonding agent or adhesive.
   8. Joint fillers.

E. Field quality-control test reports.

F. LEED Submittals
   1. Product Data for Credit MR 4.1 and Credit MR 4.2: Include manufacture’s product data indicating separate percentages, by weight, of post-consumer and pre-consumer recycled content for projects having recycled content. Include statement indicating material costs for products.
   2. Product data for Credit MR 5.1 and Credit MR 5.2: Indicate location of manufacturing facility including name, address and distance between manufacturing facility and the proposed site. Provide manufacture’s documentation indicating location where the base materials were extracted, mined, quarried, harvested, etc. and the distance between this location and the project site. Also include material costs, excluding cost of installation.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed pavement work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
B. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94/C 94 M requirements for production facilities and equipment.
   1. Manufacturer must be certified according to the National Ready Mix Concrete Association’s (NRMCA) Plant Certification Program.

C. Testing Agency Qualifications: An independent agency qualified according to ASTM C1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
   1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.

D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer’s plant and each aggregate from one source.


F. Concrete Testing Service: The Owner will engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

G. Preconstruction Conference: Conduct conference at project site as directed by Owner’s Representative prior to start of construction. Contractor to comply with requirements, which may also be included in Division 1 Section "Project Management and Coordination."

H. Regulatory Requirements:
   I. Comply with CDOT standards for sidewalks, curbs, ramps, gutters, and driveway approaches or aprons, including standard dimensions, profiles, thicknesses, reinforcing, and compressive strength. In the event of conflict between the Contract Documents and the standards, the more stringent requirements will apply.

1.07 PROJECT CONDITIONS

A. Coordination and Scheduling: Coordinate with other trades and arrange scheduling to avoid damage to other work including grading, site utilities and piping, asphalt paving, landscaping and irrigation systems.

B. Field Measurements: Verify dimensions and existing conditions shown on the drawings by taking field measurements prior to start of work. Report discrepancies to the Owner’s Representative for clarification and make minor adjustments in layout as required by field conditions and as approved by the Owner’s Representative, at no additional cost to the Owner.

C. Environmental Requirements: Perform work only under suitable weather conditions. Comply with the environmental requirements of Section 3.6 for concrete placement.
PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
   2. Products: Subject to compliance with requirements, provide one of the products specified.
   3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
   4. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
   1. Use flexible or curved forms for curves of a radius 100 feet or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.03 COLORED ADMIXTURE

Colored Admixture: L.M. Scofield Co. “Chromix” or Rockwood Industries “Davis Colors”, color as selected by Owner’s Representative. Use for colored concrete where indicated on the drawings.

2.04 EXPANSION JOINT FILLER

A. Sealed Joints: Preformed, compressible fiber or cork filler material complying with ASTM D1751 or D1752, Type II, guaranteed compatible with expansion joint sealant materials, ½” thick unless otherwise indicated. Provide high-impact polystyrene removable “void cap” to create ½” deep reveal for installation of sealant.

B. Self-Sealing Joints: Preformed, compressible asphalt fiber joint filler complying with ASTM D994, ½” thick unless otherwise indicated. Do not use asphalt fiber filler in joints to receive elastomeric joint sealants.
2.05 CONCRETE MATERIALS

A. Cementitious Material: Use one of the following cementitious materials, of the same type, brand, and source throughout the Project:
   1. Portland Cement: CDOT Section 701 and ASTM C 150, Type V
      a. Fly Ash: ASTM C 618, Class F.
      b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregates: CDOT Section 703 and ASTM C 33, coarse aggregate, uniformly graded. Provide aggregates from a single source.
   1. Maximum Coarse-Aggregate Size: 3/4 inch (19 mm) nominal.
   2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
   3. Do not use fine or coarse aggregates containing substances that cause spalling.

C. Water: CDOT Section 712 and ASTM C 94/C 94M potable.

D. Contractor to provide cost of cementitious materials to satisfy LEED requirements.

2.06 ADMIXTURES

A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cement and to be compatible with other admixtures.

B. Air-Entraining Admixture: CDOT Section 711 and ASTM C 260.

C. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.
   5. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   6. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   7. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.07 FIBER REINFORCEMENT

A. Synthetic Fiber: Monofilament polypropylene fibers engineered and designed for use in concrete pavement, complying with ASTM C 1116, Type III, 1/2 to 1-1/2 inches (13 to 38 mm) long.

2.08 CURING MATERIALS: CDOT SECTION 711

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq.yd. (305 g/sq.m) dry.

B. Moisture-Retaining Cover: ASTM C 171, waterproof paper, polyethylene film or white burlap-polyethylene sheet.
C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.

E. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type I, Class B.
   1. Provide material that has a maximum volatile organic compound (VOC) rating of 350 g/L.

F. White Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type II, Class B.
   1. Provide material that has a maximum volatile organic compound (VOC) rating of 350 g/L.

2.09 CONCRETE MIXTURES

A. Prepare design mixes, proportioned according to ACI 211.1 and ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.
   1. Use a qualified independent testing agency for preparing and reporting proposed mix designs for the trial batch method.
   2. Do not use Owner's field quality-control testing agency as the independent testing agency.

B. Proportion mixes to provide concrete with the following properties:
   1. Compressive Strength (28 Days): 4,000 psi (27.6 MPa).
   2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.40.
   3. Slump Limit: 4 inches (100 mm).
   4. Minimum 660 lb. Cement per cubic yard. (CDOT Class P)

C. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content of 5.0 to 7.0 percent.

D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing admixture and/or plasticizing and retarding admixture in concrete, as required, for placement and workability.
   2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements for concrete exposed to deicing chemicals as follows:
   1. Fly Ash: 15 - 30 percent Class F Fly Ash CDOT Section 601.02, Class P Concrete.

G. Synthetic Fiber: Uniformly disperse in concrete mix at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd.

H. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions.

CONCRETE PAVING
32 13 13 - 6
2.10 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116. Furnish batch certificates for each batch discharged and used in the Work.

2.11 LEED REQUIREMENTS

A. Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity.

B. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below concrete with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding.
   1. Completely proof-roll subbase in one direction. Limit vehicle speed to 3 mph (5 km/h).
   2. Proof-roll with a loaded 10-wheel tandem-axle dump truck weighing not less than 15 tons.
   3. Subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch (13 mm) require correction according to requirements in Division 2 Section "Earth moving."

C. Subgrade shall be tested by Geotechnical Engineer and pass required tests prior to concrete pavement placement.

D. Proceed with concrete pavement operations only after non-conforming conditions have been corrected and subgrade is ready to receive pavement.

E. Provide temporary erosion and sedimentation control measures in accordance with Division 31 Section "Temporary Erosion and Sedimentation Control" to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation control drawings and requirements of authorities having jurisdiction.

3.02 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.
3.03 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form release agent to ensure separation from concrete without damage.

3.04 STEEL REINFORCEMENT

A. General: Comply with CRSI’s "Manual of Standard Practice" for fabricating reinforcement and with recommendations in CRSI’s "Placing Reinforcing Bars" for placing and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 12-inch (300-mm) overlap of adjacent mats.

F. Recycled Content: Provide steel reinforcement with an average recycled content of steel so postconsumer recycled content plus one-half of preconsumer recycled content is not less than (25) percent.

3.05 JOINTS

A. General: Construct/install construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.

1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.

2. Contractor to provide plan of joint placement for the Engineers approval.

3. The distance between joints shall not exceed in feet, twice the pavement thickness in inches. (i.e.: 6” PCC pavement to utilize maximum 12-foot joint spacing.)
B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour, unless pavement terminates at expansion joints.
   1. Contractor may utilize preformed galvanized steel or plastic keyway-section forms or bulkhead forms with keys, unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
   2. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.
   3. Provide tie bars at sides of pavement strips where indicated.
   4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys, unless otherwise indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.

C. Expansion Joints: Form expansion joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
   1. Extend joint fillers full width and depth of joint.
   2. Terminate joint filler no less than 1/2 inch or no more than 1 inch below finished surface for joint sealant.
   3. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
   4. Protect top edge of joint filler during concrete placement with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
   1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with groover tool to the indicated radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.
   2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
   3. Tied Contraction Joints: Install deformed bars and support assemblies at joints where indicated.

3.06 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcement steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.
C. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.

D. Comply with ACI 301 and ACI 304R requirements and recommendations for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery to the project site.

F. Do not add water to fresh concrete after testing.

G. Do not add water to concrete surface during finishing operations.

H. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

I. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping. Use equipment and procedures to consolidate concrete according to recommendations in ACI 309R.
   1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

J. Screed pavement surfaces with a straightedge and strike off.

K. Commence initial floating using bull floats or darbies to form an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading dry-shake surface treatments.

L. Curbs and Gutters: Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified with expansion joints at intervals of approximately 100 feet and tooled contraction joints at 10-foot intervals. When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements.

M. Walks: Minimum 4" thick, with expansion joints at intervals of approximately 100 feet and tooled contraction joints at intervals equal to width of walks or maximum 5-foot intervals. Tool edges to rounded profile and finish as noted herein or shown on the drawings. Contractor may utilize sawed contraction joints. Pitch walks ¼" per foot for drainage unless otherwise indicated.

N. Ramps: Construct ramps similar to walks. Comply with applicable ADA Handbook, ANSI A117.1, and local and State codes, ordinances, and details including maximum allowable slope not to exceed 1 foot vertical in 12 foot horizontal, with maximum rise not to exceed 30” between level landings.
O. Steps: Minimum 6" thick at intersection of treads and risers, reinforced as indicated. Slope treads ¼" to nosing, and tool nosings to uniform ½" radius. Finish as specified below.

P. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators, unless otherwise specified and approved in mix designs.

Q. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 deg F. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover reinforcement steel with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, reinforcement steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

R. Wet-Weather Placement: Do not begin to place concrete while rain, sleet, or snow is falling unless adequate protection is provided and, when required, acceptance of protection is obtained.

3.07 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/4-inch (6-mm) radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

C. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots, and fill low spots. Refloat surface immediately to uniform granular texture.
1. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
3.08 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection and follow the recommendations of ACI 305R for hot-weather protection during curing.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

D. Begin curing after finishing concrete, but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moist Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.09 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4 inch.
3. Surface: Gap below 10-foot long, unleveled straightedge not to exceed 1/4 inch.
4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch.
5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch.
6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 1/2 inch.
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4 inch per 12 inches.
8. Joint Spacing: 3 inches.
3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
   1. Testing Frequency: Obtain at least 1 composite sample for each 2500 sq. ft. or fraction thereof of each concrete mix placed each day.
      a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day’s pour of each type of concrete mix. Perform additional tests when concrete consistency appears to change.
   3. Air Content: ASTM C 231, pressure method; one test for each composite strength test, but not less than one test for each day’s pour of each type of concrete mix.
   4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each set of composite strength specimens.
   5. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test, unless otherwise indicated. Cylinders shall be molded and stored for laboratory-cured test specimens unless field-cured test specimens are required.
   6. Compressive-Strength Tests: ASTM C 39; one set for each day’s pour of each concrete class exceeding 5 cu. yd., but less than 25 cu. yd., provide at least two tests for every 2,500 sq.ft. One specimen shall be tested at 7 days and two specimens at 28 days; one specimen shall be retained in reserve for later testing if required.
   7. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, current operations shall be evaluated and corrective procedures shall be provided for protecting and curing in-place concrete.

C. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).

D. Test results shall be reported in writing to Owner’s Representative, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, concrete type and class, location of concrete batch in pavement, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7 and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Owner’s Representative, but will not be used as the sole basis for approval or rejection.
F. Additional Tests: Testing agency shall make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by Owner’s Representative. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

G. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

H. Additional testing and inspecting, at Contractor’s expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.11 REPAIRS AND PROTECTION

A. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.

B. Drill test cores where directed by Owner’s Representative when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.

C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

3.12 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from project site and legally dispose of them in an EPA-approved landfill.
   1. Do not allow excavated materials to accumulate on-site.
   2. Maintain records of weight or volume of all recycled material.
   3. Manage construction waste in accordance with provisions of Division 1 Section “Construction Waste Management and Disposal” for recycling and disposal of waste. Submit documentation to satisfy the requirements of that section.

END OF SECTION
SECTION 32 84 23
UNDERGROUND SPRINKLERS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Work of this Section generally includes provisions for the installation of an underground landscape irrigation system including the following:
   1. Static pressure verification and coordination of irrigation system installation with landscape material installation.
   2. Trenching, stockpiling excavation materials, refilling and compacting trenches.
   3. Complete irrigation system including but not limited to piping, backflow preventer assemblies, valves, fittings, heads, controllers and wiring, and final adjustments to insure complete coverage.
   5. Replacement of unsatisfactory materials.
   6. Clean-up, Consultant Reviews, and Project Acceptance
   7. Tests.

1.02 RELATED SECTIONS

A. Examine all sections related to project work.

B. Related Sections:
   1. Division 01 Sections “Construction Waste Management and Disposal”, “Sustainable Design Requirements”, and “Temporary Facilities and Controls” for temporary erosion and sedimentation-control measures for additional LEED requirements.
   2. Division 01 Section “Submittal Procedures”.
   3. Division 01 Section “Quality Requirements”.
   4. Division 01 Section “Temporary Erosion and Sedimentation Control”.
   5. Division 32 Section “Planting”.
   6. Division 32 Section “Fine Grading and Soil Preparation”.
   7. Division 32 Section “Turf and Grasses”.
   8. Division 32 Section “Landscape Maintenance”.
   9. Division 32 Section “Planting Accessories”.

1.03 REFERENCES

A. Perform Work in accordance with requirements of Conditions of the Contract and Division 01 “General Requirements” as well as provisions of all applicable laws, codes, ordinances, rules, and regulations.

B. Conform to requirements of reference information listed below except where more stringent requirements are shown or specified in Contract Documents.
   1. American Society for Testing and Materials (ASTM) - Specifications and Test Methods specifically referenced in this Section.
   2. Underwriters Laboratories (UL) - UL Wires and Cables.
1.04 QUALITY ASSURANCE

A. Installer Qualifications - Installer shall have had considerable experience and demonstrate ability in the installation of irrigation system(s) of specific type(s) in a neat orderly, and responsible manner in accordance with recognized standards of workmanship. To demonstrate ability and experience necessary for this Project, and financial stability, submit if requested by Consultant, prior to contract award the following:

1. List of 3 projects completed in the last 2 years of similar complexity to this Project. Description of projects shall include:
   a. Name of project.
   b. Location.
   c. Owner.
   d. Brief description of work and project budget.

B. Special Requirements:

1. Work involving substantial plumbing for installation of copper piping, backflow preventer(s), and related work shall be executed by licensed and bonded plumber(s). Secure a permit at least 48 hours prior to start of installation.

2. Tolerances - Specified depths of mains and laterals and pitch of pipes are minimums. Settlement of trenches is cause for removal of finish grade treatment, refilling, compaction, and repair of finish grade treatment.

3. Coordination with Other Contractors - Protect, maintain, and coordinate Work with Work under other Section.

4. Damage To Other Improvements - Contractor shall replace or repair damage to grading, soil preparation, seeding, sodding, or planting done under other Sections during Work associated with installation of irrigation system at no additional cost to Owner.

C. Pre-Construction Conference - Contractor shall schedule and conduct a conference to review in detail quality control and construction requirements for equipment, materials, and systems used to perform the Work. Conference shall be scheduled not less than 10 days prior to commencement of Work. All parties required to be in attendance shall be notified no later than 7 days prior to date of conference. Contractor shall notify qualified representatives of each party concerned with that portion of Work to attend conference, including but not limited to Architect, Consultant, Contractor’s Superintendent, and Installer.

1. Minutes of conference shall be recorded and distributed by Contractor to all parties in attendance within five days of conference.

1.05 SUBMITTALS

A. Prepare and make submittals in accordance with conditions of the Contract.

B. Materials List - Submit six copies of a complete materials list indicating manufacturer, model number, and description of all materials and equipment to be used. Show appropriate dimensions and adequate detail to accurately portray intent of construction.
C. Record Drawings (As-Builts):

1. At onset of irrigation installation secure AutoCAD files of original irrigation design from Owner. At the end of every day, revise as-built prints for work accomplished that day in red ink. As-built field prints shall be brought up-to-date at the close of the working day every Friday by a qualified draftsperson. A print of record plan(s) shall be available at Project Site. Indicate zoning changes on weekly as-built drawings. Indicate non-pressure piping changes on as-built. Upon completion of Project, but prior to scheduling of substantial acceptance walk-through, submit for review a final set of as-built mylars and an AutoCAD disk copy. Dimensions, from two permanent points of reference (building corners, sidewalk, road intersections or permanent structures), location of following items:
   a. Connection to pump assembly.
   b. Routing of sprinkler pressure lines (dimension maximum 100 feet along routing).
   c. Sprinkler control valves.
   d. Quick coupling valves.
   e. Manual drains and stop and waste valves.
   f. Drip line blow-out stubs.
   g. Control wire routing if not with pressure mainline.
   h. Gate valves.
   i. Control wire and communication cable splices.
   j. Water meters.
   k. Locations of all sleeving including size, quantity and depth of sleeve.
   l. Flow sensors.
   m. Pressure regulating valves.

2. Owner’s Representative will not certify any pay request submitted by the Contractor if the as-built drawings are not current, and processing of pay request will not occur until as-builts are up-dated.

D. Operation Instructions - Submit 3 written operating instructions including winterization procedures and start-up, with cut sheets of products, and coordinate controller/watering operation instruction with Owner maintenance personnel.

1. Controller Charts:
   a. Do not prepare charts until Consultant has reviewed record (as-built) drawings.
   b. Provide one controller chart for each automatic controller installed.
      1) Chart may be reproduction of record drawing, if scale permits fitting of controller door. If photo reduction prints are required, keep reduction to maximum size possible to retain full legibility.
      2) Chart shall be blueline print of actual "as-built" system, showing area covered by that controller.
   c. Identify area of coverage of each remote control valve, using a distinctly different pastel color drawing over entire area of coverage.
   d. Following review of charts by Consultant, they shall be hermetically sealed between two layers of 20-mm thick plastic sheet
   e. Charts shall be completed and reviewed prior to final review of irrigation system.
E. Provide documentation of construction and demolition waste debris recycling/salvage rates. See Division 01 Section “Construction Waste Management and Disposal”.

F. LEED Submittals: Credit MR 4.1 and Credit MR 4.2: Product data and certification letter indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
   a. Credit MR 5.1 and Credit MR 5.2: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, unload, store, and handle materials, packaging, bundling, products in dry, weatherproof, condition in manner to prevent damage, breakage, deterioration, intrusion, ignition, and vandalism. Deliver in original unopened packaging containers prominently displaying manufacturer's name, volume, quantity, contents, instructions, and conformance to local, state, and federal law. Remove and replace cracked, broken, or contaminated items or elements prematurely exposed to moisture, inclement weather, snow, ice, temperature extremes, fire, or jobsite damage.

B. Handling of PVC Pipe - Exercise care in handling, loading and storing, of PVC pipe. All PVC pipe shall be transported in a vehicle that allows length of pipe to lie flat so as not to subject it to undue bending or concentrated external loads. All sections of pipe that have been dented or damaged shall be discarded, and if installed, shall be replaced with new piping.

1.07 JOBSITE CONDITIONS

A. Protection of Property:
   1. Preserve and protect all trees, plants, monuments, structures, and paved areas from damage due to Work of this Section. In the event damage does occur, all damage to inanimate items shall be completely repaired or replaced to satisfaction of Owner, and all injury to living plants shall be repaired by Owner. All costs of such repairs shall be charged to and paid by Contractor.
   2. Protect buildings, walks, walls, and other property from damage. Flare and barricade open ditches. Damage caused to asphalt, concrete, or other building material surfaces shall be repaired or replaced at no cost to Owner. Restore disturbed areas to original condition.

B. Existing Trees:
   1. All trenching or other Work under limb spread of any and all evergreens or low branching deciduous material shall be done by hand or by other methods so as to prevent damage to limbs or branches.
2. Where it is necessary to excavate adjacent to existing trees use all possible care to avoid injury to trees and tree roots. Excavation, in areas where 2 inch and larger roots occur, shall be done by hand. Roots 2 inches or larger in diameter, except directly in the path of pipe of conduit, shall be tunneled under and shall be heavily wrapped with burlap to prevent scarring or excessive drying. Where a trenching machine is operated close to trees having roots smaller than 2 inches in diameter, wall of trench adjacent to tree shall be hand trimmed, making clean cuts through roots. Trenches adjacent to trees shall be closed within 24 hours, and when this is not possible, side of trench adjacent to tree shall be kept shaded with moistened burlap or canvas.

C. Protection and Repair of Underground Lines:
   1. Request proper utility company to stake exact location (including depth) of all underground electric, gas, or telephone lines. Take whatever precautions are necessary to protect these underground lines from damage. If damage does occur, Utility Owner shall repair all damage. Contractor shall pay all costs of such repairs unless other arrangements have been made.
   2. Request Owner, in writing, to locate all private utilities (i.e., electrical service to outside lighting) before proceeding with excavation. If, after such request and necessary staking, private utilities that were not staked are encountered and damaged by Installer, Owner shall repair them at no cost to Installer. If Contractor damages staked or located utilities, they shall be repaired by Utility Owner at Contractor's expense unless other arrangements have been made.

D. Replacement of Paving and Curbs - Where trenches and lines cross existing roadways, paths, curbing, etc., damage to these shall be kept to a minimum and shall be restored to original condition.

1.08 WARRANTY/GUARANTY

A. Manufacturer shall warrant materials against defects for a period of one year from date of Substantial Completion. Installer(s) shall guaranty workmanship for similar period.

B. Settling of backfilled trenches that may occur during guaranty period shall be repaired at no expense to Owner, including complete restoration of damaged property.

C. Owner will maintain turf and planting areas during warranty period, so as not to hamper proper operation of irrigation system.

1.09 MAINTENANCE

A. Furnish the following maintenance items to Owner prior to final Acceptance:
   1. Two Sets of special tools required for removing, disassembling, and adjusting each type of sprinkler head and valve supplied on this Project.
   2. One eight foot valve key for operation of stop and waste valve.
   3. Two six foot valve keys for operation of gate valves.
   4. Two keys for each automatic controller.
   5. Two quick coupler keys and two matching hose swivels for each type of quick coupling valve installed.
   6. Two aluminum drain valve keys of sufficient length for operation of drain valves.
B. Winterization – By Owner - winterizing complete system at conclusion of sprinkling season (in which system received final acceptance) within 3 days notification by the Owner. System shall be voided of water using compressed air or similar method. Reopen, operate, and adjust system malfunctions accordingly during April of following season within 3 days of notification by Owner.

1.10 EXTRA STOCK

A. In addition to installed system furnish the following items to Owner:
   1. 10 Pop-up spray heads with nozzles of each type used.
   2. 4 Rotor heads of each type used.
   3. 30 Drip emitters of each type used.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General Piping:
   1. Pressure Supply Line (from point of connection through backflow prevention unit) - Type "k" Hard Copper (3/4” – 2 1/2”) and ductile iron (3” and larger).
   2. Pressure Supply Lines (downstream of backflow prevention units) - Class 200 PVC BE (1” - 2 1/2”).
   3. Non-pressure Lines - Class 200 PVC BE.
   4. PVC Sleevings - Class 160 PVC.
   5. Drip Tubing - Toro Dura-Pol EHD 1645 3/4” with .050 inch wall thickness.
   6. Emitter Tubing - As recommended by emitter manufacturer.
   7. Copper Pipe - Type K, hard tempered.
   8. Fittings - Wrought copper, solder joint type.
   9. Joints - Soldered with solder, 45% silver, 15% copper, 16% zinc, and 24% cadmium and solidus at 1125°F and liquids at 1145°F.

B. Brass Pipe and Fittings:
   1. Brass Pipe - 85% red brass, ANSI Schedule 40 screwed pipe.
   2. Fittings - Medium brass, screwed 125-pound class.

C. Ductile Iron Pipe and Fittings:
   1. Ductile Iron Pipe – Centrifugal cast ductile iron in metal molds for water pipe in accordance with ANSI C151 and AWWA A21.51 with asphaltic exterior coating and interior lining and coating in accordance with ANSI C151 and AWWA A21.
   2. Fittings – Mechanical joint as supplied by the pipe manufacturer and rated for working pressures of 350 psi.

D. Plastic Pipe and Fittings:
   1. Identification Markings:
      a. Identify all pipe with following indelible markings:
      b. Manufacturer's name.
      c. Nominal pipe size.
2. Schedule of class.
   a. Pressure rating.
   b. NSF (National Sanitation Foundation) seal of approval.
   c. Date of extrusion.

3. Solvent Weld Pipe - Manufactured from virgin polyvinyl chloride (PVC) compound in accordance with ASTM D2241 and ASTM D1784; cell classification 12454-B, Type 1, Grade 1.
   a. Fittings - Standard Wright, Schedule 40, injection-molded PVC; complying with ASTM D1784 and D2466, cell classification 12454-B.
   b. Threads - Injection molded type (where required).
   c. Tees and ells - Side gated.
   d. Threaded Nipples - ASTM D2464, Schedule 80 with molded threads.
   e. Teflon Tape – All PVC male threaded fittings and nipples, excluding marlex fittings, shall receive wrapping of Teflon tape applied to threaded surfaces per pipe manufacturer’s recommendations.
   f. Joint Cement and Primer - Type as recommended by manufacturer of pipe and fittings.

4. Flexible Plastic Pipe - Manufactured from virgin polyethylene in accordance with ASTM D2239, with a hydrostatic design stress of 630 psi and designated as PE 2306.
   a. Fittings – Insert type manufactured in accordance with ASTM D2609; PVC Type 1 cell classification 12454-B.
   b. Clamps - All stainless steel worm gear screw clamps. Use 2 clamps per joint on 1-1/2 inch and 2 inch fittings.

E. Drip Irrigation Systems:
1. Drip Tubing - Manufactured of flexible vinyl chloride compound conforming to ASTM D1248, Type 1, Class C, Category 4, P14 and ASTM D3350 for PE 122111C.
2. Fittings - Type and diameter recommended by tubing manufacturer.
3. Drip Valve Assembly - Type and size shown on Drawings.
   a. Wye Strainer - Plastic construction with 150 mesh nylon screen and 1/2 inch blowout assembly.
   b. Control Valve - 2 way, solenoid pilot operated type made of synthetic, non-corrosive material; diaphragm activated and slow closing. Include freely pivoted seat seal; retained (mounted) without attachment to diaphragm.
   c. Pressure Reducing Valve - Plastic construction as detailed.

4. Emitters - Single port, pressure compensating, press on type.

F. Gate Valves:
1. Gate Valves for 3/4 inch through 2-1/2 Inch Pipe - Brass construction; solid wedge, IPS threads, and non-rising stem with wheel operating handle.

G. Quick Coupling Valves - Brass two-piece body designed for working pressure of 150 PSI; operable with quick coupler. Equip quick coupler with locking rubber cover.
H. Valve Boxes:
   1. Gate Valves, Quick Coupling Valves, Drain Valves, Drip Line Blow-out Stubs, and Wire Splice or Stub Box - Carson Brooks #910-10, box as detailed.
   2. 1 inch through 2 inch Control Valves, Master Valves, Pressure Regulating Valves and Communication Cable Splice box - Carson Brooks #1419-12 box as detailed.

I. Electrical Control Wiring:
   1. Low Voltage:
      a. Electrical Control Wire - AWG UFUL approved No. 14 direct burial copper wire or larger, if required to operate system as designed.
      b. Electrical Common Wire - AWG UFUL approved No. 14 direct burial copper wire or larger, if required to operate system as designed.
      c. Wire Colors:
         1) Control Wires - Red.
         2) Common Wires - White.
         3) Master Valve Wires - Blue.
         4) Drawing Spare Control Wires - Black.
         5) Drawing Spare Common Wires - Yellow.
      d. If multiple controllers are utilized, and wire paths of different controllers cross each other, both common and control wires from each controller shall be different colors, approved by Consultant.
      e. Control Wire connections and splices shall be made with 3M DBY direct bury splice.
   2. High Voltage - Type required by local codes and ordinances, of proper size to accommodate needs of equipment serviced.

J. Automatic Controller - Size and type shown on Drawings; mounted as detailed.

K. Electric Control Valves - Size and type shown on Drawings having manual flow adjustment and manual bleed nut.

L. Sprinkler Heads - As indicated on Drawings. Fabricated riser units in accordance with details on Drawings - with fittings and nipples of equal diameter as riser inlet in sprinkler body.

M. Backflow Preventer - Size and type indicated on Drawings; Brass or iron construction with 150 psi working pressure.
PART 3 - EXECUTION

3.01 SITE CONDITIONS, LANDSCAPE PLAN REVIEW AND COORDINATION

A. Contractor will be held responsible for coordination between landscape and irrigation system installation. Landscape material locations shown on the Landscape Plan shall take precedence over the irrigation system equipment locations. If irrigation equipment is installed in conflict with the landscape material locations shown on the Landscape Plan, the Contractor will be required to relocate the irrigation equipment, as necessary, at Contractor’s expense.

B. Contractor is responsible to notify Consultant of any field conditions that vary from the conditions shown on the Landscape Construction Documents. If Contractor fails to notify Consultant of these conditions, Contractor will be held responsible for all costs associated with system adjustments required due to the change in field conditions.

C. Comply with the requirements of Division 31 Section “Temporary Erosion and Sedimentation Control” for preparation and protection of the site.

3.02 STATIC PRESSURE VERIFICATION

A. Contractor shall field verify the static pressure at the project site, prior to commencing work or ordering irrigation materials, and submit findings, in writing, to Consultant. If Contractor fails to verify static water pressure prior to commencing work or ordering irrigation materials, Contractor shall assume responsibility for all costs required to make system operational and the costs required to replace any damaged landscape material. Damage shall include all required material costs, design costs and plant replacement costs.

3.03 INSPECTION

A. Examine areas and conditions under which Work of this Section is to be performed. Do not proceed with Work until unsatisfactory conditions have been corrected.

B. Grading operations, with the exception of final grading, shall be completed and approved by Owner before staking or installation of any irrigation system begins.

C. Underground Utilities shall be installed prior to installation of irrigation system. If irrigation installation takes place prior to utility installation, Contractor shall notify Owner of this condition in writing prior to commencement of irrigation installation.
3.04 PREPARATION

A. Staking shall Occur as Follows:

1. Mark, with powdered lime, routing of pressure supply line and flag heads for first few zones. Contact Consultant 48 hours in advance and request review of staking. Proposed locations of all trees shall be field staked by Contractor and approved by Owner/Landscape Architect prior to Consultant review of irrigation staking. Consultant will advise installer as to the amount of staking to be prepared. Consultant will review staking and direct changes if required. Review does not relieve installer from coverage problems due to improper placement of heads after staking.

2. Contractor shall contact Consultant if field spacing varies by +/- 10% of the spacing shown on the irrigation plans. If Contractor fails to notify Consultant of variances exceeding 10%, Contractor assumes full responsibility for the costs associated with any required system modifications deemed necessary by the Consultant or Owner.

3. If Project has significant topography, freeform planting beds, or other amenities, which could require alteration of irrigation equipment layout as deemed necessary by Consultant, do not install irrigation equipment in these areas until Consultant has reviewed equipment staking.

B. Install sleeving under asphalt paving and concrete walks, prior to concreting and paving operations, to accommodate piping and wiring. Compact backfill around sleeves to 95% Modified Proctor Density within 2% of optimum moisture content in accordance with STM D1557.

C. Trenching - Trench excavation shall follow, as much as possible, layout shown on Drawing. Dig trenches straight and support pipe continuously on bottom of trench. Trench bottom shall be clean and smooth with all rock and organic debris removed.

   1. Clearances:
      a. Piping 3 Inches and Larger - Make trenches of sufficient width (14 inches minimum) to properly assemble and position pipe in trench. Minimum clearance of piping 3 inches or larger shall be 5 inches horizontally on both sides of the trench.
      b. Piping Smaller than 3 Inches - Trenches shall have a minimum width of 7 inches.
      c. Line Clearance - Provide not less than 6 inches of clearance between each line and not less than 12 inches of clearance between lines of other trades.

   2. Pipe and Wire Depth:
      a. Pressure Supply Piping - 24 inches from top of pipe.
      b. PVC Sleevings – To match depth of sleeved material.
      c. Non-pressure Piping (rotor) - 18 inches from top of pipe.
      d. Non-pressure Piping (pop-up) - 12 inches from top of pipe.
      e. Control Wiring/Communication Cable - Side of pressure main or at 18 inch depth if installed in a separate trench with no mainline piping.
      f. Drip Tubing - 12 inches from top of pipe.
      g. Emitter Tubing (Micro-tubing) - 8 inches from top of pipe.
3. Boring will be permitted only where pipe must pass under obstruction(s) which cannot be removed. In backfilling bore, final density of backfill shall match that of surrounding soil. It is acceptable to use sleeves of suitable diameter installed first by jacking or boring, and pipe laid through sleeves. Observe same precautions as though pipe were installed in open trench.

4. Vibratory Plow - Non-pressure piping may be installed through use of vibratory plow method if consultant determines soil conditions are satisfactory for this method of installation. Vibratory plowing does not relieve installer of minimum pipe depths.

D. Pressure Supply Piping Locating Tape for Non-Potable Systems: Markline Tape, 3” wide detectable tape, NP purple in color with the words "CAUTION: RECYCLED/RECLAIMED WATERLINE BELOW" printed every 36 inches. Place 12” below finish grade.

3.05 INSTALLATION

A. Locate other equipment as near as possible to locations designated. Consultant shall review deviations prior to installation.

B. PVC Piping - Snake pipe in trench as much as possible to allow for expansion and contraction. Do not install pipe when air temperature is below 40 degrees F. Place manual drain valves at low points and dead ends of pressure supply piping to insure complete drainage of system. When pipe installation is not in progress, or at end of each day, close pipe ends with tight plug or cap. Perform Work in accordance with good practices prevailing in piping trades.

1. Solvent Weld PVC Pipe - Lay pipe and make all plastic to plastic joints in accordance with manufacturer’s recommendations.

2. Flexible Plastic (Polyethylene) Pipe - Lay pipe and assemble fittings following manufacturer's recommendations.

C. Drip Tubing:

1. Make all fitting connections as per manufacturer’s recommendations.

2. Use only manufacturer provided or recommended hole punch when making penetrations in drip tubing for insert fittings. Use of any other hole punch shall be cause for immediate removal and replacement of all installed drip tubing.

3. Install drip line blow-out stubs at all dead ends of drip tubing.

D. Control Wiring:

1. Low Voltage Wiring:
   a. Bury control wiring between controller and electric valves in pressure supply line trenches, strung as close as possible to main pipe lines with such wires to be consistently located below and to one side of pipe, or in separate trenches.
   b. Bundle all 24 volt wires at 10 foot intervals and lay with pressure supply line pipe to one side of the trench.
   c. Provide an expansion loop at every pressure pipe angle fitting, every electric control valve location (in valve box), and every 500 feet. Form expansion loop by wrapping wire at least 8 times around a 3/4 inch pipe and withdrawing pipe.
   d. Make all splices and E.C.V. connections using 3M DBY connectors or similar dry splice method.
e. Install all control wire splices not occurring at control valve in a separate splice valve box.
f. Install one control wire for each control valve.
g. Maintenance spare wires - In addition to spare wires labeled on drawings, extend two spare #14 AWG UFUL control wires and one spare #14 AWG UFUL common wire from controller pedestal to the end of each and every leg of mainline. Label maintenance spare wires at controller and wire stub box.

2. High Voltage Wiring for Automatic Controller:
   a. Provide 120 volt power connection to automatic controller.
   b. All electric work shall conform to local codes, ordinances, and authorities having jurisdiction. All high voltage electrical work shall be performed by licensed electrician.

E. Automatic Controller:
   1. Install controller in accordance with manufacturer's instructions as detailed and where shown on Drawings.
   2. Connect remote control valves to controller in numerical sequence as shown on Drawings.
   3. Owner shall approve final location of controller prior to installation.
   4. Each controller shall be a dedicated separate ground wire and grounding rod as detailed.
   5. All above ground conduit shall be rigid galvanized with appropriate fittings. All below ground conduit shall be schedule 40 PVC.

F. Electric Control Valves: Install cross-handle four inches below finished grade where shown on Drawings as detailed. When grouped together, allow minimum of 12 inches between valve box sides. Install each remote control valve in a separate valve box. Install valve box flush with grade or when present flush with surfacing material (rock mulch). When parallel to roadway, sidewalk or other permanent element or structure, control valve and box to be installed perpendicular to element or structure, spaced equally.

G. Quick Coupling Valves: Install quick couplers on swing-joint assemblies as indicated on construction details; plumb and flush to grade. Angled nipple relative to pressure supply line shall be no more than 45 degrees and no less than 10 degrees.

H. Drip Valve Assemblies: Install drip valve assembly as detailed.

I. Drip Emitters: Stake all surface emitters as detailed and staked with acceptable tubing stakes.

J. Drain Valves: Install one manual drain valve on pressure supply line directly downstream of backflow preventer as detailed. Provide a three cubic foot drainage sump for drain valve as detailed.

K. Valve Boxes:
   1. Install one valve box for each type of valve installed as detailed. Valve box extensions are not acceptable except for master valves and flow sensors. Install gravel sump after compaction of all trenches. Place final portion of gravel inside valve box after valve box is backfilled and compacted.
2. Brand controller letter and station number on lid of each valve box. Letter and number size shall be no smaller than 1 inch and no greater in size than 1 1/2 inches. Depth of branding shall be no more than 1/8 inch into valve box lid.

L. Gate Valves: Install where shown on Drawings as detailed.

M. Sprinkler Heads: Install sprinkler heads where designated on Drawings or where staked. Set to finish as detailed. Spacing of heads shall not exceed the maximum indicated on Drawing unless re-staked as directed by Consultant. In no case shall the spacing exceed maximum recommended by manufacturer. Install heads on swing joints or riser assemblies as detailed. Adjust part circle heads for proper coverage. Adjust heads to correct height after sod is installed. Plant placement shall not interfere with intended sprinkler head coverage, piping, or other equipment. Consultant may request nozzle changes or adjustments without additional cost to the Owner.

N. Backflow Preventer: Install as detailed at location designated on Drawings.

O. Backfilling: Do not begin backfilling operations until required system tests have been completed. Backfill shall not be done in freezing weather except with review by Consultant. Leave trenches slightly mounded to allow for settlement after backfilling is completed. Trenches shall be finish graded prior to walk-through of system by Consultant.

1. Materials: Excavated material is generally considered satisfactory for backfill purposes. Backfill material shall be free of rubbish, vegetable matter, frozen materials, and stones larger than 1 inch in maximum dimension. Do not mix subsoil with topsoil. Material not suitable for backfill shall be hauled away. Contractor shall be responsible for providing suitable backfill if excavated material is unacceptable or not sufficient to meet backfill, compaction, and final grade requirements.

2. Do not leave trenches open for a period of more than 48 hours. Open excavations shall be protected in accordance with OSHA regulations.

3. Compact backfill to 90% maximum density, determined in accordance with ASTM D155-7 utilizing the following methods:
   a. Mechanical tamping.
   b. Puddling or Ponding: Puddling or ponding and/or jetting is prohibited within 20'-0" of building or foundation walls.

P. Piping Under Paving:

1. Provide for a minimum cover of 18 inches between the top of the pipe and the bottom of the aggregate base for all pressure and non-pressure piping installed under asphaltic concrete or concrete paving.

2. Piping located under areas where asphalt or concrete paving will be installed shall be bedded with sand (a layer 6" below pipe and 6" above pipe).

3. Compact backfill material in 6" lifts at 90% maximum density determined in accordance with ASTM D155-7 using manual or mechanical tamping devices.

4. Set in place, cap, and pressure test all piping under paving, in presence of Owner prior to backfilling and paving operations.
5. Piping under existing walks or concrete pavement shall be done by jacking, boring, or hydraulic driving, but where cutting or breaking of walks and/or concrete is necessary, it shall be done and replaced at no cost to Owner. Obtain permission to cut or break walks and/or concrete from Owner.

Q. Water Supply and Point of Connection: Water supply shall be extended as shown from water supply lines.

3.06 FIELD QUALITY CONTROL

A. Flushing: After piping, risers, and valves are in place and connected, but prior to installation of sprinkler heads, quick coupler assemblies, and hose valves, thoroughly flush piping system under full head of water pressure from dead end fittings. Maintain flushing for 5 minutes through furthest valves. Cap risers after flushing.

B. Pressure Testing: Conduct test in presence of Consultant. Arrange for presence of Consultant 48 hours in advance of testing. Supply force pump and all other test equipment. Compressed air shall not be used for pressure testing system.
1. After backfilling, and installation of all control valves, fill pressure supply line with water, and pressurize to 40 PSI over the designated static pressure or 120 PSI, whichever is greater, for a period of 2 hours.
2. Leakage, Pressure Loss - Test is acceptable if no loss of pressure is evident during the test period.
3. Leaks - Detect and repair leaks.
4. Retest system until test pressure can be maintained for duration of test.
5. Before final acceptance, pressure supply line shall remain under pressure for a period of 48 hours.
6. Pressure test shall be scheduled and passed prior to scheduling of Substantial Completion Walk-through.

C. LEED Requirements: Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

3.07 WALK-THROUGH FOR SUBSTANTIAL COMPLETION

A. Arrange for Consultant's presence 48 hours in advance of walk-through.

B. Entire system shall be completely installed and operational prior to scheduling of walk-through.

C. Operate each zone in its entirety for Consultant at time of walk-through and additionally, open all valve boxes if directed.

D. Generate a list of items to be corrected prior to Final Completion.

E. Furnish all materials and perform all work required to correct all inadequacies of coverage due to deviations from Contract Documents.
F. During walk-through, expose all drip emitters under operations for observation by Consultant to demonstrate that they are performing and installed as designed, prior to placing of all mulch material. Schedule separate walk-through if necessary.

G. Supply Consultant with prints of irrigation as-builts prior to scheduling substantial completion walk-through.

3.08 WALK-THROUGH FOR FINAL COMPLETION

A. Arrange for Consultant’s presence 48 hours in advance of walk-through.

B. Show evidence to Consultant that Owner has received all accessories, charts, record drawings, and equipment as required before Final Completion walk-through is scheduled.

C. Operate each zone, in its entirety for Consultant at time of walk-through to insure correction of all incomplete items.

D. Items deemed not acceptable by Consultant shall be reworked to complete satisfaction of Consultant.

E. If after request to Consultant for walk-through for Final Completion of irrigation system, Consultant finds items during walk-through which have not been properly adjusted, reworked, or replaced as indicated on list of incomplete items from previous walk-through, Contractor shall be charged for all subsequent walk-throughs. Funds will be withheld from final payment and/or retainage to Contractor, in amount equal to additional time and expenses required by Consultant to conduct and document further walk-throughs as deemed necessary to insure compliance with Contract Documents.

3.09 ADJUSTING

A. Upon completion of installation, fine-tune entire system by adjusting patterns and break-up pins, and setting pressure reducing valves at proper and similar pressure to provide optimum and efficient coverage. Flush and adjust all sprinkler heads for optimum performance and to prevent overspray onto walks, roadways, and buildings as much as possible. Heads of same type shall be operating at same pressure +/- 10%.

B. If it is determined that irrigation adjustments will provide proper coverage, and improved water distribution as determined by Consultant, contractor shall make such adjustments prior to Final Acceptance, as directed, at no additional cost to Owner. Adjustments may also include changes in nozzle sizes, degrees of arc, and control valve throttling.

C. All sprinkler heads shall be set perpendicular to finish grade unless otherwise noted on Construction Plans or directed by Consultant.

D. Areas which do not conform to designated operation requirements due to unauthorized changes or poor installation practices shall be immediately corrected at no additional cost to the Owner.
E. Contractor to set up controller irrigation schedules for establishing native plant materials and schedules for reduction of water to the native areas after establishment. Training of the facilities staff will be the responsibility of the contractor to make sure they understand the watering schedules and when to implement the reduced watering schedules.

3.10 CLEANING

A. Maintain continuous cleaning operation throughout duration of work. Dispose of, off-site at no additional cost to Owner, all trash or debris generated by installation of irrigation system.

B. Comply with the requirements of Division 01 “General Requirements”, and Division 01 Section “Construction Waste Management and Disposal” for recycling and salvage of debris and waste.

C. Comply with the requirements of Division 31 Section “Temporary Erosion and Sedimentation Control” for preparation and protection of the site.

END OF SECTION
SECTION 32 90 00

FINE GRADING AND SOIL PREPARATION

PART 1 - GENERAL

1.01 SUMMARY

A. This Section Includes:
   1. Examination.
   2. Preparation.
   3. Subsoil Preparation.
   4. Placing Topsoil.
   5. Soil Tests.
   6. Coordination of Soil Amendments.
   7. Fine Grading.
   8. Tolerances.
   9. Field Quality Control
   10. Adjusting.
   11. Cleaning
   12. Protection.

B. Related Sections:
   1. Division 01 Sections “Construction Waste Management and Disposal”,
      “Sustainable Design Requirements”, and “Temporary Facilities and Controls”
      for temporary erosion and sedimentation-control measures for additional LEED
      requirements.
   2. Division 01 Section “Submittal Procedures”
   3. Division 01 Section “Quality Requirements”
   4. Division 31 Section “Earthwork”
   5. Division 31 Section “Site Clearing”
   6. Division 31 Section “Temporary Erosion and Sedimentation Control”
   7. Division 32 Section “Underground Sprinklers”
   8. Division 32 Section “Turf and Grasses”
   9. Division 32 Section “Planting”
   10. Division 32 Section “Planting Accessories”

1.02 REFERENCES

A. Colorado Division of Labor Rules and Regulations: Excavation.

B. State Department of Highways, Division of Highways, State of Colorado, Standard
   Specifications for Road and Bridge Construction, Section 207 of the latest edition.

C. ANSI/ASTM D698 - Test Methods for Moisture-Density Relations of Soils and Soil-
   Aggregate Mixtures, Using 5.5 lb (2.49 Kg) Rammer and 12 inch (304.8 mm) Drop.
D. ANSI/ASTM D1556 - Test Method for Density of Soil in Place by the Sand-Cone Method.

E. Association of Official Agricultural Chemists: Topsoil Analysis.

1.03 DEFINITIONS


1.04 SUBMITTAL PROCEDURES

A. Comply with Section 01 33 00 “Submittal Procedures”. All submittals shall be accepted by the Architect in writing before planting commence

B. Topsoil Testing:
   1. After topsoil spreading, submit, for Architect's approval, topsoil samples and test results from:
      a. Each off-site topsoil source.
   2. Each location submission shall include:
      a. 1 qt. representative sample in air tight container.
      b. Agricultural analysis by recognized laboratory made in accordance with methods established by the Association of Official Agricultural Chemists. Test shall include available nutrients, soil pH, soil texture, salt, and percentage organic matter, and recommended fertilization and amendment rates for plant material types specified.
      c. Location of borrow site, if applicable.
   3. Deliver copies of all test reports and samples to landscape contractor and Architect.
   4. LEED Submittals:
      a. Credit MR 4.1 and Credit MR 4.2: Product data and certification letter indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
      b. Credit MR 5.1 and Credit MR 5.2: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
      c. Provide documentation of construction and demolition waste debris recycling / salvage rates. See Section 01 74 19 - Construction Waste Management and Disposal.
C. Certificates: Submit certificates of inspection as required by governmental authorities.

D. Samples: Comply with paragraph 1.06 B. this Section.

1.05 QUALITY REQUIREMENTS

A. Comply with Division 01 Section “Quality Requirements”.

B. Qualifications:
   1. Installer: Company with minimum five (5) years successful experience in the placing on topsoil similar in scope and size to this project.
   2. Testing Agency: Certified soils laboratory with capability to analyze materials for conformance to specification requirements (where applicable).

C. LEED Requirements: Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

1.06 DELIVERY, STORAGE AND HANDLING

A. Topsoil: Protect materials from erosion, wind, rodents, deterioration and contamination during delivery, installation and site storage.

1.07 PROJECT/SITE CONDITIONS

A. Environmental Requirements:
   1. Comply with requirements of referenced standards for environmental conditions before, during, and after installation. Maintain environmental conditions and protect work during and after installation to comply with referenced standards.
   2. Moisture Content: Topsoil and other materials shall not be placed, backfilled, or spread while in a wet or saturated condition. Moisture content shall not be so great that excessive compaction will occur, nor so low that dust will form in the air or that clods will not break readily. Apply water if necessary to bring soil to optimum moisture content for tilling.
   3. Do not work soil when muddy or frozen.

B. Existing Conditions:
   1. Plants: Protect existing plant material. Do not damage any plantings indicated to remain.
   2. Utilities: Determine location of underground utilities including irrigation system. Perform work in a manner to avoid possible damage. Hand excavate, as required.
   3. Excavation: Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned. When conditions detrimental to Work are encountered, such as rubble fill, adverse drainage conditions, noxious materials or obstructions, notify Architect before proceeding.
1.08 SEQUENCING AND SCHEDULING

A. Coordination:
   1. Coordinate with seeding, sodding and landscape Contractor(s) approved schedule. Refer to Division 1. Do not place topsoil more than 3 days prior to commencement of landscaping in the area. Limit fine grading to areas which can be planted within 24 hours after fine grading.
   2. Coordinate with Contractors' work requiring access to site over topsoil areas.
   3. Coordinate with installation of underground irrigation system and outlets.

1.09 MAINTENANCE

A. Protect newly topsoiled and fine graded areas from erosion and traffic. Repair and reestablish grades in settled, eroded and disturbed areas to specified tolerances until landscape operations commence.

PART 2 - PRODUCTS

2.01 TOPSOIL

A. On-Site Topsoil: Fertile sandy loam, taken from a well drained site and free from clay subsoil, stones, lumps, stolons, plants, roots, sticks and seeds, high salt content and other materials/attributes harmful to plant life.

   1. | Sieve/Screen Size | % Passing | % Retaining |
<table>
<thead>
<tr>
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<tr>
<td>1&quot; screen</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>1/2&quot; screen</td>
<td>97-100</td>
<td>0-3</td>
</tr>
<tr>
<td>#100 mesh sieve</td>
<td>60-40</td>
<td>40-60</td>
</tr>
</tbody>
</table>

   2. pH before amendments between 5.5 and 7.5.
   3. Refer to Section 32 92 00 “Turf and Grasses”, and 32 93 00 “Planting” for topsoil amendment requirements.

B. Pre-Amended Topsoil: At the contractor's option, pre-amended topsoil may be used in lieu of imported topsoil amended on site.

   1. Supplier: Select Material, Denver CO, (303)730-6371, or approved equal.

2.02 WATER

A. Clean, fresh and free of substances or matter which could inhibit vigorous growth of plants.

2.03 HERBICIDE

A. Weed Herbicide: Round-up or approved equal.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Verifications of Conditions: Examine areas and conditions under which the Work of the Section will be performed. Report unsatisfactory or questionable conditions to the Architect. Do not proceed with the Work until unsatisfactory conditions have been corrected. Commencement of work implies acceptance of all areas and conditions.
   1. Verify that during grading, the ground surface was cleaned of materials which might hinder final operations.

3.02 PREPARATION

A. Protection: Protect areas in accordance with paragraph 3.12 this Section.

B. Herbicide Treatment:
   1. Confirm Architect’s requirement to proceed with herbicide treatment of on site soil. Herbicide treatment must be completed during the growing season.
   2. If plant growth is evident, treat site with Roundup herbicide in accordance with manufacturer’s recommendations.
   3. Water subsoil 1/2” per week if natural precipitation does not supply this amount.
   4. Ten (10) days after Roundup application, review soil surface for evidence of plant growth.
   5. Repeat steps 2, 3 and 4, up to three (3) applications, until there is no evidence of plant growth after 10 day period.
   6. Obtain Architect’s approval of soil fourteen (14) days after last herbicide application.
   7. Remove plant debris from treated area.

3.03 SUBSOIL PREPARATION

A. Verify subsoil base has been contoured and compacted and is free of contaminated material.

B. Prepare subsoil to eliminate uneven areas and low spots. Maintain lines, levels, profiles, and contours. Make changes in grade gradual. Blend slopes into level areas.

C. Remove foreign materials, stones exceeding 2 inches, weeds and undesirable plants and their roots.

D. Scarify subsoil to a depth of 6 inches where topsoil is to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.

E. Remove foreign materials, stones exceeding 2 inches, weeds and undesirable plants and their roots which came to the surface during subsoil scarification.
3.04 PLACING TOPSOIL

A. Place topsoil where seeding, sodding, and planting is scheduled and in accordance with paragraph 1.09 this Section.

B. Place topsoil during dry weather and on dry, unfrozen subsoil.

C. Remove vegetative matter and foreign, non-organic material and debris larger than 1.5 inches in diameter at the time of placement.

D. Place topsoil to the following depths:
   a. Sod Areas 4"
   b. Seed Areas 4"
   c. Shrub Beds 6"
   d. Flower Beds 6"

E. Place topsoil eliminating rough or low areas to ensure positive drainage. Maintain profiles and contour of sub-grade.

F. Manually place topsoil close to existing trees, shrubs, plants, curbs, new construction, planters and buildings to prevent damage.

G. Coordinate topsoil placement with sub-soil amending in accordance with Section Division 32 Section “Fine Grading and Soil Preparation”.

3.05 SOIL TESTS

A. Perform soil testing and submission in accordance with paragraph 1.06 this Section.

3.06 COORDINATION OF SOIL AMENDMENTS

A. Coordinate soil amendments with landscape contractor in accordance with Division 32 Section “Turf and Grasses” and Division 32 Section “Planting”.

3.07 FINE GRADING

A. Fine grade topsoil to finished elevations with smooth, even surface with loose, uniformly fine texture.

B. Remove foreign materials, stones exceeding 1.5 inches, weeds and undesirable plants and their roots which came to the surface during soil amending.

C. Roll, rake and drag lawn areas, remove ridges and fill depressions, as required to meet finish grades. Limit fine grading to areas which can be planted immediately after grading. Compact seeded areas to 90% in accordance with Earthwork Section 31 00 00.
D. Remove surplus subsoil and topsoil from site.

E. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.08 TOLERANCES

A. Topsoil: Topsoil elevations shall be within the following tolerances from elevations indicated on the drawings:
   1. Landscape Areas: ± 0.10'.
   2. Adjacent to Paving and Curbs: ± 0.04' (1/2").

3.09 FIELD QUALITY CONTROL

A. Reviews: Comply with Contract General Conditions.

3.10 ADJUSTING

A. Reconditioning Compacted Areas: When completed topsoil areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required density prior to further construction.

3.11 CLEANUP

A. During Landscape Installation:
   1. All areas shall be reasonably clean at the end of each work day. Sidewalks and other paved areas shall be swept or washed down as needed. Keep pavements clean and work area in an orderly condition.
   2. Contractor shall make a reasonable effort to clean up the project on a daily basis to maintain a neat and orderly site.

B. Project Completion:
   1. All debris, soil and trash resulting from landscape operations shall be removed from the site. Burning of waste material is prohibited. All paved areas shall be washed down.
   2. Restore all areas outside the Contract limits which have been disturbed to their original condition at no cost to the Architect.

C. Comply with the requirements of Division 01 “General Requirements”, and Division 01 Section “Construction Waste Management and Disposal” for recycling and salvage of debris and waste.

3.12 PROTECTION

A. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers.

B. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged landscape work as directed.
C. Protect existing trees, shrubs, groundcovers, perennials and turf areas from damage during construction.

D. Comply with the requirements of Division 31 Section “Temporary Erosion and Sedimentation Control” for preparation and protection of the site.

END OF SECTION
SECTION 32 92 00

TURF AND GRASSES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section Includes:
1. Examination.
2. Site Preparation.
3. Soil Preparation for Seeding
4. Seeding
5. Mulching
6. Erosion Control Blankets
7. Areas to be top Dressed
8. Field Quality Control.
10. Protection.
11. Maintenance

B. Related Sections:
1. Division 01 Section “Construction Waste Management and Disposal”, Division 01 Section “Sustainable Design Requirements”, and Division 01 Section “Temporary Facilities and Controls” for temporary erosion and sedimentation-control measures for additional LEED requirements.
2. Division 01 Section “Submittal Procedures”.
3. Division 01 Section “Quality Requirements”.
4. Division 01 Section “Temporary Erosion and Sediment Control”
5. Division 32 Section “Underground Sprinklers”.
6. Division 32 Section “Fine Grading and Soil Preparation”.
7. Division 32 Section “Planting”.
8. Division 32 Section “Landscape Maintenance”.
9. Division 32 Section “Planting Accessories”.

1.02 REFERENCES

A. ASPA (American Sod Producers Association) - Guideline Specifications to Sodding.


1.03 DEFINITIONS


1.04 SUBMITTAL PROCEDURES

A. Comply with Division 32 Section “Submittal Procedures”. All submittals shall be accepted by the Architect in writing before planting commences.

B. Topsoil Testing:
   1. Coordinate soil testing with Division 32 Section “Quality Requirements”.

C. Certificates
   1. Submit two copies of labels or certificates from State Department of Agriculture for grass species.
   2. Submit certificates of inspection as required by governmental authorities.
   3. Submit manufacturer’s certified analysis packaged with standard products.
   4. Submit all blue tags which were removed to mix the seed.
   5. Submit mix tags showing seed mix, noxious seed and crop seed content, weight, analysis and date of most recent germination test.
   6. Submit certificates of inspection certifying that straw for use as mulch is weed free.

D. Analysis and Standards: Wherever applicable, for non packaged materials, provide two copies of analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists.

E. Planting Schedule: Comply with General Contract Conditions.

F. LEED Submittals: Credit MR 4.1 and Credit MR 4.2: Product data and certification letter indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.

Credit MR 5.1 and Credit MR 5.2: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
1.05 QUALITY REQUIREMENTS

A. Comply with Division 32 Section “Quality Requirements”.

B. Qualifications:
   1. Installer: Company with minimum five (5) years successful experience in the installation of seeded dryland grass areas similar in size to this project.

C. Regulatory Requirements:
   1. Comply with regulatory agencies concerning classification, transportation, handling and storage of seed, fertilizer, herbicide and pesticide materials.
   2. Comply with regulatory agencies for fertilizer, herbicide and pesticide composition and application.

D. LEED Requirements: Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at site.

B. Seed:
   1. Deliver seed mixture in original sealed containers with certificates of inspection required by governing authorities. Labels shall show seed mix, noxious seed and crop seed content, weight, analysis and date of most recent germination test. Certified blue-tagged seed shall be supplied where a named variety is specified. Seed in damaged packaging is not acceptable.
   2. Protect materials from weather, moisture, rodents, deterioration and contamination during delivery, installation and site storage. Seed that has become wet or otherwise damaged is not acceptable.
   3. Rejection of Materials: Evidence of inadequate or inappropriate transportation or storage of seed or seed not properly identified through blue-tags or mix tags submitted to Architect shall be cause for rejection.
1.07  PROJECT/SITE CONDITIONS

A. Environmental Requirements:
   1. Seeding Season: Seeding shall occur as specified below. Variance from schedule shall be permitted only with written approval from the Engineer.

<table>
<thead>
<tr>
<th>Seed Type</th>
<th>Irrigated Areas Only</th>
<th>Non-Irrigated Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dryland Grasses</td>
<td>April 15-Sept 1</td>
<td>June 15-July 15</td>
</tr>
<tr>
<td></td>
<td>Oct 15-April 30</td>
<td></td>
</tr>
</tbody>
</table>

2. Seeding shall occur only when weather and soil conditions permit in accordance with locally accepted practice. Do not seed during periods of prolonged cold or heat, when ground is frozen or too dry, during windy periods, immediately following rain, or during excessively wet or dry periods.

B. Existing Conditions:
   1. Existing Plants: Do not damage any existing plantings indicated to remain. Seed areas after trees are planted and after final grades are established, unless otherwise directed by the Architect.
   2. Utilities: Determine location of underground utilities. Perform work in a manner to avoid possible damage. Hand excavate, as required.
   3. Excavation: Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned. When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, noxious materials or obstructions, notify Architect before planting.

1.08  SEQUENCING AND SCHEDULING

A. Work Scheduling: Proceed with and complete landscape work as rapidly as portions of the site become available, working within the specified planting season and approved schedule.

B. Coordination:
   1. Coordinate with Contractors work requiring access to site over lawn areas.
   2. Coordinate with installation of underground irrigation system and outlets.
   3. Coordinate seeding to provide maintenance for 1 year or one full growing season, whichever one is longer, after Final Acceptance in accordance with Paragraph 1.12 this Section.
   4. Coordinate with topsoil placing to conform with installation requirements specified in Division 32 Section "Fine Grading and Soil Preparation".
1.09 WARRANTY AND REPLACEMENT

A. General: Comply with General Contract Conditions.

B. Seed Warranty Conditions: Warranty all seeded areas against defects due to any cause except vandalism and acts of God. The following warranty conditions apply:
   1. Reseed all areas when grass is no longer in a satisfactory growing condition as determined by the Engineer for the entire warranty period.
      a. Dryland Grass Mixes Acceptance: 95% of seeded area covered with germinated seed and no bare spots greater than 4 inches square after 90 days.
   2. If seeded areas fail after having been replaced previously, area shall be replaced until it is approved. The warranty period begins anew and extends each time an area requires replanting. Replacement seed shall be of the same kind, condition and quality as original seed and subject to all requirements in this specification.
   3. All expenses incurred in the replacements shall be borne by the Contractor.
   4. Make replacements within seven days of notification by Engineer.
   5. If seeded in fall, review for Substantial Completion shall be no later than June 15 the following year.


1.10 MAINTENANCE (See also Division 32 Section “Landscape Maintenance”)

A. General: Maintain lawns by watering, fertilizing, weeding, mowing, trimming, and other operations such as rolling, regrading and resodding and reseeding as necessary to establish a smooth, acceptable lawn, free of eroded or bare areas or as directed by the Architect.
   1. Overwatering of lawns which causes stress to trees is not allowed.

B. Maintenance Period: Begin maintenance immediately after seeding. Maintain seeded areas in accordance with Division 32 Section “Landscape Maintenance”. If necessary sub-areas may be deemed to have achieved Substantial Completion to allow maintenance period to begin in that area.
PART 2 - PRODUCTS

2.01 SOIL AMENDMENTS

A. Certification required. Non-sludge Class I compost in compliance with Colorado Department of Public Health and Environment Regulation 64.

2.02 WATER

A. Clean, fresh and free of substances or matter which could inhibit vigorous growth of grass.

B. Available on-site at no expense to Contractor. Landscape Contractor is responsible for coordination of water needs for watering and irrigation water with the Owner.

2.03 SEED

A. Minimum seed purity shall be 95 percent with a minimum germination of 85 percent. The percentage of material, other than grass seed in the mixture, shall not include more than 18 percent non-viable seed, chaff, hulls, live seed of crop plants (other than those specified), or harmless inert matter. Weed shall not exceed 0.50 percent of the total weight of the mixture. Provide seed in labeled, original containers.

B. Substitutions: Do not make substitutions: If specified seed is not obtainable, submit proof of non-availability to Architect together with proposal for use of equivalent material for review and acceptance by Architect.

2.04 SEED MIXTURE

A. Dryland Grass Mix:

1. Dryland grass mix seeded at a rate of 30 pounds pure live seed (PLS) per acre.

<table>
<thead>
<tr>
<th>Grass</th>
<th>PLS Pounds per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Blue Stem</td>
<td>6.4</td>
</tr>
<tr>
<td>Blue Grama Grass</td>
<td>6</td>
</tr>
<tr>
<td>Sideoats Grama Grass</td>
<td>3.6</td>
</tr>
<tr>
<td>Western Wheatgrass</td>
<td>9.6</td>
</tr>
<tr>
<td>Thickske Wheatgrass</td>
<td>2.2</td>
</tr>
<tr>
<td>Slender Wheatgrass</td>
<td>2.2</td>
</tr>
</tbody>
</table>

2.05 TACKIFIER

A. Plantago-based organic tackifier such as Agri-Tac, M-Binder, AZ/Tac or approved equal.
2.06 MULCH

A. Wood Cellulose: Wood cellulose fiber mulch, dyed green, not containing any substance or factor which might inhibit germination. Mulch shall be supplied dry. Provide certification to Architect that mulch complies with above requirements.

B. Straw: Small grained straw in 60 pound bales. Apply 1.5 tons of straw per acre. Increase nitrogen fertilizer 20 pounds per ton of straw when applied in accordance with this Specification, to compensate for nitrogen tied up by straw mulch decay.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the Work of this Section will be performed. Report unsatisfactory or questionable conditions to the Architect. Do not proceed with the Work until unsatisfactory conditions have been corrected. Commencement of work implies acceptance of all areas and conditions.

1. Verify that during grading, topsoil spreading and landscape grading operations, the ground surface was be cleaned of materials which might hinder final operations.

3.02 PREPARATION

A. Protection: Protect areas in accordance with paragraph 3.07 this Section.

3.03 SOIL PREPARATION FOR SEEDING

A. Amendments:

1. Apply amendments PRIOR to topsoil spreading. Apply 5 cubic yards per 1,000 square feet of compost by volume.

B. Fine Grading: Coordinate with fine grading in accordance with Division 32 Section “Fine Grading and Soil Preparation”. Compact in accordance with Division 31 Section “Earthwork”.

C. Restore areas to specified condition if eroded or otherwise disturbed after fine grading and prior to seeding.

D. Obtain acceptance of final grading by the Architect prior to seeding.

3.04 SEEDING

A. After soil placement and preparation, roll the area to an evenly compacted, firm soil bed. Rework hard and soft areas.

B. Refer to Paragraph 2.06 this Section for seeding rates.
C. Application:
1. Mechanical Application: Seed by mechanical landscape type drills. Drill seed with approximately 1/2 inch of cover. Seed 50% of seed in one direction, and 50% at a 90 degree angle.
2. Hydroseed or Broadcast Application: Seed by hydroseed or broadcast method only when areas are too small to drill seed. Make 2 passes perpendicular to each other. First pass shall include seed, fertilizer and water. Second pass shall include mulch and tackifier.

D. Do not seed areas in excess of that which can be mulched on the same day.

E. Planting Season: Plant in accordance with paragraph 1.09 A. this Section.

F. Roll seeded area with roller not exceeding 100 lbs.

G. Apply mulch immediately following seeding and compacting or as part of seeding process, dependent on seeding method.

3.05 MULCHING

A. General:
1. Regardless of seeding method, all seeded areas require mulching.
2. Mulch all areas within 24 hours after completion of seeding. Reseeded areas not mulched within 24 hours after seeding with specified seed mix at no cost to the Owner.
3. Areas not properly mulched or areas damaged due to Contractor's negligence shall be repaired and remulched as specified at Contractor's expense.

B. Mulch Application:
1. Hydromulch
   a. Utilize hydraulic equipment with nozzle adaptable for hydraulic mulching with storage tanks having means of estimating volume used or remaining in tank.
   b. Hydromulch shall consist of tackifier applied at a rate of 100 lbs. per acre and a cellulose fiber mulch mixed to form a homogeneous slurry; spray applied to seeded area at a rate of 2,000 lbs. per acre.

C. Watering In: Apply water with a fine spray immediately after each area has been mulched. Saturate to 4 inches of soil.

3.06 FIELD QUALITY CONTROL

A. Tests: Costs of tests and material analyses made by the testing agency will be borne by the Owner when tests indicate compliance and by the Contractor when test indicated non-compliance.
B. Reviews:
2. Pre-Planting Review:
   a. All finish grading shall be inspected by Architect prior to seeding commencing. Correct any discrepancies prior to seeding.
3. Substantial Completion
   a. Comply with General Contract Conditions.
   b. At the time of this walk-through, the Contractor shall have:
      1.) Verified installed irrigation system is fully operational with heads properly adjusted.
      2.) Cleaned all walkways and curbs of debris and litter and shall have cleaned areas of soil and debris left from planting operations.
7. Warranty and Replacement: Comply with General Contract Conditions.

3.07 CLEANUP
A. During landscape installation - All areas shall be reasonably clean at the end of each work day. Sidewalks and other paved areas shall be swept or washed down as needed. Keep pavements clean and work area in an orderly condition.

B. Project Completion: All debris, soil and trash resulting from landscape operations shall be removed from the site. All paved areas shall be washed down.

3.08 PROTECTION
A. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers.

B. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged landscape work as directed.

END OF SECTION
SECTION 32 93 00

PLANTING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section Includes:
1. Examination.
2. Preparation.
3. General Planting Requirements.
4. Trees and Shrubs Planted in Individual Plant Pits or Trenches.
5. Shrubs, Perennials and Groundcovers Planted in Prepared Planting Beds.
7. Field Quality Control.
8. Protection.

B. Related Sections:
1. Division 01 Sections “Construction Waste Management and Disposal”, “Sustainable Design Requirements”, and Division 31 Section “Temporary Facilities and Controls” for temporary erosion and sedimentation-control measures for additional LEED requirements.
2. Division 01 Section “Submittal Procedures”.
3. Division 01 Section “Quality Requirements”.
4. Division 31 Section “Temporary Erosion and Sediment Control”
5. Division 32 Section “Underground Sprinklers”.
6. Division 32 Section “Fine Grading and Soil Preparation”.
7. Division 32 Section “Turf and Grasses”.
8. Division 32 Section “Landscape Maintenance”
9. Division 32 Section “Planting Accessories”

1.02 REFERENCE

A. American Standards for Nursery Stock (ANSI Z60.1 - most recent edition), American Association of Nurseymen, Washington D.C.


1.03 DEFINITIONS


B. Plants: Trees, shrubs, groundcovers, annuals perennials, and bulbs specified in the plant list.

1.04 SUBMITTAL PROCEDURES

A. Comply with Division 01 Section “Submittal Procedures”. All submittals and plant materials shall be accepted by the Architect in writing before planting commences.

B. Topsoil Testing:
   1. Coordinate soil testing with General Conditions.

C. Certificates:
   1. Submit certificates of inspection as required by governmental authorities.
   2. Submit manufacturer’s certified analysis packaged with standard products.

D. Analysis and Standards: Wherever applicable, for non packaged materials, provide analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists.

E. Planting Schedule: Submit in accordance with Division 01 Section “Submittal Requirements”

F. Plant Photographs: Submit one color photograph or 35 mm color transparency of all trees over 2 inch caliper or 7 foot height for any plant materials which are located outside of 30 mile radius of Pueblo for approval by Architect prior to shipment to the site or the contractor’ holding yard.

G. Tree Planting Material Submittal: Submit 1 tree collar and 1 sample of tree wrap.

H. Samples: Submit 1 quart sample of wood chips for acceptance by Architect.

I. Contractor Qualifications: Submit nursery and installation company qualifications in accordance with paragraph 1.06 B. this Section for acceptance by Architect.
J. LEED Submittals:
1. Credit MR 4.1 and Credit MR 4.2: Product data and certification letter indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
2. Credit MR 5.1 and Credit MR 5.2: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
3. Provide documentation of construction and demolition waste debris recycling/salvage rates. See Section 01 74 19 “Construction Waste Management and Disposal”.

1.05 QUALITY REQUIREMENTS

A. Comply with Division 01 Section “Quality Requirements”.

B. Qualifications:
1. Nursery: Company specializing in growing and cultivating the plants with minimum five (5) years experience, and certified by the State of Colorado Department of Agriculture.
2. Installer: Company with minimum five (5) years successful experience in the installation of landscape areas similar in size and complexity to this project. Company shall be a member in good standing of one of the following organizations:
   a. Associated Landscape Contractors of America.
   b. American Association of Nurserymen.
   c. A member of the Nurserymen’s Association of the state in which the work is being performed.

C. Regulatory Requirements:
1. Comply with regulatory agencies concerning classification, transportation, handling and storage of plants, fertilizer, herbicide and pesticide materials.
2. Comply with regulatory agencies for fertilizer, herbicide and pesticide composition and application.

D. Rejection of Materials:
1. Evidence of inadequate or inappropriate protection after digging, transportation, or improper handling or storage, shall be cause for rejection.
2. Architect will inspect plants for proper shipping procedures upon arrival at the temporary storage location or the site. The Architect will reject injured plants including those with dried out roots, broken large branches, broken, or loosened balls or earth, split trunks or torn areas of bark.
3. The Contractor shall immediately remove and replace rejected plants.
E. Plant List: Plant quantities are provided for the Contractor’s convenience only. The Contractor shall provide all plants in quantities as shown on Drawings despite any discrepancies which may exist with quantities called for on the plant list.

F. LEED Requirements: Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at site.

B. Shipping of Plants:
1. Plant Names and Labeling: Botanic and common names given in the plant list are in conformance with standard horticultural practice in the area. Deliver all plants to the site with tags bearing the botanical name and size as indicated in the plant list.

2. Nursery Harvesting: Provide freshly dug trees and shrubs. Do not prune prior to delivery unless otherwise approved by Architect. Plants shall be dug and prepared for shipment in a manner that will not cause damage to branches, shape and future development after planting. Trunks shall be wrapped for added protection. All balled and burlapped trees are to be dug during the appropriate time of year for the species listed, but in no case after buds have opened or prior to fall leaf drop. Do not bend or bind-tie trees or shrubs in such manner as to damage bark, break branches or destroy natural shape. Wounds, scars or damage shall be grounds for rejection. Do not drop balled and burlapped stock during delivery.
   a. If necessary obtain Architect’s approval to dig plants in full leaf. Spray foliage with antidessicant such as Wilt-proof or approved equal.

3. Transportation
   a. Open vehicles used to transport plants to the project shall be covered with tarpaulins or other suitable covers securely fastened to the vehicle to prevent damage to the plants. Closed vehicles shall be adequately ventilated to prevent overheating of the plants. Do not remove plants from refrigerated trucks into hot weather without allowing time for plants to adjust to heat.
   b. Ship landscape materials with certificates of inspection required by governing authorities. Comply with regulations applicable to landscape materials.
   c. Keep plants moist fresh and protected at all times.

4. Contractor shall exercise care in the handling of plant materials to avoid damage or stress.
5. Acceptance of Plants at Site: Unless otherwise authorized by the Architect, the Contractor shall notify the Architect at least two working days in advance of the anticipated delivery date of any plant material. A legible copy of the bill of lading, showing the quantities, kinds, and sizes of materials included for each shipment shall be furnished to the Architect.

C. Storage and Protection of Plants:
1. Keep plants moist fresh and protected at all times, including entire period of transit, handling, and temporary storage.
2. Deliver trees and shrubs after preparations for planting have been completed and plant immediately. If planting is delayed more than 6 hours after delivery, set trees and shrubs in shade, protect from weather and mechanical damage, and keep roots moist by covering with mulch, burlap or other acceptable means of retaining moisture. Duration and method of storage are subject to Architect's approval. Plants shall not remain on the site more than 3 days prior to planting unless specific authorization is obtained by the Architect.

1.07 PROJECT/SITE CONDITIONS

A. Environmental Requirements:
1. Planting Season: Planting shall occur only after April 15 and before October 1 or as specified on the Drawings without written approval from Architect. Northern Red Oaks (Quercus Rubra) shall be planted no later than May 31.
2. Planting shall occur only when weather and soil conditions permit in accordance with locally accepted practice. Do not plant during periods of prolonged cold or heat, or during excessively wet or dry periods.

B. Existing Conditions:
1. Existing Plants: Do not damage any existing plantings indicated to remain. Plant areas after final grades are established in accordance with Division 32 Section “Fine Grading and Soil Preparation”, unless otherwise directed by the Architect.
2. Utilities: Determine location of underground utilities. Perform work in a manner to avoid possible damage. Hand excavate, as required.
3. Excavation: Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned. When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, noxious materials or obstructions, notify Architect before planting.

1.08 SEQUENCING AND SCHEDULING

A. Work Scheduling: Proceed with and complete landscape work as rapidly as portions of the site become available, working within the specified planting season and approved schedule.
B. Coordination:
   1. Coordinate with Contractor's work requiring access to site through planting areas.
   2. Coordinate with installation of underground irrigation system and outlets.
   3. Coordinate Planting with Seeded and Sodded Areas: Plant trees and shrubs after final grades are established and prior to seeding and sodding, unless otherwise acceptable to Architect. If planting occurs after seeding or sodding, protect areas and promptly repair damage resulting from planting operations.
   4. Coordinate planting to provide maintenance up to date of Substantial Completion in accordance with Paragraph 1.12 this Section.

1.09 WARRANTY AND REPLACEMENT

A. General: Refer to Division 01.

B. Plant Warranty Conditions: Warranty all plants against defects due to any cause except vandalism and acts of God. The following warranty conditions apply:
   1. Replant when plants are no longer in a satisfactory growing condition as determined by the Architect for the entire warranty period.
   2. If plants fail after having been replaced previously, plant shall be replaced until it is approved. Replacement plants shall be of the same kind, condition and quality as original plants and subject to all requirements in this specification.
   3. Plants shall be healthy, and in flourishing condition at the end of the warranty period. Plants shall be free of dying branches and branch tips, and shall bear foliage of normal density, size and color.
   4. All expenses incurred in the replacements shall be borne by the Contractor.
   5. Make replacements within seven days of notification by Architect.

C. Post Construction Inspection (Review for Final Warranty Compliance): Comply with Division 01 requirements.

1.10 MAINTENANCE

A. General: Maintain plants by watering, fertilizing, pruning, restoring planting saucers, tightening and repairing stake supports, resetting trees and shrubs to proper grades or vertical position as required, spraying as required to keep trees and shrubs free of insects and disease, cultivating and weeding as required for healthy growth or as directed by the Architect.
   1. Monitor watering of plants and lawns to verify overwatering is not causing stress to trees.
   2. Tree Wrap
      a. Apply a coating of insecticide and fungicide to the tree trunk area to be wrapped.
      b. Apply wrap to overlap 1-1/2" from ground line up to the lowest branch. Wrap trunks in late fall (approximately November 15).
      c. Tie securely in at least five places with jute twine, placed at least 12" apt.
d. Remove tree wrap the beginning of the growing season (approximately April 15).
e. Do not wrap cottonwoods (Populus spp.).

B. Maintenance Period: Begin maintenance immediately after planting. Maintain plants in accordance with Division 32 Section “Landscape Maintenance”. If necessary sub-areas may be deemed to have achieved Substantial Completion to allow maintenance period to begin in that area.

PART 2 – PRODUCTS

2.01 SOIL AMENDMENTS
A. Compost: Non-sludge Class 1 Compost in compliance with Colorado Department of Public Health and Environment Regulation 64.

2.02 COMMERCIAL FERTILIZER
A. Organic Fertilizer: Provide fertilizer of neutral character, with some elements derived from organic sources and containing the percentages of available plant nutrients given below. Deliver fertilizers to the site fully labeled according to applicable state fertilizer laws and bearing the name, tradename, trademark and warranty of the supplier. Fertilizers which are mixed into soil shall be:
1. Gro-Power Plus: Granular fertilizer meeting Gro-Power Plus analysis (5-3-1); with 50% humus, 15% humic acids, 1.25% soil penetrant, and bacterial culture included, containing no animal, human, or poultry waste. Submit manufacturer's guaranteed analysis. Guaranteed analysis shall conform to amendment requirements as given in Part 3 of this Section.
   a. Manufacturer: So. California Organic Fertilizer Co., P.O. Box 769, Glendale, CA. 91029, 213-245-6849; 714-750-3830; and as distributed by Direct Landscape Supply, 1501 West Campus Drive, Unit D, Littleton, CO, 80120, 303-797-7733, or approved equal.
2. Fertilizer Tablets: Provide tablets of Gro-Power 12/8/8 analysis with 20% humus, 4% humic acid, in 7 gram tablet, or approved equal.
3. Bone Meal: Commercial, raw, finely ground; 4% nitrogen and 20% phosphoric acid.
B. Inorganic Fertilizers: None.

2.03 WATER
A. Clean, potable and free of substances or matter which could inhibit vigorous growth of plants.
B. Available on-site at no expense to Contractor. Landscape Contractor is responsible for coordination of water needs for watering and irrigation water with the Owner.
2.04 GENERAL PLANT REQUIREMENTS

A. Health: Plant materials provided shall:
   1. Be healthy and vigorous.
   2. Be free from disease, injury, insects and their eggs, larvae.
   3. Have a well developed fibrous root system.
   4. Be free of physical damage such as scrapes, broken or split branches, scars, bark abrasions, sun scalds, fresh limb cuts, disfiguring knots, or other defects.
   5. Be free of weed roots.

B. Size and Form: Plant materials provided shall:
   1. Meet the sizes indicated on the Plant List. Where a size or caliper range is stated, at least 50% of the plants shall be closer in size to the top of the stated range. Plants larger or smaller than specified may be used only if accepted by the Architect.
   2. Meet the requirements of the reference standards for size, branching, condition, ball size, number of canes and all other conditions particular to each species.
   3. Be well branched and proportioned with respect to height and width relationships, and characteristic of the exact type called for in the plant list.

C. Balled and Burlapped Plants: Nursery grown stock adequately balled with firm, natural balls of soil in sizes and ratios in accordance with the reference standards. Balls shall be firmly wrapped with non-treated burlap, secured with wire or jute. Broken balls will not be accepted.

D. Container Grown Plants: Nursery grown in fibrous, plastic or metal containers and shall have sufficient roots to hold the entire soil mass together after container removal without being root-bound.

E. Collected Plants: Plants collected from native stands or established plantings which have a root system greater than roots of nursery grown plants. Collected plants require a larger root ball than recommended for transplanted nursery stock as specified in reference standards. Collection tags shall be attached to each plant as required by regulatory agencies.

F. Spaded Plants: Plants shall be dug with tree spade and directly planted on site, or temporarily burlapped and placed in a wire basket while plant pit is hand dug on site. Size of tree spade in proportion to plant shall be as specified in reference standard for collected plants.

G. Options: If all other requirements are met, a balled and burlapped plant may be substituted for a container grown plant of the same or larger size at the Contractor's option upon acceptance of the Architect.

H. Architect shall inspect and tag all deciduous and evergreen trees at tree sources, within 30 miles of Denver, prior to digging and shipment to site. Approval of plant material
from sources outside the 30 mile radius shall be reviewed in accordance with paragraph 1.05 F. this Section.

I. Substitutions: Do not make substitutions: If specified landscape material is not obtainable, submit proof of non-availability to Architect together with proposal for use of equivalent material for review and acceptance by Architect.

2.05 DECIDUOUS TREES AND SHRUBS

A. Provide plants of height, size, condition, and recommended branching configuration scheduled. Trees shall be uniformly shaped, quality plants with single leader, and evenly distributed branching in all directions.

B. If in leaf, trees shall be fully leafed-out with healthy, full and vigorous growth. Leaf damage caused by insects, hail and/or transplant shock shall be cause for rejection. If dormant, tree shall have pliable, green twigs and viable buds to indicate the healthy condition of plants, as appropriate to the species.

C. Adjacent plants of the same variety and size shall be consistent in size, shape, and overall appearance. Particular emphasis will be placed on this requirement for trees which occur in a straight row or otherwise formal relationship.

D. Trees with damaged bark will not be accepted.

2.06 EVERGREEN TREES AND SHRUBS

A. Provide plants of height, size, condition, and recommended branching configuration scheduled. Trees shall be uniformly shaped, quality plants with single leader and evenly distributed branching in all directions.

B. Coniferous trees shall be heavily branched, full needled, low branching, specimen quality plants. Evidence of dormant buds and secondary needles shall be present. Damage caused by excessive pruning, insect infestation, galls or other plant disorders or damage shall be cause for rejection. Container grown evergreens will be acceptable subject to paragraph 2.04 D. this Section.

C. Adjacent plants of the same variety and size shall be consistent in size, shape, and overall appearance. Particular emphasis will be placed on this requirement for trees which occur in a straight row or otherwise formal relationship.

2.07 GROUND COVERS, VINES AND PERENNIALS

A. Provide plants established and well-rooted in removable containers or integral peat pots with not less than minimum number and length of canes, runners or blades as required by the reference standard.
2.08 ACCESSORIES

A. Tree Stakes: Two-inch diameter lodgepole stake, straight and true, treated for resistance to rot, 8 foot length. Or Metal T-stakes, 8 foot length.

B. Staking Wire: Annealed, galvanized steel, 12 gauge wire.

C. Tree Collar: Non-stretch fabric with grommets, 1.5 inches wide by 12 inches length.
   1. Supplier: Central Bag and Burlap Co., 2715 Blake Street, Denver, CO 80205, (303)297-9955, or approved equal.

D. Wrapping Material: First quality 4 inch wide, bituminous impregnated tape, corrugated or crepe paper, specifically manufactured for tree wrapping and having qualities to resist insect infestation.

E. PVC: 1/2" diameter PVC pipe.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the Work of this Section will be performed. Report unsatisfactory or questionable conditions to the Architect. Do not proceed with the Work until unsatisfactory conditions have been corrected. Commencement of Work implies acceptance of all areas and conditions.
   1. Verify that during grading, topsoil spreading and landscape grading operations, the ground surface was cleaned of materials which might hinder final operations.

3.02 PREPARATION

A. Protection: Protect areas in accordance with paragraph 3.08 this Section.

B. Layout: Stake locations of individual plants and outline areas for multiple plantings. Secure Architect’s approval prior to starting Work.

3.03 GENERAL PLANTING REQUIREMENTS

A. Planting Season: Plant in accordance with paragraph 1.08 A. this Section.
3.04 TREES AND SHRUBS PLANTED IN INDIVIDUAL PLANT PITS OR TRENCHES

A. Excavation for Trees and Shrubs in Individual Plant Pits or Trenches:
1. Excavate pits, beds and trenches with sides shaped and sized as detailed. Scarpify subsoil on bottom and sides of excavation.
2. In tree pits without tree pit drains, fill each pit with water to test drainage. Pits shall drain within 24 hours.
   a. In the event non-draining soil is encountered, recommend to the Architect method to achieve subsurface drainage from details on the Drawings.
   b. Drainage system shall be approved by Architect prior to installation.
   c. Payment for subsurface drainage not included in the original Drawings shall be in accordance with the unit price submitted during base bid.
3. For balled and burlapped and container grown stock, excavate as shown on the Drawings. Adjust excavation to size of container width and depth, shaping excavation as indicated.
4. Preserve soil removed from tree and shrub planting excavations for reuse as tree and shrub planting soil.

B. Soil Preparation for Trees and Shrubs in Individual Plant Pits:
1. Clean soil in plant pits of roots, plants, sods, stones over 1.5 inches, clay lumps, asphaltic materials, concrete, metal and wire fragments and other extraneous materials harmful or toxic to plant growth. Remove contaminated subsoil.
2. Mix soil amendments with soil from pit at rates specified below:
   a. 70% soil from pit by volume
   b. 30% compost by volume
3. Uniformly mix planting soil mix, turning several times to achieve a uniform, evenly blended consistency, free of all pockets of unblended materials and any clods or stones greater than 1.5 inches in their greatest dimension.

C. Planting Trees and Shrubs in Individual Plant Pits:
1. Plant container grown and balled and burlapped (B&B) material in same manner except where noted.
2. Place planting soil mix in pit and compact to depth which will place top of rootball at specified height above surrounding grade. Set plants slightly high, as detailed and accepted by the Architect.
3. Set plant on layer of compacted planting soil mix, plumb and in center of pit or trench with top of ball at required elevation.
4. Place plant for best appearance for review and final orientation by the Architect.
5. Remove non-biodegradable root containers.
   a. Wire Baskets: Cut and remove wire baskets.
   b. Containers: Cut container cans on 2 sides with an approved can cutter; remove container so as not to damage root balls; a spade shall not be used.
6. Space fertilizer tablets evenly around root ball no higher than 1/3 of the way up the root ball. Place approximately 2 inches away from root tips for container stock, and adjacent to ball for B&B stock. Use the following number of tablets:
   a. 3 for 1 gallon containers.
   b. 9 for 5 gallon containers.
   c. 13 for balled and burlapped stock.

7. When set, place additional backfill around base and sides of root ball, and work each layer to settle backfill and eliminate voids and air pockets. When excavation is approximately 2/3 full, water thoroughly. Repeat watering until no more is absorbed.

8. Place remaining planting soil mix and tamp firmly. Water again after placing final layer of planting soil mix.

9. Dish top of backfill to allow for mulching as indicated.

10. Unless otherwise directed by Architect, do not cut tree leaders and remove only injured or dead branches from trees and shrubs, if any. Make flush cuts perpendicular to the secondary branches being removed in accordance with the References.

11. Remove and replace excessively pruned or stock.

12. Stake trees immediately after planting, as detailed using stakes or guying as noted on planting plan. Set trees plumb. Wrap only trees noted on plant list.

3.05 TREES, SHRUBS, PERENNIALS GROUNDCOVERS AND BULBS PLANTED IN PREPARED PLANTING BEDS AND PLANTERS

A. Soil Preparation For Shrubs, Perennials and Groundcovers Planted In At Grade Prepared Planting Beds:
   1. Prior to placing imported topsoil mix, disc or scarify existing subsoil in planting beds to a minimum depth of 6 inches or to a depth as indicated in drawings using a cultimulcher or similar equipment. Remove roots, plants, sods, stones over 1.5 inches, clay lumps, asphaltic materials, concrete, metal and wire fragments and other extraneous materials harmful or toxic to plant growth. Remove contaminated subsoil.
   2. Soil Preparation for Planting Beds:
      a. Organics: Apply 5 cubic yards per 1,000 square feet of compost by volume.
      b. Fertilizer: Apply 150 pounds of Gro-Power Plus per 1,000 square feet. Verify application rate after reviewing soils analysis.
      c. Substantiate quantities with delivery tickets and empty manufacturer's bags on a daily basis to Architect.
      d. Incorporate 50% of the required organic amendments and fertilizer. Thoroughly rototill into existing subsoil to a depth of 5 inches to achieve a uniform, evenly blended consistency free of all pockets of unblended materials and any clods or stones greater than 1.5 inches.
      e. Spread imported topsoil mix in accordance with Division 32 Section “Fine Grading and Soil Preparation” over amended subsoil in all planting bed areas. Remove roots, plants, sods, stones over 1.5 inches, clay
lumps, asphaltic materials, concrete, metal and wire fragments and other extraneous materials harmful or toxic to plant growth.

f. Incorporate remaining 50% of the required organic amendments and fertilizer with topsoil mix. Rototill to a depth of 7 inches. Apply and rototill in fertilizer no more than 48 hours before planting.

g. Fill prepared planting bed with water and allow to percolate out before planting. If water does not drain out in 24 hours, notify Architect.

1.) In the event non-draining soil is encountered, recommend to Architect method to achieve subsurface drainage.

2.) Drainage system shall be approved by Architect prior to installation.

h. Total depth of soil mixture shall be a uniform 10 inches in all planting beds after light rolling and natural settlement or as indicated in drawings. Compact soil in planting beds to 90% in accordance with Division 32 Section “Fine Grading and Soil Preparation”.

3. Soil Preparation for Planters:

a. Soil Mix for Planters:

1.) Imported pre-amended topsoil mix.

2.) Fertilizer: Apply Gro-Power planting tablets per manufacturer's recommendations for each plant type. Verify application rate after reviewing soils analysis.

3.) Soil pH range: 5.5. to 7. Add amendments if necessary.

4.) Substantiate quantities with delivery tickets and empty manufacturer's bags on a daily basis to Architect.

b. Fill planters in accordance with the Drawings. Fill planters no more than 48 hours before planting. Compact soil in planters to 90% in accordance with Division 32 Section “Fine Grading and Soil Preparation”.

C. Planting Shrubs, Ground Covers, Vines, and Perennials in Prepared Planting Beds and Planters:

1. Plant container grown and balled and burlapped (B&B) material in same manner except where noted.

2. Space plants as shown on the Drawings.

3. Place plant for best appearance for review and final orientation by the Architect.

4. Remove non-biodegradable root containers, including wire baskets. Cut container cans on 2 sides with an approved can cutter; remove stock so as not to damage root balls. A spade shall not be used.

5. Dig holes large enough to allow for rootball container and backfill with amended soil in the plant beds or soil mix in planters.
6. Space fertilizer tablets evenly around root ball no higher than 1/3 of the way up the root ball. Place approximately 2 inches away from root tips for container stock, and adjacent to ball for B&B stock. Use the following number of tablets:
   a. 3 for 1 gallon containers.
   b. 9 for 5 gallon containers.
   c. 13 for balled and burlapped stock.

7. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water. Water thoroughly after planting, taking care not to cover crowns of plants with wet soils.

8. Dish top of backfill to allow for mulching as indicated.

9. Unless otherwise directed by Architect, remove only injured or dead branches from shrubs, if any. Make flush cuts perpendicular to the secondary branches being removed.

10. Remove and replace excessively pruned or stock.

3.06 FIELD QUALITY CONTROL

A. Tests: Costs of tests and material analyses made by the testing agency will be borne by the Owner when tests indicate compliance and by the Contractor when test indicated non-compliance.

B. Reviews:
   1. General: Comply with Division 01.
   2. Pre-Planting Review
      a. Plant Procurement Inspection
         1.) Contractor shall notify Architect upon selection of all trees and shall designate source and location for inspection. Proposed materials shall be flagged by the Contractor to facilitate inspection.
         2.) Architect may choose to attach his seal to each tree or to representative samples. Inspection and/or sealing of plants by the Architect at the source does not preclude his rejection of trees for improper handling, transportation, storage, damage, insects or disease or otherwise not meeting this specification at the site of planting.
         3.) Do not ship trees to site without the Architect's approval.

      b. Plant Inspection:
         1.) All plant materials must be inspected by the Architect at supplier's or contractor's nursery and at the site before planting commences. Tag acceptable plant material with Contractor's numbered tag and verify upon arrival at the project site. Notify Architect 48 in advance to request inspection of plant material. Any materials planted prior to acceptance are subject to rejection. Inspection of plant materials may be sequenced by major planting areas to accommodate efficient planting operations. All rejected materials must be removed from the site.
site, replaced and reinspected before any additional inspections are made.

2.) The Architect may elect to inspect trees and shrubs at place of growth before planting, for compliance with requirements for genus, species, variety, size and quality. Architect retains the right to further inspect trees and shrubs for size and conditions of balls and root systems, insects, injuries and latent defects, and to reject unsatisfactory or defective material at any time during progress of work.

3.) If, in the opinion of the Architect, there is probable cause to suspect root damage, root binding, or disease conditions in the container stock plants, the Contractor will remove the container for the Architect's inspection before planting.

c. Grading: All finish grading shall be inspected by Architect prior to planting commencing. Correct any discrepancies prior to planting.

d. Staking: Stake all tree and shrub locations with flags. Architect shall inspect the staked locations before digging shall occur. The Contractor shall give the Architect 48 hours notice to request inspection of staked locations.

3. Substantial Completion
   a. Comply with General Conditions.
   b. At the time of this walk-through, the Contractor shall have:
      1.) Established all planted areas free of weeds, and neatly cultivated. All plant basins shall be in good repair. Pruning shall be completed.
      2.) Verified installed irrigation system is fully operational with heads properly adjusted.
      3.) Cleaned all walkways and curbs of debris and litter and shall have cleaned areas of soil and debris left from planting operations.

4. Final Completion: Comply with General Conditions.
5. Closeout Documents: Comply with General Conditions.
6. Start Up and Instructions: Comply with General Conditions.
7. Warranty and Replacement: Comply with General Conditions.
8. Post Construction Inspection: Comply with General Conditions.

3.07 CLEANUP

A. During Landscape Installation: All areas shall be reasonably clean at the end of each work day. Sidewalks and other paved areas shall be swept or washed down as needed. Keep pavements clean and work area in an orderly condition.

B. Project Completion: All debris, soil and trash resulting from landscape operations shall be removed from the site. All paved areas shall be washed down. All tags shall be removed from plant material.
C. Comply with the requirements of Division 01, General Requirements, and Section 01 74 19 “Construction Waste Management and Disposal” for recycling and salvage of debris and waste.

3.08 PROTECTION

A. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers.

B. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged landscape work as directed.

C. Comply with the requirements of Division 31 Section “Temporary Erosion and Sedimentation” for preparation and protection of the site.

END OF SECTION
SECTION 32 93 50

LANDSCAPE MAINTENANCE

PART 1 - GENERAL

1.01 SUMMARY

A. This Section Includes:
   1. Tree and Plant Maintenance.
   2. Turf Maintenance.
   3. Irrigation System Maintenance.
   5. Protection.

B. Related Sections:
   1. Division 01 Sections “Construction Waste Management and Disposal”, “Sustainable Design Requirements”, and “Temporary Facilities and Controls” for temporary erosion and sedimentation-control measures for additional LEED requirements.
   2. Division 01 Section “Submittal Procedures”.
   3. Division 01 Section “Quality Requirements”.
   4. Division 31 Section “Temporary Erosion and Sedimentation Controls”.
   5. Division 32 Section “Crushed Stone Surfacing”.
   6. Division 32 Section “Underground Sprinklers”.
   7. Division 32 Section “Fine Grading and Soil Preparation”.
   8. Division 32 Section “Turf and Grasses”.
   9. Division 32 Section “Planting”.
  10. Division 32 Section “Planting Accessories”.

1.02 REFERENCE

A. American Standards for Nursery Stock (ANSI Z60.1 - most recent edition), American Association of Nurserymen, Washington D.C.


G. ASPA (American Sod Producers Association) - Guideline Specifications to Sodding.

1.03 DEFINITIONS


B. Plants: Trees, shrubs, groundcovers, annuals, perennials, and bulbs specified in the plant list.

1.04 SUBMITTAL PROCEDURES

A. Comply with Division 32 Sections “Submittal Procedures”.

B. Submit in typewritten form:
   1. Maintenance company qualification for acceptance by Architect and Owner prior to commencing Work. Include hourly rates for maintenance personnel. Submit 2 weeks prior to Final Acceptance walk-through.
   2. Procedures which Contractor shall complete during the maintenance period.
      a. Include proposed herbicide, insecticides, fertilizers, and any other chemical treatment to the Architect for review and approval prior to commencing Work.
   3. Procedures to be established by the Owner, upon completion of maintenance period, for one year maintenance of landscape. Submit 3 months prior to the expiration of the maintenance period.
   4. LEED Submittals:
      a. Credit MR 4.1 and Credit MR 4.2: Product data and certification letter indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
      b. Credit MR 5.1 and Credit MR 5.2: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
      c. Provide documentation of construction and demolition waste debris recycling / salvage rates. See Section 01 74 19 “Construction Waste Management and Disposal”.

LANDSCAPE MAINTENANCE
32 93 50 - 2
1.05 QUALITY REQUIREMENTS

A. Comply with Section 01 40 00 “Quality Requirements”.

B. Qualifications:
   1. Maintenance Company: The work of this Section shall be the responsibility of the landscape subcontractors ONLY. This Section may be performed by the landscape subcontractor or his sub-subcontractor. Company shall be a member in good standing of one of the following organizations:
      a. Associated Landscape Contractors of America.
      b. American Association of Nurserymen.
      c. A member of the Nurserymen's Association of the state in which the work is being performed.

   2. Work Force: Contractor's representative shall be experienced in the maintenance and repair of all types of plantings and irrigation systems which are part of this Contract.

C. REGULATORY REQUIREMENTS
   1. Comply with regulatory agencies concerning classification, transportation, handling and storage of plants, fertilizer, herbicide and pesticide materials.
   2. Comply with regulatory agencies for fertilizer, herbicide and pesticide composition and application.
   3. Licenses and Taxes:
      a. Licenses: Contractor shall obtain and pay for all licenses required by city, county, state and federal governments that are necessary for the legal conduct of his business.
      b. Taxes: Contractor shall pay all applicable taxes, including sales taxes on materials supplied.

D. LEED Requirements: Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Materials: All materials used in maintenance and repair shall conform to these Specifications or shall be otherwise accepted by the Owner.
PART 3 - EXECUTION

3.01 GENERAL

A. General: Furnish all supervision, labor, material, equipment and transportation required to maintain the planting and irrigation system called for under this Contract, in an attractive, healthy, operable condition for a period of one-year or for one full growing season, whichever one is longer, from the date of final acceptance. Contractor shall be responsible for all maintenance and shall provide winter watering as needed to insure healthy, vigorous plant growth.

B. Pre-Maintenance Inspection: Schedule pre-maintenance inspection prior to the beginning of the warranty period in accordance with Division 32 Section “Underground Sprinklers”, Division 32 Section “Turf and Grasses”, and Division 32 Section “Planting”.

3.02 TREE AND PLANT MAINTENANCE

A. Watering: Maintain large enough water basin around plants so that enough water can be applied to establish moisture through the major root zone. When hand watering, use a water wand to break the water force. Utilize mulches to reduce evaporation and watering frequency. Contractor is responsible for all winter water requirements.

B. Pruning: None required except at time of planting and as needed to correct damage.

C. Stakes and Guys: Inspect regularly to prevent girdling of trunks or branches and to prevent rubbing which might cause bark wounds. Remove and replace stakes and guys as directed by the Owner’s Representative.

D. Weed Control: Maintain tree and shrub basins free of weeds and grasses on a weekly basis using a pre-approved herbicide. Frequent soil cultivation which might destroy shallow roots is not permitted. Apply approved pre-emergent herbicide to shrub beds in the spring. Use of mulches to prevent seed germination is permitted.

E. Insects and Disease Control: Control insects and disease as necessary to prevent damage to the health or appearance of plants. Use only approved materials and methods.

F. Fertilization: Fertilize trees and shrubs by means of foliar application of an approved water soluble fertilizer. Submit fertilizer specifications to Architect for approval. Fertilize trees and shrubs at the following times when they occur during the maintenance period:
   1. Early April.
   2. June.
   3. Early August.
G. Replacement of Plants: Replace plant material during the warranty period in accordance with Division 32 Section “Turf and Grasses”, and Division 32 Section “Planting”. Remove dead and dying plants and replace with plants of equal size, condition and variety of original planting. Make replacements within 7 days of notification from Owner except as prohibited by season and authorized by the Owner, and remove rejected plants within 7 days of notice.

H. Tree Protection: Remove and/or apply tree wrap starting wrap from the bottom up. Wrap all trees, except for Cottonwoods (Populus spp.).
   1. Apply a coating of insecticide and fungicide to the tree trunk area to be wrapped.
   2. Apply wrap to overlap 1-1/2" from ground line up to the lowest branch. Wrap trunks in late fall (approximately November 15).
   3. Tie securely in at least five places with jute twine, placed at least 12" apart.
   4. Remove tree wrap the beginning of the growing season (approximately April 15).

I. Emergency Repairs: Contractor shall be available to the Owner at any time during the maintenance period to perform emergency repairs that may be necessary. Costs will be negotiated by the Owner and the Contractor at the time based on Contractor’s submitted hourly rates.

3.03 TURF MAINTENANCE

A. Mowing and Edging: Trim edges of curbs and walks at least three times during growing season or as needed for neat appearance. Pick up trash before each mowing. Vacuum or Blow off and remove clippings from walks and streets. Mowing schedule to be reviewed by and coordinated with the Owner. Remove grass clippings from the premises. Trimming up of lower branches of trees and shrubs for ease of maintenance is not permitted. Mow areas as follows:
   1. Dryland Grass: Mow dryland grass seeded areas 3 times during growing season. Do not mow until after first blooming of flowers.

B. Watering: Water lawns at such frequency as weather conditions require to replenish soil moisture below the root zone. Watering shall only be done in the evening hours. Normal watering may entail as much as 1-1/2" of water weekly in hot weather.

C. Weed Control: Control broad-leaf weeds in seeded areas only. Use selective herbicides as accepted by Owner. Follow all manufacturer’s recommendations and precautions.

D. Insect and Disease Control: Apply necessary insecticides and fungicides as condition of turf requires and as approved by the Owner.
3.04  IRRIGATION SYSTEM MAINTENANCE

A. Reviews and Repairs:  Check all systems for proper operation after each mowing.  Make all repairs before the next watering cycle.  Any damage caused to the system by Contractor’s operations shall be repaired at no cost to the Owner.
   1. Correct any repairs needed as a result of improper winterization or negligence due to the Contractor at no additional cost to the Owner.

B. Controller Programing:  Program the irrigation controller including schedule, cycles, amount of water, etc.  Review watering schedule with Owner.
   1. Take extra care to balance the requirements of trees, shrubs and lawns which are in the same vicinity.  Adjust watering timing and rates frequently to insure the health of each type of plant material.  Adjust sprinkler nozzle settings and sizes to refine application rates in specific areas as necessary.

C. Winterization:  Under the maintenance period, drain the system in preparation for the period of one-year or for one full growing season, whichever one is longer.  Remove all water from the system using compressed air.

D. Spring Start-Up:  Under the maintenance period, Contractor shall be responsible for starting up the irrigation system for a period of one-year or for one full growing season, whichever one is longer.  Activate the system and demonstrate that it is in full working order.  Repairs needed as a result of improper winterization or negligence due to the Contractor shall be corrected by the Contractor at no additional cost to the Owner.

3.05  CLEANUP

A. During landscape Maintenance:  All areas shall be reasonably clean at the end of each work day.  Sidewalks and other paved areas shall be swept or washed down as needed.  Keep pavements clean and work area in an orderly condition.

B. Comply with the requirements of Division 01 “General Requirements”, and Division 01 Section “Construction Waste Management and Disposal” for recycling and salvage of debris and waste.

3.06  PROTECTION

A. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers.

B. Treat, repair or replace damaged landscape work as directed.

C. Protect adjacent pavements from fertilizer staining.

D. Comply with the requirements of Division 32 Section “Erosion and Sedimentation Control” for preparation and protection of the site.

END OF SECTION
SECTION 32 94 00
PLANTING ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section Includes:
   1. Examination.
   2. Preparation.
   3. Wood Mulch.
   5. Landscape Edging.
   6. Weed Barrier Fabric
   7. Field Quality Control.
   9. Protection.

B. Related Sections:
   1. Division 01 Sections “Construction Waste Management and Disposal”, “Sustainable Design Requirements”, and “Temporary Facilities and Controls” for temporary erosion and sedimentation-control measures for additional LEED requirements.
   2. Division 01 Section “Submittal Procedures”.
   3. Division 01 Section “Quality Requirements”.
   4. Division 31 Section “Temporary Erosion and Sedimentation Control”.
   5. Division 32 Section “Underground Sprinklers”.
   6. Division 32 Section “Fine Grading and Soil Preparation”.
   7. Division 32 Section “Turf and Grasses”.
   8. Division 32 Section “Planting”.
   9. Division 32 Section “Landscape Maintenance”.

1.02 REFERENCES


1.03  DEFINITIONS


1.04  SUBMITTAL PROCEDURES

A.  Comply with Division 01 Section “Submittal Procedures”. All submittals shall be accepted by the Architect in writing before planting commences.

B.  Descriptive Product Data: Submit catalog cuts, brochures, and analyses of any manufactured items.

C.  Certificates:
   1.  Submit certificates of inspection as required by governmental authorities.
   2.  Submit manufacturer’s certified analysis packaged with standard products.

D.  Analysis and Standards: Wherever applicable, for non packaged materials, provide analysis by recognized laboratory made in accordance with methods established by the Association of Official Agriculture Chemists.

E.  Mulch Submittal: Submit 1 quart sample of each mulch type to be installed, full color range. Obtain Architect’s approval prior to bulk delivery to site.

F.  LEED Submittals:
   1.  Credit MR 4.1 and Credit MR 4.2: Product data and certification letter indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
   2.  Credit MR 5.1 and Credit MR 5.2: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   3.  Provide documentation of construction and demolition waste debris recycling/salvage rates. See Section 01 74 19 “Construction Waste Management and Disposal”.

1.05  QUALITY REQUIREMENTS

A.  Comply with Division 01 Section “Quality Requirements”.

B.  Regulatory Requirements: Comply with regulatory agencies concerning classification, transportation, handling and storage of landscape materials.
C. LEED Requirements: Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Comply with Division 01 Section “Quality Requirements”.

B. Packaged Materials: Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at site.

C. Mulch: Exercise care in the storage of mulches on site to avoid mixing soil with mulch.

D. Weed Barrier Fabric: Exercise care in the storage of fabric on site to prevent damage to fabric prior to and during installation.

E. Rejection of Material:
   1. Evidence of inadequate protection or improper handling or storage, shall be cause for rejection.
   2. Any product or material exhibiting signs of damage due to nonconformity to specifications or due to delivery, storage or handling shall be rejected by the Architect. Contractor shall be responsible for hauling off-site and disposing of according to general conditions and codes of the governing jurisdiction.

1.07 PROJECT/SITE CONDITIONS

A. Environmental Requirements: Work shall occur only when weather and soil conditions permit in accordance with locally accepted practice.

B. Existing Conditions:
   1. Existing Plants: Do not damage any existing plantings indicated to remain.
   2. Utilities: Determine location of underground utilities. Perform work in a manner to avoid possible damage. Hand excavate, as required.
   3. Excavation: Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned.

1.08 SEQUENCING AND SCHEDULING

A. Work Scheduling: Proceed with and complete landscape work as rapidly as portions of the site become available, working within the specified planting season and approved schedule.

1.09 WARRANTY AND REPLACEMENT

A. General: Refer to General Conditions.
1.10 MAINTENANCE

A. General: Maintain Work in accordance with standard industry practice or as directed by
the Architect.

B. Maintenance Period: Begin maintenance immediately after Work is completed.
Maintain areas in accordance with Division 32 Section “Landscape Maintenance”.

PART 2 - PRODUCTS

2.01 WATER

A. Clean, potable and free of substances or matter which could inhibit vigorous growth of
plant material.

B. Available on-site at no expense to Contractor. Landscape Contractor is responsible for
coordination of water needs for watering and irrigation water with the Owner.

2.02 WOOD MULCH

A. Shredded bark mulch, free from deleterious materials and suitable for top dressing of
trees, shrubs and ground covers. Mulch shall be of a long fibrous nature capable of
matting together and interlocking when moistened and settled. Shredded cedar bark
mulch or accepted substitute.

B. Submit samples prior to delivery to the site in accordance with paragraph 1.06 E. this
Section.

C. Substitutions: Do not make substitutions. If specified wood mulch is not obtainable,
submit proof of non-availability to Architect together with proposal for use of
equivalent material for review and acceptance by Architect.

2.03 STONE MULCH

A. Mineral Mulch: Mineral mulch to match existing mineral mulch around existing
transformer. Submit samples of existing mulch and proposed mulch.

B. Cobble Mulch: Washed 2-½” diameter cobble river rock. Submit samples of mulch.

2.04 LANDSCAPE EDGING

A. Steel Edging: 14 gauge (5/64”) x 4 inches deep roll-top galvanized steel edging with hot-
dipped galvanized stakes placed 3 feet on center. Provide steel edging in all locations
shown on the drawings.

1. Where steel edging surrounds stone mulch adjacent to building walls provide
½” diameter holes 12” o.c. located at mid-height of edging to provide drainage.
B. Manufacturer: Ryerson Steel, Box 16445, Denver, CO, 80216, (303)287-0101, or approved equal.

2.05 WEED BARRIER FABRIC

A. Fabric: Nonwoven porous fabric, Dupont 'Typar', for use as indicated in details.

B. Manufacturer: Dupont, Reemay, P.O. Box 511, Old Hickory, TN, 37138, (800)321-6271 or approved equal.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the Work of this Section will be performed. Report unsatisfactory or questionable conditions to the Architect. Do not proceed with the Work until unsatisfactory conditions have been corrected. Commencement of work implies acceptance of all areas and conditions.

1. Verify that during grading, topsoil spreading and landscape grading operations, the ground surface was cleaned of materials which might hinder final operations.

3.02 PREPARATION

A. Protection: Protect areas in accordance with paragraph 3.08 this Section.

B. All areas within the limits of planting shall be seeded, sodded, planted with trees, shrubs, groundcovers, perennials or mulched as indicated on the Drawings and Specifications.

3.03 WOOD MULCH

A. Mulch areas area around trees in accordance with drawings. Place 3 inches thick. Trees in native grass to receive a 6 foot diameter mulch ring around trunk, 3 inches thick.

3.04 STONE MULCH

A. Mulch areas around generator with 3 inches thick (mineral mulch to match existing) over weed barrier fabric.

B. Washed Cobble Mulch:

1. General: Areas to receive stone mulch shall be rough graded in accordance with Division 32 Section “Earth Moving” before Work of this Section is performed. Final fine grading, stone installation and compaction of these materials as required to form a firm, uniform, accurate and unyielding surface at required elevations and to required lines, shall be done under this Section.
2. Grading:
   a. Remove existing subgrade material which will not readily compact as required and replaced with satisfactory materials. Additional materials needed to bring subgrade to required line and grade and to replace unsuitable material removed shall be material conforming to this Section.
   b. Maintain shape and drainage of graded or compacted areas during construction. Repair, reshaped as required, and recompacted ruts in subgrade greater than or equal to 1 inch deep, before placing stone mulch.
      1) Compacted subgrade shall provide positive drainage as indicated on Grading Plan.
      2) Set subgrade 6” below adjacent finish grade to accommodate 2-4” depth of stone mulch.

   c. Do not store or stockpile materials on subgrade.

   d. Subgrade Compaction:
      1) For Stone Mulch: Recompacted as required to achieve top 4 inches of materials at a minimum compaction of 90% of maximum density, as determined by ASTM D 1557. Extend subgrade compaction minimum 1 foot beyond proposed edge of mulch.

3. Installation of Stone Mulch:
   a. General: Install stone mulch only after excavation and construction work which might damage it have been completed, and after steel edging has been completely staked. Damage caused during construction shall be repaired before acceptance.

   b. Drainage: Verify subgrade exhibits positive drainage.
      1) Any areas which show signs of poor subgrade drainage shall have mulch and fabric removed, subgrade drainage repaired and compacted, and fabric and mulch reinstalled as per these specifications at no cost to the Owner.

   c. Weed Barrier: Apply weed barrier fabric to full width of all areas to be mulched as well as wrapping fabric up side of edging, building, wall, etc. Overlap ends by a minimum 6 inches.

   d. Stone Mulch Installation
      1) Stone Mulch: Spread evenly over weed barrier fabric and prepared subgrade to a final depth indicated in this section. Spread stone mulch evenly so that the surface conforms to the finish grades indicated, and so that the grade is at a uniform slope.
4. Tolerances: Variations in smoothness of finished stone mulch shall be less than or equal to 2-inches when tested with a 10 foot straightedge, applied both parallel and at right angles to centerline of stone mulched areas. Irregularities exceeding these amounts of which retain water on surface shall be corrected by removing defective work and replacing with new material conforming to this specification.

3.05 LANDSCAPE EDGING

A. General: Install steel edging at locations indicated in the Drawings. Where required, cut edging square and accurately to required length.

B. Installation:
   1. Secure edging at beginning and end points to adjacent structure where this is possible as shown on Drawings. Repair damage to concrete or other structures if damage occurs. Repairs shall be in accordance with Division 01 Section “Summary”.
   2. Securely stake edging in required position and in accordance with manufacturer’s instructions
   3. Butt adjacent ends and lock together with a widened stake.
   4. Set edging plumb and vertical at required line and grade. Straight sections shall not be wavy; curved sections shall be smooth and shall have no kinks or sharp bends.
   5. For steel edging bend angles using a jig.
   6. For steel edging weld together cut pieces if unable to lock together with stakes.

3.06 FIELD QUALITY CONTROL

A. Tests: Costs of tests and material analyses made by the testing agency will be borne by the Owner when tests indicate compliance and by the Contractor when test indicated non-compliance.

B. Reviews:
   1. General: Comply with General Conditions.
   2. Pre-Planting Review
      a. All mulches and edging shall be inspected and accepted at the site by the Architect before they are used in planting operations.
   3. Substantial Completion
      a. Comply with General Conditions.
      b. At the time of this walk-through, the Contractor shall have:
         1) Installed all items in accordance with this Section.
         2) Cleaned all walkways and curbs of debris and litter and shall have cleaned areas of soil and debris left from planting operations.
   4. Final Completion: Comply with General Conditions.
5. Closeout Documents: Comply with General Conditions.
6. Start Up and Instructions: Comply with General Conditions.
7. Warranty and Replacement: Comply with General Conditions.
8. Post Construction Inspection: Comply with General Conditions.

3.07 CLEANUP

A. During landscape installation: All areas shall be reasonably clean at the end of each work day. Sidewalks and other paved areas shall be swept or washed down as needed. Keep pavements clean and work area in an orderly condition.

B. Project Completion: All debris, soil, trash, and excavated and/or stripped material resulting from landscape operations and unsuitable for or in excess of requirements for completing work of this Section shall be disposed of off-site. All paved areas shall be washed down.

C. Comply with the requirements of Division 01 “General Requirements”, and Division 01 Section “Construction Waste Management and Disposal” for recycling and salvage of debris and waste.

3.08 PROTECTION

A. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers.

B. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged landscape work as directed.

C. Comply with the requirements of Division 31 Section “Temporary Erosion and Sedimentation Control” for preparation and protection of the site.

END OF SECTION
SECTION 33 31 00

SANITARY UTILITY SEWERAGE PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Work Included: Connection to existing manholes, and installation of pipe, manholes, service wyes, cleanouts, service lines, testing, and all necessary appurtenances and safety precautions. This section also includes gravity-flow, force-main, sanitary sewerage outside the building, with the following components:
   1. Special fittings for expansion and deflection.
   2. Cleanouts.

B. Related Sections:
   1. Division 01 Section “LEED” or “Sustainable Design” requirements for product data and manufacturing documentation.
   2. Division 01 Section “Construction Waste Management and Disposal” for recycling and disposal of waste.
   3. Division 31 Section “Site Clearing” for temporary utilities and support facilities may be included.
   4. Division 31 Section “Earth Moving” for soil materials, site grading, site excavation and filling.
   5. Division 31 Section “Trenching and Backfilling” for excavating and backfilling of utilities.
   6. Division 32 Section “Asphalt Paving” pavement patching over trenches.
   7. Division 32 Section “Concrete Paving” for concrete structures, concrete materials and exterior concrete paving or walks.
   8. Division 31 Section “Temporary Erosion and Sedimentation Control” for erosion and sedimentation control measures.

C. All items under this section shall, at a minimum, conform to agency having jurisdiction.

1.02 DEFINITIONS

A. HDPE: High Density Polyethylene plastic.

B. PE: Polyethylene plastic.

C. PVC: Polyvinyl chloride plastic.

1.03 SUBMITTALS

A. Submit shop drawings or product data showing specific dimensions and construction materials for pipe, fittings, and manholes or certifications that products conform with specifications.

B. Test Reports: Submit all field quality control test reports.
C. Permits: Contractor is responsible for obtaining all applicable utility agency, City, County and State permits for the project. Submit copies of all permits issued for project.

D. LEED Submittals
1. Product Data for Credit MR 4.1 and Credit MR 4.2: Include manufacture’s product data indicating separate percentages, by weight, of post-consumer and pre-consumer recycled content for projects having recycled content. Include statement indicating material costs for products.
2. Product data for Credit MR 5.1 and Credit MR 5.2: Indicate location of manufacturing facility including name, address and distance between manufacturing facility and the proposed site. Provide manufacture's documentation indicating location where the base materials were extracted, mined, quarried, harvested, etc. and the distance between this location and the project site. Also include material costs, excluding cost of installation.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic pipe and fittings in direct sunlight.
B. Protect pipe, pipe fittings, and seals from dirt and damage.
C. Handle manholes according to manufacturer's written rigging instructions.

1.05 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Owner’s Representative no fewer than two days in advance of proposed interruption of service.
   2. Do not proceed with interruption of service without written permission.

B. Environmental Requirements: Except by specific written authorization, cease concreting when descending air temperature in shade and away from artificial heat falls below 35 degrees F., and there is frost in subgrade. When concreting is permitted during cold weather, temperature of mix shall not be less than 60 degrees F at time of placing.

C. Immediately pump or bail out water found in excavations, whether rain or seepage. Coordination and use of electric power is the Contractor's responsibility. Excavations must be kept free from water at all times.

D. It shall be the responsibility of the Contractor to take all measures and furnish all equipment and labor necessary to control the flow, drainage and accumulation of water as required to permit completion of the work under this section to avoid damage to all work at no additional cost to the Owner. Contractor is responsible for discharge permit as required by local or State jurisdiction.

SANITARY UTILITY SEWERAGE PIPING
33 31 00 - 2
1.06 PROJECT RECORD DOCUMENTS

A. Maintenance of Documents: Store documents apart from drawings used for construction. File submitted documents in accordance with the specifications' section numbers. Maintain documents in a clean, dry, legible condition and in good order. Do not use record documents for construction purposes.

B. Recording: Label each document "PROJECT RECORD" in neat, large, printed letters. Record information concurrently with construction progress. Do not cover work until required information is recorded. Marking of project records shall be legible and with a dark pen or pencil. Ink shall not be water based due to easy smearing. Mark drawings to record actual construction including field dimensions, elevations, details, changes made by a modification, details not on original drawings, horizontal and vertical locations of underground utilities and appurtenances referenced to a minimum of two permanent surface improvements, and depths of various elements of work in relation to project datum.

C. Submission: Accompany submittal with transmittal letter in duplicate containing date, project title and number, Contractor's name, address and telephone number, title and number of each record document, and signature of Contractor or his authorized representative. Contractor shall submit two drawings and certification of data by a Professional Land Surveyor depicting all as-built information to the Engineer.

1.07 PROTECTION

A. Barricades and Safety Provisions: Place and maintain until completion of work adequate barricades, construction signs, warning lights and guards to avoid property damage and to protect persons from injury. Flares with open flames will not be permitted. Protect all materials, equipment, pipe, and earth piles that may serve as hazards to vehicular or pedestrian traffic by barricades or guards and warning lights.

B. Utilities: Protect from damage existing utility lines shown on drawings or locations of which are made known to contractor prior to work, and utility lines constructed during construction operations of the project. Hand excavate within 6-inches of known piping or objects to prevent damage from equipment. Before commencing work, obtain information concerning location, type, and extent of concealed existing utilities on the site and adjacent properties. Repair damage to utilities at no cost to the Owner.

C. Drainage: Maintain the excavations and site free from water throughout the work. Remove any water encountered in the trench to provide firm subgrade, to permit joints to be made dry at the final grade, and to prevent entrance of water into the pipeline.

Rock, gravel, and other appurtenances used to keep trenches free from water or used to add support to installed piping is considered incidental to construction and all costs shall be the responsibility of the Contractor.

D. Survey Control Range Boxes: Protect existing survey control monuments from damage. Contractor will be responsible for replacement or repair of any monument damaged or destroyed. Replacement of monuments must be performed by a qualified land surveyor.
PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 PVC PIPE AND FITTINGS


C. PVC Pressure Pipe: AWWA C900 ASTM D2241, Class 150, for gasketed joints and using ASTM F 477, elastomeric seals.
   1. Fittings 4-inches to 8-inches: PVC pressure fittings complying with AWWA C907, for gasketed joints and using ASTM F 477, elastomeric seals.
   2. Fittings 10-inches and Larger: Ductile-iron, compact fittings complying with AWWA C153, for push-on joints and using AWWA C111, rubber gaskets.

2.03 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:
   1. For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
   3. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
   4. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

2.04 PRESSURE-TYPE PIPE COUPLINGS

A. Reducing or transition, metal, bolted, sleeve-type, reducing or transition coupling, for joining underground pressure piping. Include 150-psig minimum pressure rating and ends of same sizes as piping to be joined.

B. Tubular-Sleeve Couplings: AWWA C219, with center sleeve, gaskets, end rings, and bolt fasteners.
   1. Manufacturers:
      a. Cascade Waterworks Mfg.
b. Dresser, Inc.; DMD Div.
c. Ford Meter Box Company, Inc. (The); Pipe Products Div.
d. JCM Industries.
e. Romac Industries, Inc.
f. Smith-Blair, Inc.
g. Viking Johnson.

2. Center-Sleeve Material: Stainless steel.
3. Gasket Material: Natural or synthetic rubber.
4. Metal Component Finish: Corrosion-resistant coating or material.

2.05 CLEANOUTS

A. Gray-Iron Cleanouts: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
1. Manufacturers:
   b. MIFAB Manufacturing Inc.
   d. Wade Div.; Tyler Pipe.
   e. Watts Industries, Inc.
   g. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

   2. Top-Loading Classification: Heavy duty.
   3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

   B. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.
   1. Manufacturers:
      a. Canplas Inc.
      b. IPS Corporation.
      c. NDS Inc.
      d. Plastic Oddities, Inc.
      e. Sioux Chief Manufacturing Company, Inc.
      f. Zurn Light Commercial Specialty Plumbing Products; Zurn Plumbing Products Group.

2.06 MANHOLES

A. Standard Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
   1. Diameter: 48-inches minimum, unless otherwise indicated.
   2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
3. Base Section: 8-inch minimum thickness for floor slab and minimum thickness for walls and base riser section, being 1/12 of internal diameter and having separate base slab or base section with integral floor. Base to have integral wall section one to three (1-3) feet high.

4. Riser Sections: minimum wall thickness of 1/12 of internal diameter (IE: 1/12 – 48” Ø = 4” minimum thickness), and of length to provide depth indicated.

5. Top Section: Eccentric-cone type, unless flat-slab-top type is indicated. Top of cone of size that matches grade rings.

6. Manhole Joint Sealant: All joints in the manhole barrel, cone and/or flat top sections including the joint between the cast-in-place base slab and the bottom barrel section shall be sealed with a preformed, flexible plastic gasket conforming to the following requirements.
   a. The flexible plastic gasket shall be in conformance with Federal Specification SS-S 00210, "Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints".
   b. The plastic sealing compound shall be packaged in extruded preformed rope-like shape of proper size to completely fill the joint when fully compressed. The material shall be protected by a suitable, removable, two-piece wrapper so that one wrapper may be removed as the compound is applied to the joint surface without disturbing the other wrapper, which remains attached to the compound for protection. The sealing compound shall be impermeable to water, have high immediate bonding strength to the primed concrete surface, and shall maintain permanent plasticity, resistance to water, acids, and alkalis.
   c. All surfaces of the tongue and groove joint of the manhole barrel shall be primed with an approved priming compound prior to the installation of the sealing compound. The application of the priming compound and the sealing compound shall be accomplished in strict conformance with the manufacturer’s instructions, as to the method of application, quantity of material, the grade of the materials, and the application temperatures.
   d. All lifting holes shall be sealed with the plastic sealing compound.
   e. All joints shall be sealed with non-shrink grout both inside and outside.
   f. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.

7. Manhole Steps: All manhole steps shall be similar and equal to those specified below and shall be installed in a straight line vertically. Manhole steps shall be cast into the wall at the same time the barrel section is cast. Except for unusual circumstances, steps which are inserted or grouted in the wall after the wall has been cast will not be accepted. Steps shall be installed with a nominal spacing of 15-inches and a minimum of 5.5-inches from face of manhole.
   a. Polypropylene Reinforced Plastic: ASTM Specifications
      1) ASTM C-478
      2) ASTM A-615 Grade 60 (steel rod)
      3) ASTM 2146 69, Type II Grade 16906 (polypropylene)
      4) Provide a minimum 500 lb carrying load 6-inches from face of manhole.
b. Aluminum, Federal specification QQ-A-200/8, or ALMAG35. Two non-skid grooves in surface of step and capable of carrying load of 1000 lbs. 6" from face of manhole.

8. Grade Rings: Reinforced-concrete rings, 3 to 9-inch total thickness, to match diameter of manhole frame and cover.

9. Manhole Frames and Covers: Ferrous; 24-inch ID by 7-inch to 9-inch riser with 4-inch minimum width flange and 26-inch diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to “SANITARY SEWER.” Ring and cover combined weight greater than 400 lbs., machined to fit securely. Non-rocking cover.
   a. Material: ASTM A 48 iron, unless otherwise indicated.

2.07 CONCRETE

A. General: Contractor is responsible for replacement of curb, gutter, sidewalks and cross pans as per authority having jurisdiction. Removal and replacement of the above items will be included under piping bid item. All workmanship and products furnished shall be per Division 2, section “Concrete Paving.”

B. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:
   1. Cement: ASTM C 150, Type II.

C. Portland Cement Design Mix: 4000 psi at 28 days minimum, with 0.45 maximum water/cementitious materials ratio.
   1. Proportions:
      Cement 5-1/2 sacks per cubic yard.
      Coarse aggregate – 43%.
      Water – 5.5 gallons per sack.
      Maximum size aggregate – ¾-inch.
   2. Slump: 4” maximum.
   3. Air Content: 5% - 7%.
   4. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

D. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi at 28 days minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
   1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
      a. Invert Slope: 2 percent minimum through manhole or as shown on drawings.
   2. Benches: Concrete, sloped to drain into channel.
      a. Slope: 8 percent.
E. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.48 maximum water/cementitious materials ratio.
   2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

F. Job Mixed Concrete will not be allowed.

G. Ready Mixed Concrete: Proportioned, mixed, and transported in accordance with ASTM C94. Any concrete not plastic and workable when it reaches project shall be rejected.


I. Curing Materials:
   1. Burlap Cloth from Jute or Kenaf: AASHTO M182.
   2. White Liquid Membrane: AASHTO M148, 1 gal/150 SF.

2.08 MORTAR

A. The mortar shall consist of one part cement, 0.15 part lime, and three parts sand, measured by volume. The cement, lime and sand shall be first mixed dry to a uniform color in a suitable box or batch mixer and then mixed with water thoroughly; the water being added gradually until the required consistency is obtained. Mortar shall be mixed in batches of such size as will be used immediately. Retempered mortar, or any mortar which has been mixed for more than one-half hour shall not be used. When mortar is molded into briquettes one square-inch in cross-section, it shall attain an ultimate tensile stress of 125 pounds per square-inch after one day in air and six days in water, and 175 pounds per square-inch after one day in air and twenty-seven days in water.

2.09 LEED REQUIREMENTS

A. Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity.

B. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

PART 3 - EXECUTION

3.01 EARTH MOVING

A. Excavating, trenching, and backfilling are specified in Division 2 Section "Trenching." In addition meet the following requirements:
B. Exploratory Excavation: It shall be the Contractor's responsibility to excavate and locate all existing utilities which may affect construction of the sewer facilities. All exploratory excavations shall occur far enough in advance to permit any necessary relocation to be made with minimum delay. All costs incurred by the Contractor in making exploratory excavations shall be considered to be included in the unit price bid for constructing each section of sewer line or the associate structures.

C. Provide temporary erosion and sedimentation control measures in accordance with Division 31 Section "Temporary Erosion and Sedimentation Control" to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation control drawings and requirements of authorities having jurisdiction.

3.02 UNSTABLE TRENCH BOTTOM

Where trench does not have sufficient strength to support pipe and bedding, or stream crossings are encountered, use one of following methods to prepare trench bottom as approved by Engineer. At a minimum, 2-feet of soil beneath pipe shall be stabilized.

A. Embankment: Clear and strip existing surface of all unacceptable material. Place embankment material agreed to by Engineer, compact to 95% AASHTO T99.

B. Aggregate Trench Bottom, Percent by Weight Passing Square Mesh Sieves: 1 ½", 90-100; 3/4", 50-90; No. 4, 30-50; No. 200, 3-12.

3.03 GROUNDWATER

A. Water seeping from trench banks or flowing in trench bottom, but not flowing in trench bottom: Install gravel in accordance with drawings.

3.04 PIPING APPLICATIONS

A. Pipe couplings and special pipe fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping, unless otherwise indicated.
   a. Unshielded flexible couplings for same or minor difference OD pipes.
   b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.

2. Use pressure-type pipe couplings for force-main joints.

3.05 PIPING INSTALLATION

A. Remove and dispose of existing sanitary sewer pipe where shown on drawings. Service is to be diverted and maintained during installation of the new pipeline. Pumping between manholes is acceptable.
B. Construct pipe accurately to line and grade shown on drawings. Pipe installation will be lamped daily by Engineer or Owner's representative. Remove and replace pipe not conforming to line and grade at Contractor's expense.

C. Install per manufacturer's recommendations by placing pipe continuously upgrade. Bell ends to face upgrade. Prior to making joints, clean and dry all surfaces. Use lubricants in conformance with manufacturer's recommendations for insertion of pipe in joint. Set pipe in position and check line and grade. Keep dirt from entering all exposed pipe ends. Joints to be watertight.

D. Install manholes for changes in direction, unless fittings are indicated. Use fittings for branch connections, unless direct tap into existing sewer is indicated.

E. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

F. Install gravity-flow, nonpressure, drainage piping according to the following:
   1. Install piping pitched down in direction of flow, at a slope shown on plans.
   2. Install piping with 36-inch minimum cover unless otherwise indicated.
   3. Install piping below frost line.
   4. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

G. Install force-main, pressure piping according to the following:
   1. Install piping with restrained joints at tee fittings and at horizontal and vertical changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
   2. Install piping with 48-inch minimum cover unless otherwise indicated.
   3. Install piping below frost line.
   4. Install PVC pressure piping according AWWA M23 or ASTM D 2774 and ASTM F 1668.

H. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

I. Wyes and Risers for Service Connections: Angle upward so 1/8 bend connected to fitting will make service line invert equal to inside crown of sewer main. Where elevation of top of service is more than 12' below finished grade, install riser pipe as directed by Engineer.

J. Keep trenches free from water during pipe laying and jointing. Dewatering of trench, including rock or gravel underdrain, considered as incidental to construction and all costs shall be included in contract prices. When pipe laying is not in progress, close open ends of pipe by watertight plug, or other means approved by Engineer.

K. Dewatering shall be accomplished by the use of well points, sump pumps, rock or gravel drains placed below subgrade foundations or subsurface pipe drains. All water shall be disposed of in a suitable manner without being a menace to public health or causing public inconvenience. No water shall be drained into other work being completed or under construction.
L. The dewatering operation shall continue until such time as it is safe to allow the water table to rise in the excavations. Pipe trenches shall contain enough backfill to prevent pipe flotation.

M. Water shall not be allowed to rise until the concrete has set a minimum of twenty-four (24) hours, and the forms have been removed. Water shall not be allowed to rise unequally against unsupported structural walls.

N. Contractor is responsible for obtaining dewatering permit through the State as required.

3.06 UTILITIES ENCOUNTERED

A. Protection of all existing gas, water, sewer services, culverts, drains, cable, telephone lines, and electric lines encountered during construction is the Contractor’s responsibility, and if utilities are disturbed, they shall be maintained and/or restored to original condition at his expense. Backfill around utilities shall be adequately compacted to assure permanent stability.

3.07 WATER LINE CROSSING

A. Normal Conditions: Whenever possible, lay sanitary sewer under water main to provide vertical separation of at least 18” between invert of water main and crown of sewer.

B. Unusual Conditions: If above separation cannot be met, use the following:
   1. Sewer passing over or less than 18” under water main:
      a. One continuous length of watertight pipe 18-feet to 20-feet long centered on water main. Joints between different pipes encased in concrete 6-inches thick and extending 6-inches either side of joint; or
      b. Sewer pipe encased in 6-inches of concrete around pipe, and extend 10-foot either side of water main.

   2. Water mains passing under sewers: If vertical separation less than 18-inches, provide structural support for sewer.

3.08 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure, drainage piping according to the following:
   1. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.
   2. Join dissimilar pipe materials with nonpressure-type, flexible couplings.

B. Join force-main, pressure piping according to the following:
   1. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.
   2. Join PVC pressure piping according AWWA M23 for gasketed joints.
3.09 MANHOLE INSTALLATION

A. General: Install manholes complete with appurtenances and accessories indicated.

B. Manhole: Construct in accordance with drawings for cast-in-place manholes. Extend concrete manhole base at least 10" below pipe barrel. Slope floor of manhole from centerline of pipe to maximum of 2" above top of pipe at face of manhole. Shape invert exactly to lower half of pipe. Construct side branches with as large a radius of curvature as possible to connect to main invert. Inverts shall be smooth and clean with no obstructions, allowing insertion of an expandable plug in pipe. Form concrete ring monolithically with manhole base, minimum of 3" above top of pipe. Terminate future extension of pipe with bell of pipe as close as practical to manhole base. Install watertight plug in bell. Do not set precast manhole sections on manhole base for minimum of 2 days after base placement. Thoroughly clean top of formed concrete base ring in manhole. Form complete and continuous roll of joint sealant on base ring in sufficient quantity so there will be no spaces allowing infiltration. Join each succeeding manhole section in similar manner. Trim away all excess material and repair all lifting holes. Turn eccentric cone and steps away from roadway ditch.

C. Manhole Ring and Cover: Install at grade of finished surface. Where surface will be completed after manhole construction, set top of cone so maximum of two courses of grade rings will adjust ring and cover to final grade. Grout as required.

D. Install precast concrete manhole sections with sealants according to ASTM C 891 SS-S 00210.

3.10 CONNECTION TO EXISTING MANHOLE

A. Make connections to existing manholes, where no pipe is stubbed out, in similar manner as new manhole. Break small opening in existing manhole as necessary to insert new pipe and attain watertight seal. Chip existing concrete bench inside manhole to provide enough thickness for mortar bed to make new smooth continuous invert. Place expandable waterstop around portion of sewer pipe inserted into existing manhole. Use expandable grout to completely fill hole in manhole to create watertight repair.

3.11 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use gray-iron heavy-duty, top-loading classification cleanouts in vehicle-traffic service areas.
2. Use extra-heavy-duty, top-loading classification cleanouts in truck traffic.
3. Use PVC cleanouts as indicated or in non-traffic areas.

B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18-inches by 18-inches by 8-inches deep. Set with tops 1/2-inch above surrounding grade.

C. Set cleanout frames and covers in concrete pavement with tops ¾-inch below pavement surface.
3.12 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping to building’s sanitary building drains specified in Division 15 Section.

B. Make connections to existing piping.
   1. Use commercially manufactured saddle wye tap fittings for piping branch connections. Stainless steel straps shall be used full diameter to hold saddle. Existing pipe shall be core drilled full diameter of branch.
   2. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

C. Existing sanitary sewer service connection: Includes reconnection of existing services to new mainline. Place true to line and grade in accordance with drawings, in shortest direct route. Each wye and transition connection shall be observed by Engineer or Owner representative prior to backfilling. Service line minimum grade of ¼-inch per foot. Contractor is responsible for determining if existing services are active. Non-active service shall not be reconnected to the new sanitary sewer line.

3.13 CLOSING ABANDONED SANITARY SEWERAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
   1. Close open ends of piping with at least 8-inch thick, brick masonry bulkheads.
   2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
   3. Fill abandoned pipe if pipe is 15-inches or longer with sand or flowfill.

B. Backfill to grade according to Division 2 Section "Trenching."

3.14 IDENTIFICATION

A. Materials and their installation are specified in Division 2 Section "Trenching." Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
   1. Use warning tape over ferrous piping.
   2. Use warning tape over nonferrous piping and over edges of underground manholes.

3.15 TRAFFIC REGULATION

   1. Unless otherwise authorized, keep at least one lane of traffic open at all times.
   2. When work is not in progress, keep all traffic lanes open.
B. Keep traffic areas free of excavated material, construction equipment, pipe, and other materials and equipment.

C. Warning Signs and Lights: Protect all roadways by effective barricades on which are placed acceptable warning signs. Provide suitable barricades and warning signs for open trenches, other excavations, and obstructions. Illuminate by means of warning lights all barricades and obstructions from sunset to sunrise.

D. Flagmen where required are to provide for public safety and regulation of traffic.

E. Roadway Usage Between Operations: At all times when work is not actually in progress, Contractor shall make open, passable, and maintain to traffic such portions thereof as may be agreed upon between Contractor and District and all other authorities or parties having jurisdiction over properties involved.

3.16 FIELD QUALITY CONTROL

A. Notify Engineer at least 24 hours in advance of pipe being laid in any trench. Cover no pipes until observed by Engineer or Owner’s Representative. Notify Engineer at least 48 hours before pipe is to be tested.

B. Where testing by infiltration or exfiltration is not practical due to service line connections, taped televising of the entire pipe line installed will be required. Payment for televising shall be included within the unit price bid for sanitary sewer.

C. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24-inches of backfill is in place, and again at completion of Project.
   1. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between structures.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Crushed, broken, cracked, or otherwise damaged piping.
      d. Infiltration: Water leakage into piping.
      e. Exfiltration: Water leakage from or around piping.

   2. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.

   3. Reinspect and repeat procedure until results are satisfactory.
D. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction, but meet the following as a minimum:
   a. General: Conduct infiltration or exfiltration test for each section between manholes. Test first section of pipe laid to verify if watertight. Testing may be required during course of work where infiltration appears to be greater than maximum allowable, or quality of work is questionable. No sewer line will be accepted where watertightness tests show leakage exceeding 200 gallons per-inch diameter per mile per day. Flush and clean sewer line prior to testing, wetting pipe, and cleaning out debris. Plug all pipe outlets to resist test pressure.
   b. Infiltration Test: In high ground water table installation only. Plug upper manhole to determine leakage in section of line between consecutive manholes. Record quantity of water collected in time period to calculate infiltration rate.
   c. Exfiltration Test by Water: Plug line just above upper manhole, and pipe entrance in lower manhole. Fill pipe from upper manhole to no less than 4' depth at upper manhole. Make mark at water surface level in manhole and allow to stand for 4 hours to allow absorption in walls of manhole and pipes. Add water to bring water surface back to mark. Record drop in elevation of water surface in one hour; convert to exfiltration rate.
   d. Exfiltration Test by Air: Test each section of pipe between consecutive manholes to determine test duration for section by computation from Air Test Tables. Pressure-holding time is based on an average holding pressure of 3 psi gauge or a drop from 3.5 psi to 2.5 psi gauge. Add air until internal air pressure of sewer line is raised to approximately 4.0 psi gauge. After internal pressure of approximately 4.0 psi is obtained, allow time for air pressure to stabilize. Pressure will normally show some drop until temperature of air in test section stabilizes. When pressure has stabilized and is at or above starting test pressure of 3.5 psi gauge, commence test. Before starting test, pressure may be allowed to drop to 3.5 psi. Record drop in pressure for test period. If pressure has dropped more than 1.0 psi gauge during test line has failed. Test may be discontinued when prescribed test time has been completed even though 1.0 psi drop has not occurred. ASTM C828 "Low Pressure Air Test for Sanitary Sewers".
### SANITARY UTILITY SEWERAGE PIPING

**REQUIRED FOR A 1.0 PSIG PRESSURE DROP FOR SIZE AND LENGTH OF PIPE**

<table>
<thead>
<tr>
<th>1 Pipe Diameter</th>
<th>2 Minimum Time for Minimum Length</th>
<th>3 Length for Minimum Time (in feet)</th>
<th>4 Time for Longer Specified Minimum for Length Shown (min:sec)</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td>100 ft</td>
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<tr>
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</tr>
<tr>
<td>36</td>
<td>34:00</td>
<td>66</td>
<td>51:17</td>
</tr>
</tbody>
</table>

3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.

4. Submit separate report for each test.

5. **Hydrostatic Tests:** Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
   a. Allowable leakage is maximum of 50 gal./inch of nominal pipe size per mile of pipe, during 24-hour period.
   b. Close openings in system and fill with water.
   c. Purge air and refill with water.
   d. Disconnect water supply.
   e. Test and inspect joints for leaks.
   f. **Option:** Test ductile-iron piping according to AWWA C600, "Hydrostatic Testing" Section. Use test pressure of at least 10 psig.

E. Leaks and loss in test pressure constitute defects that must be repaired.

F. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.17 LOCATION OF EXISTING SERVICES

A. The Contractor is responsible for locating existing services.

3.18 CLEANUP AND RESTORATION

A. Restore all pavements, curbs, gutters, utilities, fences, culverts, irrigation ditches, yards, lawns, and other structures or surfaces to condition equal to or better than before work began, and to satisfaction of Engineer. Deposit all waste material off-site. Complete topsoil and reseeding of site, is required.

B. General cleanup of the area shall be performed on a daily basis to the satisfaction of the Engineer. Proper safety provisions, including ropes, fence, barricades, construction signs, and warning signs, shall be maintained until completion of work.

C. Maintain records of weight or volume of all recycled material.

D. Manage construction waste in accordance with provisions of Division 1 Section “Construction Waste Management and Disposal” for recycling and disposal of waste. Submit documentation to satisfy the requirements of that section.

END OF SECTION
SECTION 33 41 00

STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Additional information concerning storm sewer systems may be found on the civil drawings. In case of conflict between the drawings and the information specified herein, the more stringent requirements shall govern.

1.02 REFERENCES

C. Reference Standards: Comply with the requirements of the reference standards noted herein, except where more stringent requirements are listed herein or otherwise required by the Contract Documents.

1.03 SUMMARY

A. This Section includes gravity-flow, STORM UTILITY DRAINAGE PIPING outside the building, with the following components:
   1. Cleanouts.
   2. Drains and inlets.

B. Related Sections include the following:
   1. Division 01 Section “LEED” or “Sustainable Design” requirements for product data and manufacturing documentation.
   2. Division 01 Section “Construction Waste Management and Disposal” for recycling and disposal of waste.
   3. Division 31 Section “Trenching and Backfilling” for excavating and backfilling of utilities.
   4. Division 32 Section “Miscellaneous Concrete Paving” for concrete materials.
   5. Division 31 Section “Earth Moving” for Site Grading.
   6. Division 31 Section “Temporary Erosion and Sedimentation Control” for erosion and sedimentation control measures.

C. Permits and Fees:
   1. Obtain and pay for all permits required for the work of this section.
   2. Pay all fees for inspections by local authorities and utility agency for work specified in this section.
D. Existing Utilities:
   1. It shall be the Contractor's responsibility to excavate and verify the location (depth, horizontal alignment, etc.) of all existing utilities that may affect construction of the proposed STORM UTILITY DRAINAGE PIPING line. All exploratory excavations shall occur far enough in advance to permit any necessary relocation to be made with minimum delay and to verify existing vertical and horizontal location to determine alignment for the proposed STORM UTILITY DRAINAGE PIPING line. All costs incurred by the Contractor in making exploratory excavations shall be considered to be included in the unit price bid for construction of each section of STORM UTILITY DRAINAGE PIPING line or the associated structures.

E. All standard details and specifications of the utility agency shall apply as noted on the construction permit and as required by the agency.

1.04 DEFINITIONS

A. HDPE: High Density Polyethylene Pipe.

B. PVC: Polyvinyl Chloride Plastic Pipe.

C. RCP: Reinforced Concrete Pipe.

D. RCBC: Reinforced Concrete Box culvert.

E. CMP: Corrugated Metal Pipe.

1.05 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: 10-foot head of water (30 kPa). Pipe joints shall be watertight with gasketed joint.

1.06 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Cleanouts, inlets and area drains.
   2. Channel drainage systems.
   3. Trench drainage systems.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments for the following:
   1. Precast concrete manholes and other structures, including frames, covers and grates.
   2. Cast-in-place concrete manholes and other structures, including frames, covers and grates.
   3. Catch Basins and Trench Drains. Include plans elevations, sections, details and frames, covers and grates.
   4. Design Mix Reports and Calculations: For each class of cast-in-place concrete.
C. Field Quality-Control Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. LEED Submittals:
   1. Product Data for Credit MR 4.1 and Credit MR 4.2: Include manufacturer’s product data indicating separate percentages, by weight, of post-consumer and pre-consumer recycled content for projects having recycled content. Include statement indicating material costs for products.
   2. Product data for Credit MR 5.1 and Credit MR 5.2: Indicate location of manufacturing facility including name, address and distance between manufacturing facility and the proposed site. Provide manufacturer’s documentation indicating location where the base materials were extracted, mined, quarried, harvested, etc. and the distance between this location and the project site. Also include material costs, excluding cost of installation.

1.07 DELIVERY, STORAGE AND HANDLING

   A. Do not store plastic inlets, pipe, and fittings in direct sunlight.
   B. Protect pipe, pipe fittings, and seals from dirt and damage.
   C. Handle manholes according to manufacturer’s written rigging instructions.
   D. Handle catch basins and trench drains according to manufacturer’s written rigging instructions.
   E. Deliver piping in manufacturer’s original bundles, securely strapped, and with protective blocking as required. Label or tag each bundle with type, size and quantity of material.
   F. Exercise care to prevent damage to materials during loading, transportation and unloading. Do not drop pipe or fittings.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

   A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
      1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
      2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
2.02 PVC PIPE AND FITTINGS

A. PVC Pressure Pipe: AWWA C900, Class 150, for gasketed joints and using ASTM F 477, elastomeric seals.
   1. Fittings NPS 4 to NPS 8 (DN 100 to DN 200): PVC pressure fittings complying with AWWA C907, for gasketed joints and using ASTM F 477, elastomeric seals.
   2. Fittings NPS 10 (DN 250) and Larger: Ductile-iron, compact fittings complying with AWWA C153, for push-on joints and using AWWA C111, rubber gaskets.


C. PVC Sewer Pipe and Fittings, NPS 18 (DN 450) 18” and Larger: ASTM F 679, T-1 wall thickness, with bell-and spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.03 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:
   1. For Concrete Pipes: ASTM C 443 (ASTM C 443m), rubber.
   2. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
   3. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

2.04 CLEANOUTS

A. Gray-Iron Cleanouts: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
   1. Available Manufacturers:
      b. MIFAB Manufacturing Inc.
      d. Wade Div.; Tyler Pipe.
      e. Watts Industries, Inc.
      g. Zurn Industries, Inc.; Zurn Specification Drainage Operation.

   2. Top-Loading Classification(s): Heavy duty.
   3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

B. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.
2.05 MANHOLES

A. Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
   1. Diameter: As shown on drawings (48 inches (1200 mm) minimum, unless otherwise indicated).
   2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
   3. Base Section: 6-inch (150-mm) minimum thickness for floor slab and the minimum thickness as noted on plans for walls and base riser section.
   4. Riser Sections: 4-inch (100-mm) minimum thickness or as noted on the plans and the lengths to provide depth indicated.
   5. Top Section: Eccentric-cone type unless flat-slab-top type is indicated. Top of cone of size that matches grade rings.
   6. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.

B. Manhole Joint Sealant: All joints in the manhole barrel, cone and/or flat top sections including the joint between the cast-in-place base slab and the bottom barrel section shall be sealed with a preformed, flexible plastic gasket conforming to the following requirements:
   2. The plastic sealing compound shall be packaged in extruded preformed rope-like shape of proper size to completely fill the joint when fully compressed. The material shall be protected by a suitable, removable, two-piece wrapper so that one wrapper may be removed as the compound is applied to the joint surface without disturbing the other wrapper, which remains attached to the compound for protection. The sealing compound shall be impermeable to water, have high immediate bonding strength to the primed concrete surface, and shall maintain permanent plasticity, resistance to water, acids, and alkalis.
   3. All surfaces of the tongue and groove joint of the manhole barrel shall be primed with an approved priming compound prior to the installation of the sealing compound. The application of the priming compound and the sealing compound shall be accomplished in strict conformance with the manufacturer’s instructions, as to the method of application, quantity of material, the grade of the materials, and the application temperatures.
   4. All lifting holes shall be sealed with the plastic sealing compound.

C. Manhole Steps: All manhole steps shall be similar and equal to those specified below and shall be installed in a straight line vertically. Manhole steps shall be cast into the wall at the same time the barrel section is cast. Except for unusual circumstances, steps which are inserted or grouted in the wall after the wall has been cast will not be accepted. Steps shall be installed with a nominal spacing of 15 inches (375-mm) and 6 inches (150-mm) from face of manhole.
   1. Aluminum, Federal specification QQ-A-200/8, or ALMAG35. Two non-skid grooves in surface of step and capable of carrying load of 1000 lbs. 6 inches (150 mm) from face of manhole.
   a. ASTM C-478.
   b. ASTM A-615 Grade 60 (steel rod).
   c. ASTM 2146 69, Type II Grade 16906 (polypropylene).

D. Manhole Grade Rings: Reinforced-concrete rings, 3-inch to 9-inch (75 to 225-mm) total thickness, to match diameter of manhole frame and cover.

F. Manhole Frames and Covers: Ring and cover shall have a combined weight greater than 400 lbs shall be machined to fit securely with non-rocking cover, and shall be hot-dipped in asphalt. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
   1. Material: ASTM A 48, Class 35 gray iron, unless otherwise indicated.
   2. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint or hot dipped asphalt; 10-mil (0.26-mm) minimum thickness applied to all surfaces, unless otherwise indicated.

2.06 STORM WATER INLETS

A. Area Inlets: Type and manufacture as indicated on plans.

B. Trench Drains: Type and manufacturer as indicated on plans.

2.07 STORM WATER DETENTION STRUCTURES

A. Cast-in-Place Concrete, Storm Water Detention Structures: Construct of reinforced-concrete bottom, walls, and top; designed according to ASTM C890 for A-16, heavy-traffic, structural loading; of depth, shape, dimensions, and appurtenances indicated on the plans.
   1. Ballast: Increase thickness of concrete, as required to prevent flotation.

B. Precast Concrete, Storm Water Detention Structures: As designated on plans.

2.08 CONCRETE

A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:
   1. Cement: ASTM C 150, Type II.

B. Portland Cement Design Mix: 4000 psi with 0.45 maximum water-cementitious materials ratio, 5-7% entrained air and maximum 4 inch slump. Refer to Division 32 Concrete Paving.
   2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60 (420 MPa), deformed steel.
2.09 POLYMER-CONCRETE, CHANNEL DRAINAGE SYSTEMS

A. Description, General: Modular system of precast, polymer-concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include number of units required to form total lengths indicated. Use model indicated on plans.

B. Sloped-Invert, Polymer-Concrete Systems: Include the following components:
   1. Channel Sections: Interlocking-joint, precast, modular units with end caps. Include 4-inch (102-mm) inside width and deep, rounded bottom, with built-in invert slope of 0.6 percent and with outlets in number, sizes, and locations indicated. Include extension sections necessary for required depth.
      a. Frame: Include gray-iron or steel frame for grate.
   2. Grates with manufacturer’s designation "Heavy Duty," with slots or perforations that fit recesses in channels.
      a. Material: Galvanized steel, gray iron.
   3. Covers: Solid gray iron, if indicated.
   4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

2.10 LEED REQUIREMENTS

A. Materials/products shall contain the maximum amount of recycled content allowed that retains material integrity.

B. Preference shall be given to materials that are manufactured, harvested, extracted, mined, quarried, etc. within a 500 mile radius of the project site.

PART 3 - EXECUTION

3.01 EARTHWORK

A. Site excavation and filling are specified in Division 31 Section “Earth Moving."

B. Excavation and backfilling for utilities are specified in Division 31 Section “Trenching and Backfilling."

C. Provide temporary erosion and sedimentation control measures in accordance with Division 31 Section "Temporary Erosion and Sedimentation Control" to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion and sedimentation control drawings and requirements of authorities having jurisdiction.
3.02 PREPARATION

A. Piping: Prior to installation, verify that insides of pipe and pipe joints are clean and free of dirt, mud, oil, shavings from cutting, or other deleterious materials.

3.03 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate location and arrangement of underground STORM UTILITY DRAINAGE PIPING. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer’s written instructions.

B. General:
1. Use only undamaged material.
2. Lay pipe on firm bedding with full length of barrel fully supported. Maintain straight lines and uniform grades between invert elevations shown. Inside of pipe shall be smooth and clean.
3. Begin all pipe installation at downstream end of pipe run, with lower segment of pipe in contact with specified bedding. Place bell or groove ends facing upstream.
4. Plug ends temporarily during installation, until connections are made to adjoining pipe or to manholes or inlet structures.
5. Trench excavation and placement and compaction of bedding and backfill are specified in Division 31 Section “Trenching and Backfilling.”

C. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer’s written instructions for use of lubricants, cements, and other installation requirements. Plug all lifting holes in pipe with approved rubber plug or grout.

D. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

E. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

F. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or a combination of both.

G. Install gravity-flow, nonpressure drainage piping according to the following:
1. Install piping pitched down in direction of flow, at slopes indicated on plan.
2. Install corrugated steel piping according to ASTM A798/A798M.
3. Install corrugated aluminum piping according to ASTM B 788/B 788M.
4. Install PVC sewer pipe according to ASTM D 2321 and ASTM F1668.
5. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA’s "Concrete Pipe installation Manual."
6. Install HDPE piping per manufacturer’s recommendation.
3.04 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use PVC or cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron valve boxes for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 inches by 18 inches by 6 inches deep (450 by 450 by 150 mm). Set with tops 1 inch (25 mm) above surrounding grade.

C. Set cleanout frames and covers in pavement with tops 1/8 inch below pavement surface.

3.05 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Construct cast-in-place manholes as indicated.

D. Manholes:
   1. Construct manholes in accordance with drawings and applicable agency having jurisdiction standards. Carry pipe through manhole with split pipe. Extend cast-in-place concrete manhole base at least 8 inches below pipe barrel.
   2. Slope floor of manhole from centerline of pipe to maximum of 2 inches above top of pipe at face of manhole. Shape invert when manhole base is poured to conform exactly to lower half of pipe.
   3. Form or shape inverts smooth and clean, with no obstructions. Allow insertion of an expandable plug in pipe. Construct side branches with radii as large as possible to connect to main invert.
   4. Extend concrete base ring minimum 3 inches above top of pipe.
   5. Place future extension of pipe from manholes in manhole base. Shape invert with pipe extended to outside face of manhole base and terminated with bell of pipe as close as practical to manhole base.
   6. Do not place precast manhole sections on manhole base for two days minimum after placement of concrete base. Thoroughly clean top of formed concrete base ring prior to placing manhole barrel sections.
   7. Place a complete and continuous roll of sealant in groove or keyway of concrete base ring in sufficient quantity that when precast manhole barrel is placed there will be no voids. Join each succeeding precast manhole barrel in similar manner. Install sealant in groove side of tongue and groove joints.
   8. Trim away all excess material and repair all lifting holes.
E. Manhole Rings and Covers:
   1. Set tops of frames and covers 1/8 inch below finished surface of manholes that occur in pavements. Set tops 1 inch (25 mm) above finished surface elsewhere, unless otherwise indicated.
   2. Where finished surface will be completed after manhole construction, set top of cone where a maximum of two courses of brick will be required to adjust ring and cover to final grade. Final elevations of lid will be adjusted with bricks, mortar or precast concrete rings with a minimum of 6 inches and a maximum of 18 inches of adjustment.

3.06 INLETS, OUTLETS AND CATCH BASIN INSTALLATION

A. Set frames and grates to elevations indicated.
   1. Cast-in-place or precast concrete in accordance with drawings and applicable agency having jurisdiction standards. Comply with applicable requirements of Division 03 Section “Miscellaneous Cast-in-Place Concrete.”
   2. Construct inverts of pipe or concrete smoothed inverts same size as pipe up to centerline of pipe. Form perimeter bench as indicated.
   3. Embed steel angles or other accessories as indicated or required to anchor and support frames, grates, or covers.

B. Frames, Grates, Covers and Steps: Install accurately to placement dimensions shown on drawings. Anchor castings in place and set in adjustment mortar to assure a firm foundation.

C. Connection to Existing Structures:
   1. Cut and patch or rebuild existing manhole, catch basins, or other drainage structures as required to receive new drain lines.
   2. Core drill openings to receive new pipe. Chip existing bench to provide sufficient thickness for mortar bed to form new invert.
   3. Seal around new pipe penetration with expandable waterstop sealant, completely filling space between pipe and cut opening to provide a watertight repair.

3.07 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318/318R.

3.08 TRENCH DRAINAGE SYSTEM INSTALLATION

A. Assemble and install components according to manufacturer's written instructions.

B. Install with top surfaces of components, except piping, flush with finished surface.

C. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.

D. Embed channel sections and drainage specialties in 4-inch (102-mm) minimum concrete around bottom and sides.
E. Fasten grates to channel sections as indicated.

F. Assemble channel sections with flanged or interlocking joints.

3.09 CLOSING ABANDONED STORM UTILITY DRAINAGE PIPING SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use one of procedures listed below:
   1. Fill pipe with stone or gravel flowfill.
   2. Close open ends of piping with at least 8-inch thick, brick masonry bulkheads.
   3. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
   1. Remove manhole or structure and close open ends of remaining piping.
   2. Remove top of manhole or structure down to at least 36-inches below final grade. Fill to within 12-inches of top with stone, gravel or sand. Fill to top with concrete.

C. Backfill to grade according to Division 31, Section "Earth Moving" and Section "Trenching and Backfilling."

3.10 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
   1. Use warning tape over nonferrous piping and over edges of underground structures.

3.12 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place, and again at completion of Project.
   1. Submit separate report for each system inspection.
   2. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between structures.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Crushed, broken, cracked, or otherwise damaged piping.
      d. Infiltration: Water leakage into piping.
      e. Exfiltration: Water leakage from or around piping.
   3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
   4. Reinspect and repeat procedure until results are satisfactory.
B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
   1. Do not enclose, cover, or put into service before inspection and approval.
   2. Test completed piping systems according to requirements of authorities having jurisdiction.
   3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours advance notice.
   4. Submit separate report for each test.
   5. Gravity-Flow STORM UTILITY DRAINAGE PIPING: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
      a. Option: Test plastic piping according to ASTM F 1417.
      b. Option: Test concrete piping according to ASTM C924 (ASTM C 924M).

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.13 CLEANING

A. Clean interior of piping, inlets and manholes of dirt and superfluous materials. Flush with potable water.

3.14 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from project site and legally dispose of them in an EPA-approved landfill.
   1. Do not allow excavated materials to accumulate on-site.
   2. Maintain records of weight or volume of all recycled material.

B. Manage construction waste in accordance with provisions of Division 1 Section "Construction Waste Management and Disposal" for recycling and disposal of waste. Submit documentation to satisfy the requirements of that section.

END OF SECTION
GEOTECHNICAL INVESTIGATION
PROJECT C9103
ACADEMIC RESOURCES CENTER REMODEL
COLORADO STATE UNIVERSITY - PUEBLO
PUEBLO, COLORADO

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CTL/T Project No. SC02493-125

December 8, 2008
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SCOPE

This report presents the results of our Geotechnical investigation for additions to the University Library at the Colorado State University campus in Pueblo, Colorado. The purpose of our investigation was to evaluate subsurface conditions and develop geotechnical design criteria for the proposed additions. This report summarizes the results of our field and laboratory investigations and presents our design and construction recommendations for foundations for the proposed construction. We believe this investigation was performed in general accordance with our proposal No. SC-08-0123, dated November 14, 2008.

The report was prepared based on conditions encountered in our exploratory borings, results of laboratory tests, engineering analysis, and our experience. The criteria presented are for the construction as described. Revision in the scope of the project could influence our recommendations. If changes occur, we should review the plans and their effect on our recommended design criteria. The following section summarizes our evaluation. A more complete description of conditions found and our recommendations are included in the report.

SUMMARY

1. The subsurface conditions encountered consisted of up to 17 feet of sandy to very sandy clay and clayey to very clayey sand underlain by claystone bedrock. Samples of the sand and clay exhibited compression or low measured swell and the claystone showed high to very high measured swell upon wetting.

2. Ground water was encountered in three of our borings during drilling at depths of 13 to 29 feet. Our experience on campus indicates the presence and amount of ground water can change significantly over relatively short horizontal and vertical distances.

3. Based on the subsurface conditions encountered, we recommend a deep foundation system such as drilled piers bottomed in bedrock for the proposed construction. Micropiles are a suitable alternative to drilled piers. Ground water may affect drilled pier installation.
4. We believe there is a high risk of movement and damage of slabs constructed near the claystone. Structurally supported floors are the more reliable floor system at this site.

5. Site grading plans should provide for the rapid removal of surface water away from the additions.

SITE CONDITIONS

The University Library was built in 1965. The main core of the building is six stories and has a basement. The library wing is two stories and is constructed as an elevated structure over a breezeway. Portions of the north and south core are also built over breezeways. The building is located in the western part of the Colorado State University – Pueblo campus in Pueblo, Colorado. The existing structure is constructed of cast-in-place concrete with pre-cast concrete twin “T’s”. The existing building is constructed on drilled piers and has structurally supported floors.

The ground surface generally slopes down to the south. Sidewalks and landscaped areas are located adjacent to the existing structure on all sides. Concrete sidewalks and walkways are generally to the east, while irrigated grass is west of the building. The general size and shape of the existing structure and the vicinity of the site are shown on Fig. 1.

PROPOSED CONSTRUCTION

We understand one or several additions will be made to the existing building. The exact size, shape, and construction type were not known as the design was in the schematic phase when this report was prepared. The addition(s) is planned to total about 20,000 square feet. The addition(s) will likely be one or two stories high. A basement may be constructed under the addition(s). The construction type was not known at the time of this report. Areas under the existing breezeways may also be enclosed to create more habitable space.
SUBSURFACE INVESTIGATION

Subsurface conditions were investigated by drilling four exploratory borings at the approximate locations shown on Fig. 1. One boring was drilled near each of the four possible addition areas. The borings drilled for this investigation were advanced to depths of 25 to 35 feet using a 4-inch diameter, continuous flight auger and a truck-mounted drill rig.

A representative of our firm observed drilling, obtained samples, and logged the conditions encountered. Graphical logs of the conditions found in our borings, the results of field penetration resistance tests, and laboratory test results are presented on Fig. 2.

Samples obtained during drilling were returned to our laboratory, visually classified, and samples were selected for laboratory testing. Laboratory tests included moisture content and dry density, swell-consolidation, sieve analysis, and water-soluble sulfate concentration. Swell-consolidation test results are shown graphically on Figs. 4 through 10. Results of laboratory tests are summarized on Table I.

SUBSURFACE CONDITIONS

Subsurface conditions encountered in our borings for this investigation consisted of up to 17 feet of sandy to very sandy clay and clayey to very clayey sand underlain by claystone bedrock. About 6 inches of concrete was encountered at the ground surface in borings TH-2 and TH-4. The concrete was cored to facilitate drilling. Ground water was measured in three borings at depths of 13 to 29 feet during drilling. The characteristics of the subsurface conditions are described in more detail in the following sections.

Clay and Sand

Natural clay and/or sand was encountered in all four of our borings and
extended to depths of 9 to 17 feet below the existing ground surface. The clay was stiff to very stiff and the sand was loose to medium dense based on field penetration resistance tests. Three samples of the clay exhibited low swell and two samples of the sand exhibited compression when wetted under an applied pressure of 1,000 psf. Samples of the sand and clay contained 45 to 53 percent silt and clay-size particles (passing the No. 200 sieve).

Claystone Bedrock

Claystone bedrock was encountered in all four borings at depths of 9 to 17 feet. The claystone was medium hard to very hard based on field penetration resistance testing. Samples of the claystone exhibited high to very high measured swell when wetted under an applied pressure of 1,000 psf.

Ground Water

Ground water was encountered in three of the borings at depths of 13 to 29 feet during drilling. The borings were backfilled after drilling. We believe the ground water is likely flowing through fissures and cracks in the bedrock. Our experience at the campus indicates the ground water may occur sporadically and vary significantly over relatively short horizontal and vertical distances. Ground water levels should be expected to fluctuate in response to precipitation, irrigation, and changes in surface drainage patterns.

Seismicity

This area, like most of southern Colorado, is subject to a degree of seismic activity. The subsurface conditions encountered consisted of up to 17 feet of clay and sand underlain by claystone bedrock to depths of up to 35 feet. Based on subsurface conditions encountered during our investigation, we believe the site classifies as Site Class C according to the 2003 International Building Code (IBC).
FOUNDATION SYSTEMS

Based on results of our field investigation, we expect sandy to very sandy clay, clayey to very clayey sand, and claystone are present near proposed shallow foundation elevations. The claystone exhibited high to very high measured swell. Plans were in the schematic phase at the time of this report. Relatively thick layers of low-swelling sand and clay may be present near foundations if no basements are constructed. It is possible, depending on the final building design, that footings could be used for the additions if basements are not constructed and foundations will be constructed near existing grades. However, considering the fact that several buildings on campus have experienced movement and damage and the existing building is constructed on drilled piers, we believe a deep foundation system is appropriate. We recommend the proposed additions be constructed on a deep foundation system such as drilled piers bottomed in bedrock. Micropiles are a suitable alternative to piers.

Ground water was encountered in three of our borings during drilling. Our experience in the area indicates ground water may occur sporadically over relatively short horizontal and vertical distances. The use of temporary casing or the use of a concrete pump truck may be required to properly dewater piers. The bedrock became very hard with depth. The use of a large, commercial pier drilling rig will be required. Our recommendations for the design and construction of piers and micropiles are presented below.

Drilled Piers

1. Piers should be designed for a maximum allowable end pressure of 30,000 psf and an allowable skin friction of 3,000 psf for the portion of pier in bedrock. Skin friction should be neglected where bedrock occurs within 6 feet of the top of the pier.

2. Piers should be designed for a minimum deadload pressure of 10,000 psf based on pier cross-sectional area. If this deadload cannot be achieved through the weight of the structure, the pier length and bedrock penetration should be increased beyond the minimum values specified in the next paragraph. The bedrock should be assigned a skin friction value of 3,000 psf for uplift resistance.
3. Piers should penetrate at least 10 feet into the unweathered bedrock and have a minimum drilled and concreted length of at least 26 feet.

4. Piers should be reinforced their full-length to resist tension in the event of swelling. We recommend the cross-sectional area of reinforcement be equal to at least 1.0 percent of the gross cross-sectional area of the pier. More reinforcement may be required for structural considerations. Grade 60 (420 Mpa) reinforcing bars (or equivalent) should be used. Reinforcement should extend into grade beams and foundation walls.

5. There should be a 6-inch (or thicker) continuous void beneath all grade beams and foundation walls, between piers, to concentrate the deadload of the structure on the piers.

6. Piers should have a center-to-center spacing of at least three pier diameters when designing for vertical loading conditions, or they should be designed as a group. Piers aligned in the direction of lateral forces should have a center-to-center spacing of at least six pier diameters. Reduction factors for closely-spaced piers are discussed in a subsequent section of the report.

7. Permanent connections between the proposed additions and the existing building should be flexible and capable of accommodating differential movements.

8. Some movement of the drilled pier foundation is anticipated to mobilize the strength of the bedrock. We estimate this movement to be on the order of ¼ to ½-inch to mobilize skin friction. Differential movement may be equal to the total movement. Designs should consider these potential movements and accommodate them as much as practical.

9. Piers should be carefully cleaned prior to placement of concrete. Ground water may be encountered during pier installation. Temporary casing, tremie equipment, and/or pumping may be necessary for proper cleaning, dewatering, and concrete placement. Concrete should not be placed by free fall if there is more than 3 inches of water in the bottom of the hole.

10. Concrete placed in cased pier holes should have sufficient slump to fill the pier holes and not hang on the sides of the casing or reinforcement during casing removal. We recommend a slump in the range of 5 to 7 inches if casing is used. The slump should be 4 to 6 inches for uncased piers.

11. Formation of mushrooms or enlargements at the top of piers should be avoided during pier drilling and subsequent construction operations.

12. Installation of drilled piers should be observed by a representative of our firm to identify the proper bearing strata and observe construction techniques.
Micropiles

Constructing micropiles involves installing heavy-duty, hollow, reinforcing bars by attaching a drill bit on the end of the bar and drilling to the bearing depth. Grout is then pumped through the reinforcing bar under pressure. This leaves the reinforcing bar surrounded by a column of grout. Depending on subsurface conditions, grout may be pumped continually during drilling to keep the hole open or grout may be placed after the hole is drilled. Considering the subsurface conditions encountered, continuous pumping of grout during drilling will probably be required. Micropile construction is generally performed on a design/build basis. The micropile contractor or their engineer designs the piles for minimum bedrock penetration depending on the anticipated loads and the type of micropiles being installed. We should review the design of the micropiles, if this option is chosen.

Laterally Loaded Piers or Piles

Several methods are available to analyze laterally loaded piers or piles. With a pier length to diameter ratio of seven or greater, we believe the method of analysis developed by Matlock and Reese is most appropriate. The method is an iterative procedure using applied lateral load, movement, vertical load, and pier diameter to develop deflection and moment versus depth curves. The computer program LPILE can be used to calculate deflections for the various pier diameters and loading conditions anticipated by the structural engineer. Suggested criteria for LPILE analysis are presented in the Table A below.

| TABLE A  
| SOIL DATA FOR LPILE |
|-----------------------------------|------|------|
| Density (pci)                     | 0.06 | 0.07 |
| Cohesion, c (psi)                 | 7    | 45   |
| Friction Angle, \( \phi \) Degrees| 0    | 0    |
| \( \varepsilon_{50} \) (in/in)   | 0.020| 0.004|
| \( k_s \) (pci)                   | 200  | 2,000|
Other procedures require input of a horizontal modulus of subgrade reaction ($K_h$). For purpose of design, we believe the soil types can be assigned the following values:

- **Sand and Clay**: $K_h = 30/d$ (tons/ft$^3$)
- **Bedrock**: $K_h = 350/d$ (tons/ft$^3$)

Where, $d = $ pier diameter (ft)

**Closely-Spaced Pier Reduction Factors**

For axial loading, a minimum spacing of three pier diameters is recommended to achieve full skin friction. At one diameter (piers touching), the skin friction load reduction factor for both piers would be 0.5. End bearing values would not be reduced provided the bases of the piers are at similar elevations. Interpolation can be used between one and three diameters.

Piers in-line with the direction of lateral loads should have a minimum spacing of six diameters (center-to-center) based upon the larger pier for full capacity. If a closer spacing is required, the modulus of subgrade reaction for initial and trailing piers should be reduced. At a spacing of three diameters, the effective modulus of subgrade reaction of the first pier can be estimated by multiplying the given modulus by 0.6. For trailing piers in a line at a three-diameter spacing, the factor is 0.4. Linear interpolation can be used for spacing between three and six diameters.

Reductions to the modulus of subgrade reaction can be accomplished in LPILE by inputting the appropriate modification factors for the p-y curves. Reducing the modulus of subgrade reaction in trailing piers will result in greater computed deflections on these piers. In practice, the grade beam can force deflections of all piers to be equal. Load-deflection graphs can be generated for each pier by using the appropriate p-multiplier values. The sum of the piers lateral load resistance at selected deflections can be used to develop a total lateral load versus deflection graph for the system of piers.
For lateral loads perpendicular to the line of piers, a minimum spacing of three diameters can be used with no capacity reduction. At one diameter (piers touching) the piers can be analyzed as one unit. Interpolation can be used for intermediate conditions.

FLOOR SYSTEMS AND SLABS-ON-GRADE

We recommend all floors within the additions be constructed as structurally supported slabs. Crawl space areas should be well ventilated or conditioned in accordance with building codes. If plans change to include slab-on-grade construction, we should be contacted for recommendations for design and construction. Exterior slabs should be separated from the proposed structures.

BELOW-GRADE CONSTRUCTION

We understand some below-grade areas may be constructed. Below-grade walls that will retain earth need to be designed to resist lateral earth pressures. For the on-site soils, we recommend foundation walls be designed to resist an “at rest” earth pressure condition corresponding to an equivalent fluid density of at least 55 pcf. The “at rest” condition is applicable to walls that are restrained from rotation at the top of the wall.

The recommended lateral earth pressure does not include allowances for construction live loads or the development of hydrostatic pressure. To reduce the risk of developing hydrostatic pressure behind below-grade walls, we recommend a foundation wall drain be installed where floor elevations are below exterior grades. The drain should include a column of free-draining rock or a drain board for walls retaining more than 8 feet of earth. A slotted or perforated, smooth wall pipe encased in free-draining gravel should be placed at the base of the wall. The pipe should slope to a sealed sump pit where water can be removed by pumping or to a positive gravity outfall that discharges well away from the structure. A typical drain detail for below-grade walls is presented on Fig. 3. Considering the erratic ground water known to exist at the site, we believe a drain should be considered surrounding crawl space areas as well.
Foundation wall backfill should be moisture conditioned to within 2 percent of optimum and compacted to at least 95 percent of maximum standard Proctor dry density (ASTM D 698). Placement and compaction of foundation wall backfill should be observed and tested by a representative of our firm during construction.

CONCRETE

Concrete that comes into contact with soils can be subject to sulfate attack. We measured soluble sulfate concentrations in two samples from this site. The measured concentrations were 1.4 and 2.3 percent. Our experience in the area indicates the high sulfate levels are typical. Water-soluble sulfate concentrations in soil greater than 2 percent indicate potential for Class 3 exposure to sulfates, according to ACI 201.2R-01 as published in the 2008 ACI Manual of Concrete Practice. The American Concrete Institute (ACI) recommends using a blend of Type V portland cement and fly ash that meets the performance requirements (ASTM C 1012) of ACI 201, with a maximum water-to-cementitious material ratio of 0.40 and air entrainment of 5 to 7 percent for concrete with Class 3 exposure to sulfates. ACI also indicates concrete with Class 3 exposure should have a minimum compressive strength of 4,500 psi.

We understand Type V cement may not be readily available locally. We believe concrete made with cement that meets ASTM C 150 Type II requirements, 20 percent fly ash, and a maximum water-to-cementitious material ratio of 0.40, and exhibits a minimum compressive strength of 4,000 psi can be used to provide similar resistance. The fly ash should meet ASTM C 618 Class F requirements. The fly ash content can be reduced to 15 percent for placement in cold weather months provided a water-to-cementitious material ratio of 0.40 or less is maintained. We believe this approach should be used as a minimum at this project. The more stringent measures outlined in the previous paragraph will better control risk of sulfate attack and are more in alignment with written industry standards.
SURFACE DRAINAGE / IRRIGATION

Performance of the foundations is influenced, to a large degree, by the moisture conditions existing within the near-surface soils. Overall surface drainage patterns should be planned to provide for the rapid removal of storm runoff. Water should not be allowed to pond adjacent to building foundations. We recommend the following precautions be observed during construction and maintained at all times after the additions are completed.

1. Wetting or drying of the open foundation excavations should be avoided.

2. Foundation wall backfill should be graded to provide for the rapid removal of runoff. We suggest a slope equivalent to at least 6 inches in the first 10 feet. In paved areas, the slope may be reduced to at least 2 inches in the first 10 feet.

3. Exterior foundation wall backfill should be moisture conditioned to within 2 percent of optimum and compacted to at least 95 percent of maximum standard Proctor dry density (ASTM D 698).

4. Roof downspouts and drains should discharge well beyond the limits of all backfill. Downspout extensions and splash blocks should be provided.

5. Landscaping concepts should concentrate on use of native plants that require little or no supplemental irrigation after the establishment period.

LIMITATIONS

Our borings were located to obtain a reasonably accurate indication of subsurface foundation conditions. The borings are representative of conditions encountered at the exact boring locations only. Variations in subsurface conditions not indicated by the borings are possible. Representatives of our firm should be present during construction to perform construction observation and materials testing services. Plans for the proposed construction were in the conceptual phase at the time of this report. We should review the plans after they are completed to evaluate whether changes to our recommendations are required.
We believe this investigation was conducted with that level of skill and care normally used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report, or in the proposed construction from a geotechnical point of view, please call.

John R. Carrillo, E.I.T.
Staff Engineer

Reviewed by:

Michael N. Lemons, P.E.
Associate Engineer

Richard A. Phillips, P.E.
Principal Engineer

JRC:MNL:RAP:eas
(5 copies sent)
Summary Logs of Exploratory Borings

TH - 1

TH - 2

TH - 3

TH - 4

LEGEND:

- CONCRETE FLATWORK, APPROXIMATELY 6 INCHES THICK.
- CLAY, SANDY TO VERY SANDY, STIFF TO VERY STIFF, MOIST, BROWN (CL)
- SAND, CLAYEY TO VERY CLAYEY, LOOSE TO MEDIUM DENSE, MOIST, BROWN (SC)
- CLAYSTONE, MEDIUM HARD TO VERY HARD, SLIGHTLY MOIST TO MOIST, BROWN, OLIVE-BROWN, GRAY.

- DRIVE SAMPLE. THE SYMBOL 36/12 INDICATES 36 BLOWS OF A 145-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.
- GROUND WATER LEVEL MEASURED AT TIME OF DRILLING.

NOTES:

1. THE BORINGS WERE DRILLED NOVEMBER 18, 2008 USING A 4-INCH DIAMETER, CONTINUOUS-FLIGHT AUGER AND A CME-55, TRUCK-MOUNTED DRILL RIG.
2. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS, AND CONCLUSIONS AS CONTAINED IN THIS REPORT.
3. W/C - INDICATES MOISTURE CONTENT (%)
   DD - INDICATES DRY DENSITY (pcf)
   SW - INDICATES SWELL WHEN WETTED UNDER 1 KSF LOAD (%)
   COM - INDICATES COMPRESSION WHEN WETTED UNDER 1 KSF LOAD (%)
   -200 - INDICATES PASSING NO. 200 SIEVE, (%)   
   SS - INDICATES WATER-SOLUBLE SULFATE CONTENT, (%)
Cover entire width of gravel with non-woven geotextile fabric (Mirafl 140N or equivalent). Roofing felt is an acceptable alternative.

4-inch diameter perforated drain pipe. The pipe should be placed in a trench with a slope of at least 1/8-inch drop per foot of drain.

Encase pipe in 1/2" to 3/4" washed gravel. Fill entire trench with gravel. Extend gravel laterally to void and at least 1/2 height of void.

NOTES:

1.) The bottom of the drain should be at the bottom of void at the highest point and slope downward to a positive gravity outlet or to a sump where water can be removed by pumping.

2.) To help control the humidity in the crawl space, a minimum 10-mil polyethylene vapor retarder may be placed over the crawl space soils. The retarder should be attached to concrete foundation elements and extend up foundation walls at least 8 inches above top of void. Overlap joints 3 feet and seal.
EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

APPLIED PRESSURE - KSF
Sample of    CLAY, SANDY (CL)
From        TH-1 AT 4 FEET

Swell Consolidation Test Results

DRY UNIT WEIGHT = 118 PCF
MOISTURE CONTENT = 12.6 %
EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

APPLIED PRESSURE - KSF
Sample of: CLAYSTONE
From: TH-1 AT 14 FEET

DRY UNIT WEIGHT = 108 PCF
MOISTURE CONTENT = 17.4 %

Swell Consolidation Test Results

COLORADO STATE UNIVERSITY - PUEBLO
PROJECT C9103 ACADEMIC RESOURCES CENTER REMODEL
PROJECT NO. SC02493-125
M:ISC-2400 - 2493/ISC02493.000126/2. Reports/sc02493-125_SWELL.xls

FIG. 5
EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

APPLIED PRESSURE - KSF
Sample of CLAYSTONE
From TH-1 AT 24 FEET

DRY UNIT WEIGHT = 116 PCF
MOISTURE CONTENT = 18.0 %

Swell Consolidation Test Results

FIG. 6
Swell Consolidation Test Results

Sample of: CLAY, SANDY (CL)
From: TH-2 AT 9 FEET

Dry Unit Weight = 122 PCF
Moisture Content = 10.3%

Sample of: CLAY, SANDY (CL)
From: TH-2 AT 14 FEET

Dry Unit Weight = 111 PCF
Moisture Content = 20.5%
EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

APPLIED PRESSURE - KSF
Sample of CLAYSTONE
From TH-3 AT 14 FEET

DRY UNIT WEIGHT= 111 PCF
MOISTURE CONTENT= 19.6 %

Swell Consolidation Test Results

FIG. 8
ADDITIONAL COMPRESSION UNDER CONSTANT PRESSURE DUE TO WETTING

Sample of: SAND, CLAYEY (SC)
From: TH-4 AT 4 FEET

DRY UNIT WEIGHT = 112 PCF
MOISTURE CONTENT = 14.9 %

Swell Consolidation Test Results

FIG. 9
EXPANSION UNDER CONSTANT PRESSURE DUE TO WETTING

Swell Consolidation Test Results

Sample of: CLAYSTONE
From: TH-4 AT 24 FEET

APPLIED PRESSURE - KSF

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DRY UNIT WEIGHT = 115 PCF
MOISTURE CONTENT = 15.9 %

FIG. 10
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<th>DEPTH (FEET)</th>
<th>MOISTURE CONTENT (%)</th>
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<th>ATTERBERG LIMITS</th>
<th>SWELL TEST RESULTS*</th>
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* SWELL MEASURED WITH 1000 PSF APPLIED PRESSURE.
NEGATIVE VALUE INDICATES COMPRESSION.