CITY OF TULSA, OKLAHOMA

TULSA, OKLAHOMA

BIDDING REQUIREMENTS

AND

CONTRACT DOCUMENTS

for the construction of the

ZINK DAM IMPROVEMENTS

[D: Contract No. ________]

VOLUME 2

DIVISIONS 26 THROUGH 49

 ****

****

CH2M HILL

Tulsa, Oklahoma

October 2019

© CH2M HILL 2019. All rights reserved.

This document and the ideas and designs incorporated herein, as an instrument of professional service, is the property of CH2M HILL and is not to be used in whole or part, for any other project without the written authorization of CH2M HILL. Any reuse, modification, or alteration of this document and the ideas and designs incorporated herein is at the sole risk of the party(ies) reusing, modifying, or altering it. All references to CH2M HILL and its employees and all professional seals shall be removed prior to any reuse, modification, or alteration of this document.

Project No. 696780

Copy No. _______
### TABLE OF CONTENTS

**VOLUME 1**

**SPECIFICATIONS**

**DIVISION 01—GENERAL REQUIREMENTS**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 11 00</td>
<td>Summary of Work</td>
<td>1-</td>
</tr>
<tr>
<td>01 29 00</td>
<td>Payment Procedures</td>
<td>1-</td>
</tr>
<tr>
<td>01 31 13</td>
<td>Project Coordination</td>
<td>1-</td>
</tr>
<tr>
<td>01 31 19</td>
<td>Project Meetings</td>
<td>1-</td>
</tr>
<tr>
<td>01 32 00</td>
<td>Construction Progress Documentation</td>
<td>1-</td>
</tr>
<tr>
<td>01 33 00</td>
<td>Submittal Procedures</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Supplement: Transmittal of Contractor’s Submittal Form</td>
<td>1-</td>
</tr>
<tr>
<td>01 43 33</td>
<td>Manufacturers’ Field Services</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Supplement: Manufacturer’s Certificate of Proper Installation</td>
<td>1-</td>
</tr>
<tr>
<td>01 45 16.13</td>
<td>Contractor Quality Control</td>
<td>1-</td>
</tr>
<tr>
<td>01 45 33</td>
<td>Special Inspection, Observation, and Testing</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Supplements: Contractor’s Statement of Responsibility</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Fabricator’s Certificate of Compliance</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Statement of Special Inspections</td>
<td>1-</td>
</tr>
<tr>
<td>01 50 00</td>
<td>Temporary Facilities and Controls</td>
<td>1-</td>
</tr>
<tr>
<td>01 57 13</td>
<td>Temporary Erosion and Sediment Control</td>
<td>1-</td>
</tr>
<tr>
<td>01 61 00</td>
<td>Common Product Requirements</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Supplement: Manufacturer’s Certificate of Compliance</td>
<td>1-</td>
</tr>
<tr>
<td>01 64 00</td>
<td>Owner-Furnished Products</td>
<td>1-</td>
</tr>
<tr>
<td>01 77 00</td>
<td>Closeout Procedures</td>
<td>1-</td>
</tr>
<tr>
<td>01 78 23</td>
<td>Operation and Maintenance Data</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Supplement: Maintenance Summary Form</td>
<td>1-</td>
</tr>
<tr>
<td>01 88 15</td>
<td>Anchorage and Bracing</td>
<td>1-</td>
</tr>
<tr>
<td>01 91 14</td>
<td>Equipment Testing and Facility Startup</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Supplements: Unit Process Startup Form</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Facility Performance Demonstration/Certification Form</td>
<td>1-</td>
</tr>
</tbody>
</table>

*Not Included in this Submittal*
# ZINK DAM IMPROVEMENTS

## TABLE OF CONTENTS

**DIVISION 02—EXISTING CONDITIONS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>02 41 00</td>
<td>Demolition</td>
<td>1-</td>
</tr>
<tr>
<td>02 41 01</td>
<td>Electric Utilities Demolition</td>
<td>1-</td>
</tr>
<tr>
<td>02 61 00</td>
<td>Removal and Disposal of Contaminated Soil</td>
<td>1-</td>
</tr>
</tbody>
</table>

**DIVISION 03—CONCRETE**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>03 01 32</td>
<td>Repair of Vertical and Overhead Concrete Surfaces</td>
<td>1-</td>
</tr>
<tr>
<td>03 01 33</td>
<td>Repair of Horizontal Concrete Surfaces</td>
<td>1-</td>
</tr>
<tr>
<td>03 10 00</td>
<td>Concrete Forming and Accessories</td>
<td>1-</td>
</tr>
<tr>
<td>03 15 00</td>
<td>Concrete Joints and Accessories</td>
<td>1-</td>
</tr>
<tr>
<td>03 21 00</td>
<td>Steel Reinforcement</td>
<td>1-</td>
</tr>
<tr>
<td>03 30 00</td>
<td>Cast-in-Place Concrete</td>
<td>1-</td>
</tr>
</tbody>
</table>

Supplements:
- Concrete Mix Design, Class 5000F3S1P2C2 .................................. 1-
- Concrete Mix Design, Class 4500F2S1P1C1 .................................. 1-
- Concrete Mix Design, Class 4500F1S1P0C1 .................................. 1-
- Concrete Mix Design, Class 4500F3S1P1C2 .................................. 1-

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>03 37 13</td>
<td>Shotcrete</td>
<td>1-</td>
</tr>
<tr>
<td>03 37 14</td>
<td>Faux Rock</td>
<td>1-</td>
</tr>
<tr>
<td>03 39 00</td>
<td>Concrete Curing</td>
<td>1-</td>
</tr>
<tr>
<td>03 45 39</td>
<td>Sculpted Concrete</td>
<td>1-</td>
</tr>
<tr>
<td>03 50 00</td>
<td>Articulating Concrete Block (ACB) System</td>
<td>1-</td>
</tr>
<tr>
<td>03 62 00</td>
<td>Grouting</td>
<td>1-</td>
</tr>
</tbody>
</table>

Supplement:
- 24-hour Evaluation of Nonshrink Grout Test Form and Grout Testing Procedures .................................. 1-

**DIVISION 04—MASONRY**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>04 21 13.13</td>
<td>Masonry Veneer</td>
<td>1-</td>
</tr>
<tr>
<td>04 22 00</td>
<td>Concrete Unit Masonry</td>
<td>1-</td>
</tr>
</tbody>
</table>

*Not Included in this Submittal*
DIVISION 05—METALS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>05 05 19</td>
<td>Post-Installed Anchors</td>
<td>1-</td>
</tr>
<tr>
<td>05 05 23</td>
<td>Welding</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Supplement:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Welding and Nondestructive Testing Table</td>
<td>1-</td>
</tr>
<tr>
<td>05 12 00</td>
<td>Structural Steel Framing</td>
<td>1-</td>
</tr>
<tr>
<td>05 21 19</td>
<td>Open Web Steel Joist Framing</td>
<td>1-</td>
</tr>
<tr>
<td>05 31 00</td>
<td>Steel Decking</td>
<td>1-</td>
</tr>
<tr>
<td>05 50 00</td>
<td>Metal Fabrications</td>
<td>1-</td>
</tr>
<tr>
<td>05 52 10</td>
<td>Site Metal Railings</td>
<td>1-</td>
</tr>
<tr>
<td>05 52 19</td>
<td>Steel Railings</td>
<td>1-</td>
</tr>
<tr>
<td>05 53 00</td>
<td>Metal Gratings</td>
<td>1-</td>
</tr>
<tr>
<td>05 70 00</td>
<td>Miscellaneous Metals</td>
<td>1-</td>
</tr>
</tbody>
</table>

DIVISION 06—NOT USED

DIVISION 07—THERMAL AND MOISTURE PROTECTION

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>07 21 00</td>
<td>Thermal Insulation</td>
<td>1-</td>
</tr>
<tr>
<td>07 26 16</td>
<td>Belowgrade Vapor Retarders</td>
<td>1-</td>
</tr>
<tr>
<td>07 41 13</td>
<td>Metal Roof Panels</td>
<td>1-</td>
</tr>
<tr>
<td>07 92 00</td>
<td>Joint Sealants</td>
<td>1-</td>
</tr>
</tbody>
</table>

DIVISION 08—OPENINGS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>08 11 16</td>
<td>Aluminum Doors and Frames</td>
<td>1-</td>
</tr>
<tr>
<td>08 30 00</td>
<td>Specialty Doors</td>
<td>1-</td>
</tr>
<tr>
<td>08 90 00</td>
<td>Louvers</td>
<td>1-</td>
</tr>
</tbody>
</table>

DIVISION 09—FINISHES

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>09 90 00</td>
<td>Painting and Coating</td>
<td>1-</td>
</tr>
</tbody>
</table>

Supplements:

- Paint System Data Sheet (PSDS)                                            | 1-    |
- Paint Product Data Sheet (PPDS)                                            | 1-    |

*Not Included in this Submittal
## TABLE OF CONTENTS

**DIVISION 10—SPECIALTIES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 14 00</td>
<td>Signage</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Supplement:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sign Schedule</td>
<td>1-</td>
</tr>
<tr>
<td>10 44 00</td>
<td>Fire Protection Specialties and Safety Equipment</td>
<td>1-</td>
</tr>
</tbody>
</table>

**DIVISION 11—EQUIPMENT**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 38 00</td>
<td>WaveShapers and Gates</td>
<td>1-</td>
</tr>
</tbody>
</table>

**DIVISIONS 12 THROUGH 21—NOT USED**

**DIVISION 22—PLUMBING**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 47 13</td>
<td>Drinking Fountains, Yard Hydrants, and Showers</td>
<td>1-</td>
</tr>
</tbody>
</table>

**DIVISION 23—HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 05 48</td>
<td>Vibration Isolation for HVAC Piping and Equipment</td>
<td>1-</td>
</tr>
<tr>
<td>23 05 93</td>
<td>Testing, Adjusting, and Balancing for HVAC</td>
<td>1-</td>
</tr>
<tr>
<td>23 07 00</td>
<td>HVAC Insulation</td>
<td>1-</td>
</tr>
<tr>
<td>23 31 13</td>
<td>Metal Ducts and Accessories</td>
<td>1-</td>
</tr>
<tr>
<td>23 34 00</td>
<td>HVAC Fans</td>
<td>1-</td>
</tr>
<tr>
<td></td>
<td>Supplement:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fans Schedule</td>
<td>1-</td>
</tr>
<tr>
<td>23 37 00</td>
<td>Air Outlets and Inlets</td>
<td>1-</td>
</tr>
<tr>
<td>23 82 00</td>
<td>Terminal Heating and Cooling Units</td>
<td>1-</td>
</tr>
</tbody>
</table>

**DIVISIONS 24 AND 25—NOT USED**

**DIVISION 26—ELECTRICAL**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 05 02</td>
<td>Basic Electrical Requirements</td>
<td>1-</td>
</tr>
<tr>
<td>26 05 04</td>
<td>Basic Electrical Materials and Methods</td>
<td>1-</td>
</tr>
<tr>
<td>26 05 05</td>
<td>Conductors</td>
<td>1-</td>
</tr>
<tr>
<td>26 05 26</td>
<td>Grounding and Bonding for Electrical Systems</td>
<td>1-</td>
</tr>
<tr>
<td>26 05 33</td>
<td>Raceway and Boxes</td>
<td>1-</td>
</tr>
<tr>
<td>26 05 70</td>
<td>Electrical Systems Analysis</td>
<td>1-</td>
</tr>
</tbody>
</table>

*Not Included in this Submittal*

©COPYRIGHT 2019 CH2M HILL
## ZINK DAM IMPROVEMENTS

### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Division</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 08 00</td>
<td>Commissioning of Electrical Systems</td>
<td>1-</td>
</tr>
<tr>
<td>26 09 13</td>
<td>Power Measurement and Control</td>
<td>1-</td>
</tr>
<tr>
<td>26 14 13</td>
<td>Low-Voltage Switchboards</td>
<td>1-</td>
</tr>
<tr>
<td>26 20 00</td>
<td>Low-Voltage AC Induction Motors</td>
<td>1-</td>
</tr>
<tr>
<td>26 22 00</td>
<td>Low-Voltage Transformers</td>
<td>1-</td>
</tr>
<tr>
<td>26 24 16</td>
<td>Panelboards</td>
<td>1-</td>
</tr>
<tr>
<td>26 24 19</td>
<td>Low-Voltage Motor Control</td>
<td>1-</td>
</tr>
<tr>
<td>26 27 26</td>
<td>Wiring Devices</td>
<td>1-</td>
</tr>
<tr>
<td>26 29 23</td>
<td>Low-Voltage Adjustable Frequency Drive System</td>
<td>1-</td>
</tr>
<tr>
<td>26 41 00</td>
<td>Facility Lightning Protection</td>
<td>1-</td>
</tr>
<tr>
<td>26 50 00</td>
<td>Lighting</td>
<td>1-</td>
</tr>
<tr>
<td>26 56 00</td>
<td>Exterior Lighting</td>
<td>1-</td>
</tr>
</tbody>
</table>

### DIVISIONS 27 THROUGH 30—NOT USED

### DIVISION 31—EARTHWORK

<table>
<thead>
<tr>
<th>Division</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 10 00</td>
<td>Site Clearing</td>
<td>1-</td>
</tr>
<tr>
<td>31 23 13</td>
<td>Subgrade Preparation</td>
<td>1-</td>
</tr>
<tr>
<td>31 23 16</td>
<td>Excavation</td>
<td>1-</td>
</tr>
<tr>
<td>31 23 19.01</td>
<td>Dewatering</td>
<td>1-</td>
</tr>
<tr>
<td>31 23 23</td>
<td>Fill and Backfill</td>
<td>1-</td>
</tr>
<tr>
<td>31 23 23.15</td>
<td>Trench Backfill</td>
<td>1-</td>
</tr>
<tr>
<td>31 32 19.16</td>
<td>Geotextile</td>
<td>1-</td>
</tr>
<tr>
<td>31 35 00</td>
<td>Start-Up and Tuning</td>
<td>1-</td>
</tr>
<tr>
<td>31 37 00</td>
<td>Riprap</td>
<td>1-</td>
</tr>
<tr>
<td>31 38 00</td>
<td>Rock</td>
<td>1-</td>
</tr>
<tr>
<td>31 41 00</td>
<td>Shoring</td>
<td>1-</td>
</tr>
<tr>
<td>31 68 13</td>
<td>Prestressed Rock Anchors</td>
<td>1-</td>
</tr>
</tbody>
</table>

### DIVISION 32—EXTERIOR IMPROVEMENTS

<table>
<thead>
<tr>
<th>Division</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 13 13.13</td>
<td>Exposed Aggregate Concrete Paving</td>
<td>1-</td>
</tr>
<tr>
<td>32 31 10</td>
<td>Fences and Gates</td>
<td>1-</td>
</tr>
<tr>
<td>32 84 00</td>
<td>Landscape Irrigation</td>
<td>1-</td>
</tr>
<tr>
<td>32 91 13.19</td>
<td>Planting Soil System Procurement</td>
<td>1-</td>
</tr>
<tr>
<td>32 91 19.13</td>
<td>Planting Soil System Installation</td>
<td>1-</td>
</tr>
<tr>
<td>32 92 01</td>
<td>Prairies, Meadows, and Wetlands</td>
<td>1-</td>
</tr>
<tr>
<td>32 93 00</td>
<td>Planting and Fine Grading</td>
<td>1-</td>
</tr>
</tbody>
</table>

*Not Included in this Submittal*
## TABLE OF CONTENTS

**DIVISION 33—UTILITIES**

- 33 05 01 Water Conveyance Pipe ........................................................... 1-
- 33 13 00 Disinfection of Water Utility Distribution Facilities ............... 1-
- 33 41 01 Storm Drain Piping ................................................................ 1-
- 33 41 01.05 Reinforced Concrete Data Sheet .............................................. 1-
- 33 44 13.13 Stormwater Structures .............................................................. 1-
- 33 46 00 Subsurface Drainage ................................................................ 1-

**DIVISION 34—NOT USED**

**DIVISION 35—WATERWAY AND MARINE CONSTRUCTION**

- 35 20 25 Pneumatic Gate Systems .......................................................... 1-
- 35 31 19.16 Concrete Masonry Unit Revetments ........................................ 1-

**DIVISIONS 36 THROUGH 39—NOT USED**

**DIVISION 40—PROCESS INTERCONNECTIONS**

- 40 05 15 Piping Support Systems ........................................................... 1-
- 40 27 00 Process Piping—General ......................................................... 1-
- 40 27 00.08 Stainless Steel Pipe and Fittings—General Service
  Data Sheet ............................................................................. 1-
- 40 27 00.10 Polyvinyl Chloride (PVC) Pipe and Fittings Data Sheet ......... 1-
- 40 27 01 Process Piping Specialties ....................................................... 1-
- 40 80 01 Process Piping Leakage Testing .............................................. 1-
- 40 90 01 Instrumentation and Control for Process Systems ................... 1-
  Supplements:
  Instrument List ......................................................................... 1-
  Loop Specifications ..................................................................... 1-
  PLC Input and Output List.............................................................. 1-
  Instrument Calibration Sheet .......................................................... 1-
  Performance Acceptance Test Sheet ........................................ 1-
- 40 91 00 Instrumentation and Control Components............................... 1-
- 40 99 90 Package Control Systems .......................................................... 1-

*Not Included in this Submittal*
DIVISIONS 41 THROUGH 49—NOT USED

VOLUME 3

DRAWINGS

END OF SECTION

*Not Included in this Submittal
PART 1  GENERAL

1.01 RELATED SECTIONS

A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

4. UL.

1.03 SUMMARY OF WORK

A. The Contractor shall furnish and install all materials, equipment and supplies as shown on Drawings and described in these Specifications, and as may otherwise be required to provide a complete and functional electrical system for the multiple areas of development.

B. The Contractor shall coordinate with the Supplying Electric Utility for new underground electric service(s) at all locations as shown on Drawings. Refer to Article Electric Service Division of Responsibility.

C. The Contractor shall provide for the trench excavation, water pumping and draining, supply of clean fill, backfilling, consolidation and compaction required for all underground electrical work.

D. The Contractor shall apply the appropriate relay settings as furnished by Section 26 05 70, Electrical System Analysis, and shall provide a complete checkout and testing of the installed system prior to energization per Section 26 08 00, Commissioning of Electrical Systems. Contractor shall provide Arc-Flash Hazard labeling for all electrical distribution and control equipment as described in Section 26 05 70, Electrical System Analysis.
E. The Contractor shall provide for the temporary power requirements of all disciplines as needed for the construction of the new facilities, and the temporary powering of the existing dam gate operators. The Contractor shall coordinate these needs directly with the Owner.

1.04 GENERAL REQUIREMENTS

A. Specifications and Drawings shall be considered as supplementary to each other, requiring materials and labor indicated, specified, or implied. Contradictions noted by the Contractor shall be presented to the Owner’s Engineer for resolution.

B. NFPA 70, National Electrical Code (NEC) shall establish the minimum requirements for the installation. Where Drawings and/or Specifications provide a more rigid requirement for the installation, then Drawings and/or Specifications shall prevail.

C. Interpretation of the Specifications or Drawings, if deemed necessary by the Contractor, shall be made only by the Owner’s Engineer.

D. These electrical specifications shall be considered prescriptive, meaning that there are specific manufacturer products called out and required for the work, and set the basis of design and material’s acceptance for installation. It is the Contractor’s responsibility to read, understand and procure the material items identified in these electrical specifications to meet these standards. Failure by the Contractor to procure and install manufactured materials identified on Drawings and Specifications will be cause for rejection of the work.

1.05 DEFINITIONS

A. Provide: To both furnish and install.

B. Standard Supplier: The party under contract for furnishing the products covered by this Work.

C. Contractor/Subcontractor/Installing Contractor: The party under contract to install the products furnished for this Work.

D. For the purposes of this Project, the Standard Supplier and the Contractor/Subcontractor/Installing Contractor shall be the same party.
1.06 COORDINATION

A. The Contractor performing the work is henceforth referred to be the Installing Contractor, Contractor, Standard Supplier or Electrical Subcontractor.

B. Other work that is either directly, or indirectly, related to the scheduled performance of work under these Drawings and Specifications is anticipated to be performed by others.

C. Coordinate the work of these Drawings and Specifications with the work of others.

D. Include sequencing constraints specified as part of the progress schedule.

E. Reference Drawings and Specifications for limits of work provided by others.

F. Refer to coordination requirements with the Supplying Electric Utility as described in Article Electric Service Division of Responsibility.

1.07 ELECTRIC SERVICE DIVISION OF RESPONSIBILITY

A. Multiple points of Service Delivery will be required by this Project on both the East and West Banks. Incoming overhead and underground electric service facilities provided by the Supplying Electric Utility (as part of its service arrangement with the Owner) is work provided outside this Contract. Under this Contract, the Contractor shall initiate all service request(s) under its name for later transfer to the Owner, and coordinate service delivery with the Supplying Electric Utility. Under this Contract, the Contractor shall provide customer required service provisions and electrical work including, but not limited to, primary service conduits, transformer pad and site preparation, transformer pad, installation of metering components and associated conduit, and all secondary facilities and conductors.

1.08 SEISMIC DESIGN REQUIREMENTS

A. Where required for the support of all installed electrical equipment to meet the seismic requirements as stated in Article Anchoring, Bracing, and Mounting, provide anchorage and bracing design drawings, calculations, seismic certification, and related information, signed/sealed by a Structural Engineer in the State of Oklahoma.

B. Refer to Submittal requirements in Article Submittals.
1.09 SUBMITTALS

A. Review, acceptance, or approval of substitutions, schedules, Shop Drawings, list of materials and procedures submitted or requested by the Standard Supplier shall not add to the contract amount, and additional costs which may result shall solely be the obligation of the Standard Supplier.

B. The Owner is not precluded, by virtue of review, acceptance or approval from obtaining a credit for savings resulting from allowed concessions in the work or materials, or from the reduction in quantities of components.

C. All approved documents shall be submitted to the Owner in the “Native Form” so that the Owner will have the ability to edit them as needed. Refer to the Project Specifications for procedures and requirements concerning Shop Drawing.

D. The Owner’s and/or Owner’s Engineer’s review and approval of Contractor Submittals does not relieve the Contractor of the responsibility of assuring full compliance with Drawings and Specifications. Contractor shall be fully responsible that all equipment, material and installations meet the full intent of these Drawings and Specifications regardless of submittal reviews.

E. Shop Drawings:

1. Shall be defined as Drawings, diagrams, illustrations, schedules and other data which are specifically prepared by/for the Standard Supplier to illustrate the work to be done or the material/equipment to be provided.
2. Refer to the Section 01 33 00, Submittal Procedures, for procedures and requirements concerning Shop Drawings.

F. Quality Control Submittals:

1. Furnish manufacturer’s certification of proper installation stating system/equipment has been installed in accordance with manufacturer’s recommendations and has been inspected by a manufacturer’s authorized representative.
2. Functional test certificate shall be required from the manufacturer monitoring the test and certifying in writing that the equipment tested is both functional and ready for continuous operation.
3. Refer to Section 01 33 00, Submittal Procedures, for procedures and requirements concerning quality control submittals.
G. Operation and Maintenance Data:

1. Furnish for each system, or item of equipment, as necessary for the Owner to properly operate and maintain the equipment in accordance with the manufacturer’s recommendations.

2. Refer to Section 01 33 00, Submittal Procedures, for procedures and requirements concerning operation and maintenance data.

1.10 PRODUCT SHIPMENT, HANDLING, STORAGE, AND PROTECTION

A. Standard Supplier shall provide Owner’s representative on site notice of shipment of at least 7 days prior to shipment.

B. All products, where practical, shall be fully factory assembled.

C. Package or crate products to provide protection from damage during shipment, handling and storage.

D. Mark spare parts and special tools to identify the associated products by name, equipment, and part number.

E. The Contractor shall be responsible for receiving, inspecting and documenting the delivered condition of all materials, and its subsequent offloading, transporting and storage at the jobsite.

1.11 MANUFACTURER’S SERVICES

A. As required and shown on Drawings and as described elsewhere in these Specifications.

1.12 QUALITY ASSURANCE

A. Provide the Work in accordance with the NEC. Where required by the Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory (NRTL) or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied NRTL listing mark or label.
1.13 ENVIRONMENTAL CONDITIONS

A. The following areas are classified nonhazardous and wet. Use materials and methods required for such areas.
   1. Outdoor abovegrade and belowgrade areas.
   2. Indoors, PSO pump room.

B. The following areas are classified as nonhazardous and damp:
   1. Indoors, all hydraulic pump control modular enclosures.

C. The following areas are classified and nonhazardous and dry:
   1. Indoors, air compressor control room.

PART 2 PRODUCTS

2.01 GENERAL

A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F, inclusively.

C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range of 0 degrees F to 104 degrees F, inclusively.

2.02 EQUIPMENT FINISH

A. Manufacturer’s standard finish color, except where specific color is indicated on Drawings or in these Specifications. If manufacturer has no standard color, finish equipment with color ANSI No. 61; Sky Blue Grey.

2.03 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws: Stainless steel.

C. Color: White, engraved to a black core, unless specified differently elsewhere on Drawings or in these Specifications.
D. Letter Height:
   2. Other Electrical Equipment: 1/4-inch.

2.04 SIGNS AND LABELS
   A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

PART 3 EXECUTION

3.01 GENERAL
   A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer.
   B. Check approximate locations of luminaire, wiring devices, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.
   C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.
   D. Keep openings in boxes and equipment closed during construction.
   E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

3.02 ANCHORING, BRACING, AND MOUNTING
   A. Equipment anchoring and mounting shall be in accordance with manufacturer’s requirements for USGA/FEMA Seismic Design Criteria ‘A’.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY
   A. Drawings show each homerun circuit to be provided. Do not combine homeruns, feeders or branch circuits into common raceways unless specifically indicated on Drawings, or as described in Paragraph B below.
B. Homerun circuits shown on Drawings indicate functional wiring requirements for power and control circuits. Circuits may only be combined into common raceways in accordance with the following requirements:

1. Analog control circuits from devices in same general area to same destination.
   a. No power or ac discrete control circuits shall be combined in same conduit with analog circuits.
   b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, paging system circuits shall be combined with power or Class 1 circuits.
   c. Analog circuits shall be continuous from source to destination. Do not add TJB, splice, or combine into a multi-pair cable unless specifically indicated on Drawings.
   d. Raceways shall be sized per General Circuit and Raceway Schedule.
   e. All deviations from Drawings shall be documented on Record Drawings.

2. Discrete control circuits from devices in the same general area to the same destination.
   a. No power or analog control circuits shall be combined in same conduit with discrete circuits.
   b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
   c. Raceways shall be sized per the General Circuit and Raceway Schedule.
   d. All deviations from Drawings shall be documented on record drawings.

3. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).
   a. Lighting Circuits: Shall have dedicated conduit runs and neutral conductors unless specifically indicated otherwise on Drawings.
   b. Receptacle Circuits (120V ac): Shall have dedicated conduit runs and neutral conductors unless specifically indicated otherwise on Drawings.
   c. All Other Power Circuits: Shall have dedicated conduit runs and neutral conductors. No exceptions.

3.04 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs:

1. Field mark switchboards, motor control centers, panelboards, control panels, and disconnect switches to warn qualified persons of potential
arc-flash hazards. Locate marking so to be clearly visible to persons before working on energized equipment.

2. Use arc flash hazard boundary, energy level, PPE level and description, shock hazard, bolted fault current, and equipment name from required study in Section 26 05 70, Electrical Systems Analysis.

B. Available Fault Current Signs:

1. Install label on service equipment to indicate the maximum available fault current at the equipment. Labels shall be of sufficient durability for the environment in which the equipment is installed. Labels shall include the following information:
   a. Equipment name or identification.
   b. Available fault current at the equipment.
   c. Date the fault current calculations were performed.

2. Use bolted fault current and equipment name from study required in Section 26 05 70, Electrical Systems Analysis, as basis for the label.

3. Where existing electrical systems are modified, completely remove existing fault current labels if present, and install new labels in accordance with the above requirements.

C. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.

2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.

3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.

4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.

D. Procedural Signs: Provide a procedural sign on service-entrance equipment indicating key interlock and transfer procedure from utility to standby generator connection.

3.05 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.
B. Contractor shall balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, Contractor shall maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.06 CLEANING AND TOUCHUP PAINTING

A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.

B. Touchup Paint:
   1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
   2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of Specification, and is acceptable to Engineer.

3.07 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.

B. When equipment intended for indoor installation is installed at Contractor’s convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

END OF SECTION
SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   b. E814, Method of Fire Tests of Through-Penetration Fire Stops.
2. Canadian Standards Association (CSA).
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   c. C12.6, Phase-Shifting Devices Used in Metering, Marking and Arrangement of Terminals.
   d. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   e. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
   f. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
7. UL:
   a. 98, Standard for Enclosed and Dead-Front Switches.
   b. 248, Standard for Low Voltage Fuses.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 810, Standard for Capacitors.
   g. 943, Standard for Ground-Fault Circuit-Interrupters.
1.02 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers’ data for the following:
   a. Control devices.
   b. Control relays.
   c. Circuit breakers.
   d. Fused switches.
   e. Nonfused switches.
   f. Timers.
   g. Fuses.
   h. Magnetic contactors.
   i. Intrinsic safety barriers.
   j. Firestopping.
   k. Enclosures: Include enclosure data for products having enclosures.

2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 26 05 02, Basic Electrical Requirements.

B. Informational Submittals: Seismic anchorage and bracing calculations as required by Section 26 05 02, Basic Electrical Requirements.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

1. Fuses, 0 Volt to 600 Volts: Six of each type and each current rating installed.
2. Indicator Lamps, LED: Two of each type.

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.
2. Trip Ratings: 15 amps to 800 amps.
3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
4. Suitable for mounting and operating in any position.
5. UL 489.

B. Operating Mechanism:
1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in OPEN position.
4. ON/OFF and TRIPPED indicating positions of operating handle.
5. Operating handle to assume a CENTER position when tripped.

C. Trip Mechanism:
1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.
7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.
8. Do not furnish three-pole devices for two- or single-pole circuits.

D. Short Circuit Interrupting Ratings: Equal to, or greater than, available fault current or interrupting rating as shown on Drawings.

E. Ground Fault Circuit Interrupter (GFCI):
1. Where indicated, equip circuit breaker with ground fault sensor and rated to trip on 4-mA to 6-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
2. Ground fault sensor shall be rated same as circuit breaker.
3. Push-to-test button.

F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip circuit breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).

G. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.
H. Connections:
   1. Supply (line side) at either end.
   2. Mechanical wire lugs, except crimp compression lugs where shown.
   3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
   4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.
   5. Use bolted bus connections, all devices.

I. Enclosures for Independent Mounting:
   1. As indicated on Drawings and required elsewhere in these Specifications.
   2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
   3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

C. Short Circuit Rating: 200,000 amps rms symmetrical with Class R, Class J, or Class L fuses installed.

D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

E. Connections:
   1. Mechanical lugs, except crimp compression lugs where shown.
   2. Lugs removable/replaceable.
   3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

F. Fuse Provisions:
   1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
   2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.
G. Enclosures: See Article Enclosures.

H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.03 NON-FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

D. Auxiliary Contact:
   1. Operation: Make before power contacts make, and break before power contacts break.
   2. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

E. Enclosures: As indicated on Drawings and required elsewhere in these Specifications.

F. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 FUSE, 250-VOLT AND 600-VOLT

A. Power Distribution, General:
   1. Current-limiting, with 200,000 ampere rms interrupting rating.
   2. Provide to fit mountings specified with switches.
   3. UL 248.

B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:
   2. Type: Dual element, with time delay.
   3. Manufacturers and Products:
      a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
      b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).

C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:
   1. Class: L.
   2. Double O-rings and silver links.
3. Manufacturers and Products:
   a. Bussmann; Type KRP-C.
   b. Littelfuse, Inc.; Type KLP-C.

D. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10 amp to 30 amps.
3. Dual-element time-delay, time-delay, or nontime-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
   a. Bussmann.
   b. Littelfuse, Inc.

2.05 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

B. Selector Switch Operating Lever: Standard.

C. Indicating Light: LED, full voltage, Push-to-Test.

D. Pushbutton Color:

1. ON or START: Green.
2. OFF or STOP: Red.

E. Pushbutton and selector switch lockable in OFF position where indicated.

F. Legend Plate:

1. Material: Aluminum.
2. Engraving: Enamel filled in high contrasting color.
3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
4. Letter Height: 7/64 inch.

G. Manufacturers and Products:

1. Heavy-Duty, Oil-Tight Type:
   a. General Electric Co.; Type CR 104P.
   b. Square D Co.; Type T.
   c. Eaton/Cutler-Hammer; Type 10250T.
2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
   a. Square D Co.; Type SK.
   b. General Electric Co.; Type CR 104P.
   c. Eaton/Cutler-Hammer; Type E34.
   d. Crouse-Hinds; Type NCS.

2.06 TERMINAL BLOCK, 600 VOLTS

   A. UL 486E and UL 1059.
   B. Size components to allow insertion of necessary wire sizes.
   C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.
   D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.
   E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.
   F. Yoke shall guide all strands of wire into terminal.
   G. Current bar shall ensure vibration-proof connection.
   H. Terminals:
      1. Capable of wire connections without special preparation other than stripping.
      2. Capable of jumper installation with no loss of terminal or rail space.
      3. Individual, rail mounted.
   I. Marking system, allowing use of preprinted or field-marked tags.
   J. Manufacturers:
      1. Weidmuller, Inc.
      2. Ideal.
      3. Electrovert USA Corp.

2.07 MAGNETIC CONTROL RELAY

   A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.
   B. NEMA ICS 2, Designation: A600 (600 volts).
C. Time Delay Relay Attachment:
   1. Pneumatic type, timer adjustable from 0.2 second to 60 seconds (minimum), or as indicated on Drawings.
   2. Field convertible from ON delay to OFF delay and vice versa.

D. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.

E. Manufacturers and Products:
   1. Eaton/Cutler-Hammer; D26 Type M.
   2. General Electric Co.; Type CR120B.
   3. Square D; Type X.

2.08 TIME DELAY RELAY

A. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, 360VA break.

B. NEMA ICS 2 Designation: B150 (150 volts).

C. Solid-state electronic, field convertible ON/OFF delay.

D. One normally open and one normally closed contact (minimum).

E. Repeat accuracy plus or minus 2 percent.

F. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.

G. Manufacturers and Products:
   1. Square D Co.; Type XO.
   2. Eaton/Cutler-Hammer; Type D26MR.
   3. General Electric Co.; Type CR120.

2.09 RESET TIMER

A. Drive: Synchronous motor, solenoid-operated clutch.

B. Mounting: Semiflush panel.

C. Contacts: 10 amps, 120 volts.
D. Manufacturers and Products:
   1. Eagle Signal Controls; Bulletin 125.

2.10 ELAPSED TIME METER

A. Drive: Synchronous motor.
B. Range: 0 hour to 99,999.9 hours, nonreset type.
C. Mounting: Semiflush panel.
D. Manufacturers and Products:
   1. General Electric Co.; Type 240, 2-1/2-inch Big Look.
   2. Eagle Signal Controls; Bulletin 705.

2.11 MAGNETIC CONTACTOR

A. UL listed.
B. Electrically operated, electrically held.
C. Main Contacts:
   1. Power driven in one direction with mechanical spring dropout.
   2. Silver alloy with wiping action and arc quenchers.
   3. Continuous-duty, rated 30 amperes, or as shown on Drawings.
   4. Poles: Three, or as shown on Drawings.
D. Control: Two-wire.
E. Auxiliary Contacts: Quantity as shown on Drawings, rated 7200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.
F. Enclosures: As indicated on Drawings and required elsewhere in these Specifications.
G. Manufacturers and Products:
   1. Eaton/Cutler-Hammer; Class A201.
   3. Square D Co.; Class 8910.
2.12 PHASE MONITOR RELAY

A. Features:

1. Voltage and phase monitor relay shall drop out on low voltage, voltage unbalance, loss of phase, or phase reversal.
2. Contacts: Single-pole, double-throw, 10 amperes, 120/240V ac. Where additional contacts are shown or required, provide magnetic control relays.
3. Adjustable trip and time delay settings.
4. Transient Protection: 1,000V ac.

B. Manufacturer and Product: Automatic Timing and Controls; SLD Series.

2.13 MAGNETIC LIGHTING CONTACTOR

A. Comply with NEMA ICS 2; provide UL 508 listing.

B. Electrically operated by dual-acting, single coil mechanism.

C. Inherently interlocked and electrically held in the CLOSED position.

D. Main Contacts:

1. Double-break, continuous-duty, rated 30 amperes, 600 volts, withstand rating of both 22,000 amps rms symmetrical at 250 volts, and 14,000 amps rms symmetrical at 480 volts.
2. Marked for LED, electric discharge lamps, tungsten, and general purpose loads.
3. Position not dependent on gravity, hooks, latches, or semipermanent magnets.
4. Capable of operating in any position.
5. Visual indication for each contact.

E. Auxiliary contact relay for two-wire control.

F. One normally open and one normally closed auxiliary contact rated 10 amperes continuous, 7,200VA make, 720VA break with NEMA designation of A600 (600 volts).

G. Fully rated neutral terminal.

H. Provision for remote pilot lamp with use of auxiliary contacts.

I. Clamp type, self-rising terminal plates for solderless connections.
J. Enclosures: See Article Enclosures.

K. Manufacturers and Products:
   
   1. ASCO.
   3. General Electric Co.; Class 360 (electrically held).
   4. Square D; Class 8903, Type L (electrically held).

2.14 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:
   
   1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.

B. Paint Coated Framing Channel: Carbon steel framing channel with electrodeposited rust inhibiting acrylic or epoxy paint.

C. PVC-Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.

D. Stainless Steel Framing Channel: Rolled, Type 316 stainless steel, 12-gauge minimum.

E. Extruded Aluminum Framing Channel:
   
   1. Material: Extruded from Type 6063-T6 aluminum alloy.
   2. Fittings fabricated from Alloy 5052-H32.

F. Nonmetallic Framing Channel:
   
   2. Channel fitting of same material as channel.

G. Manufacturers:
   
   1. B-Line Systems, Inc.
   2. Unistrut Corp.
   3. Aickinstrut.
2.15 SWITCHBOARD MATTING

A. Provide matting having a breakdown of 20 kV minimum.

B. Manufacturer: U.S. Mat and Rubber Company.

2.16 FIRESTOPS

A. General:

   1. Provide UL 1479 classified hourly fire rating equal to, or greater than, the assembly penetrated.
   2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
   3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by UL, or other testing and inspection agency acceptable to authorities having jurisdiction.

B. Firestop System:

   1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
   3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.
   4. Fire Stop Devices: See Section 26 05 33, Raceway and Boxes, for raceway and cable fittings.

2.17 ENCLOSURES

A. Finish: Aluminum, and Type 304 stainless steel, structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces, as well as bolted structural joints, have a complete finish coat on and between them.

B. Color: Manufacturer’s standard color (ANSI No. 61, Sky Blue Grey) baked-on enamel, unless otherwise indicated on Drawings or elsewhere in these Specifications.

C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.
D. Enclosure Selections:

1. Except as indicated otherwise on Drawings or in these Specifications, provide electrical enclosures according to the following table:

<table>
<thead>
<tr>
<th>Location</th>
<th>Finish</th>
<th>Environment</th>
<th>NEMA 250 Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor</td>
<td>Unfinished</td>
<td>Dry</td>
<td>12</td>
</tr>
<tr>
<td>Indoor and Outdoor</td>
<td>Any</td>
<td>Wet/Damp</td>
<td>4</td>
</tr>
</tbody>
</table>

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer’s recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, unless otherwise shown.

B. Install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas, unless otherwise shown.

3.03 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.

B. Channel Type:

1. Interior, Wet or Dry (Noncorrosive) Locations:
   a. Aluminum Raceway: Aluminum framing channel, and Type 304 stainless steel hardware.
   b. Steel Raceway and Other Systems Not Covered: Type 304 stainless steel framing channel and hardware.

2. Outdoor, Noncorrosive Locations:
   a. Steel Raceway: Type 304 stainless steel framing channel and hardware.
   b. Aluminum Raceway and Other Systems Not Covered: Aluminum framing channel and Type 304 stainless steel hardware.
3. Aluminum Railings: Devices mounted on aluminum railing shall use aluminum framing channel.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
4. PVC-Coated Channel: PVC patch.

3.04 SWITCHBOARD MATTING

A. Install 36-inch width at switchgear, switchboard, motor control centers, and panelboards.

B. Matting shall run full length of all sides of equipment that have operator controls or afford access to devices.

C. Provide in front of all electrical panels in buildings, rooms, and other walk-in style enclosures.

3.05 FIRESTOPS

A. Install in strict conformance with manufacturer’s instructions. Comply with installation requirements established by testing and inspecting agency.

B. Sealant: Install sealant including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):

2. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.

3. Insulated Cable Engineer’s Association, Inc. (ICEA):
   c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.

4. National Electrical Manufacturers’ Association (NEMA):
   a. CC 1, Electric Power Connectors for Substations.
   b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
   e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

5. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

7. UL:
   e. 486C, Standard for Safety for Splicing Wire Connectors.
   f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   g. 854, Standard for Safety for Service-Entrance Cables.
   h. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
   i. 1569, Standard for Safety for Metal-Clad Cables.

1.02 SUBMITTALS

A. Action Submittals:

   1. Product Data:
      a. Wire and cable.
      b. Wire and cable accessories.
   2. Cable Pulling Calculations:
      a. Ensure submitted and reviewed before cable installation.
      b. Provide for the following cable installations:
         1) VFD cable runs that cannot be hand pulled.
         2) Multi-conductor 600-volt cable sizes larger than 2 AWG that cannot be hand pulled.
         3) Feeder circuits; single conductor No. 4/0 and larger.

B. Informational Submittals: Certified Factory Test Report for conductors 600 volts and below.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

   1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied NRTL listing or labeling mark.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type:

1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper.
2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper.
3. All Other Circuits: Stranded copper.

C. Insulation: Type XHHW-2 insulation.

D. Direct Burial and Aerial Conductors and Cables:

1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

E. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.02 600-VOLT RATED CABLE

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer’s name, maximum working voltage for which cable was tested, type of cable, and NRTL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.
B. Type 1, Multiconductor Control Cable:

1. Conductors:
   a. 14 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL 1581 listed as Type THHN/THWN rated VW-1.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.

2. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.

3. Cable Sizes:

<table>
<thead>
<tr>
<th>No. of Conductors</th>
<th>Max. Outside Diameter (Inches)</th>
<th>Jacket Thickness (Mils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.41</td>
<td>45</td>
</tr>
<tr>
<td>5</td>
<td>0.48</td>
<td>45</td>
</tr>
<tr>
<td>7</td>
<td>0.52</td>
<td>45</td>
</tr>
<tr>
<td>12</td>
<td>0.72</td>
<td>60</td>
</tr>
<tr>
<td>19</td>
<td>0.83</td>
<td>60</td>
</tr>
<tr>
<td>25</td>
<td>1.00</td>
<td>60</td>
</tr>
<tr>
<td>37</td>
<td>1.15</td>
<td>80</td>
</tr>
</tbody>
</table>

4. Manufacturers:
   a. Okonite Co.
   b. Southwire.

C. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
d.  Jacket: 4-mil nominal nylon.
e.  Color Code: Pair conductors, black and red.

5.  Manufacturers:
   a.  Okonite Co.
   b.  Alpha Wire Corp.
   c.  Belden.

D.  Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1.  Outer Jacket: 45-mil nominal.
2.  Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3.  Dimension: 0.32-inch nominal OD.
4.  Conductors:
   a.  Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b.  20 AWG, seven-strand, tinned copper drain wire.
   c.  Insulation: 15-mil nominal PVC.
   d.  Jacket: 4-mil nylon.
   e.  Color Code: Triad conductors black, red, and blue.

5.  Manufacturers:
   a.  Okonite Co.
   b.  Alpha Wire Corp.
   c.  Belden.

E.  Type 5, 18 AWG, Multitwisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 requirements.

1.  Conductors:
   a.  Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
   b.  Tinned copper drain wires.
   c.  Pair drain wire size AWG 20, group drain wire size AWG 18.
   d.  Insulation: 15-mil PVC.
   e.  Jacket: 4-mil nylon.
   f.  Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
   g.  Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.

2.  Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. **Cable Sizes:**

<table>
<thead>
<tr>
<th>Number of Pairs</th>
<th>Maximum Outside Diameter (Inches)</th>
<th>Nominal Jacket Thickness (Mils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.50</td>
<td>45</td>
</tr>
<tr>
<td>8</td>
<td>0.68</td>
<td>60</td>
</tr>
<tr>
<td>12</td>
<td>0.82</td>
<td>60</td>
</tr>
<tr>
<td>16</td>
<td>0.95</td>
<td>80</td>
</tr>
<tr>
<td>24</td>
<td>1.16</td>
<td>80</td>
</tr>
<tr>
<td>36</td>
<td>1.33</td>
<td>80</td>
</tr>
<tr>
<td>50</td>
<td>1.56</td>
<td>80</td>
</tr>
</tbody>
</table>

4. **Manufacturers:**
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

F. **Type 8, Multiconductor Adjustable Frequency Drive Power Cable:**

1. **Conductors:**
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
   c. Grounding Conductors: Insulated stranded copper.

2. **Sheath:**
   a. UL 1277 Type TC, 90 degrees C.
   b. Continuous shield, A1/polyester foil, drain wires, overall copper braid.
3. **Outer Jacket:** Polyvinyl chloride (PVC) per UL 1569.
4. **Cable Size:** As shown on Drawings.
5. **Manufacturer and Product:** Belden; Series 29500.

2.03 **SPECIAL CABLES**

A. **Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:**

1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.

3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.

4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.

5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.

6. Manufacturer and Product: Belden; 7852A.

2.04 GROUNDING CONDUCTORS

A. Equipment and Grounding Electrode: Stranded copper with green, Type XHHW-2, insulation, 600V ac.

B. Direct Buried: Bare stranded copper, tin-coated.

2.05 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.


3. Arc and Fireproofing:
   a. 30-mil, elastomer.
   b. Manufacturers and Products:
      1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
      2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
   a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
   b. Manufacturers and Products:
      1) Raychem; Type D-SCE or ZH-SCE.
      2) Brady, Type 3PS.
2. Heat Bond Marker:
   a. Transparent thermoplastic heat bonding film with acrylic pressure
      sensitive adhesive.
   b. Self-laminating protective shield over text.
   c. Machine printed black text.
   d. Manufacturer and Product: 3M Co.; Type SCS-HB.
3. Marker Plate: Nylon, with legible designations permanently hot
   stamped on plate.
4. Tie-On Cable Marker Tags:
   a. Chemical-resistant white tag.
   b. Size: 1/2 inch by 2 inches.
   c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch
   minimum.

C. Connectors and Terminations:
   
   1. Nylon, Self-Insulated Crimp Connectors:
      a. Manufacturers and Products:
         1) Thomas & Betts; Sta-Kon.
         2) Burndy; Insulug.
         3) ILSCO.
   2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
      a. Suitable for use with 75 degrees C wire at full NFPA 70,
         75 degrees C ampacity.
      b. Seamless.
      c. Manufacturers and Products:
         1) Thomas & Betts; Sta-Kon.
         2) Burndy; Insulink.
         3) ILSCO; ILSCONS.
      a. UL 486C.
      b. Plated steel, square wire springs.
      c. Manufacturers and Products:
         1) Thomas & Betts.
         2) Ideal; Twister.
   4. Self-Insulated, Set Screw Wire Connector:
      a. Two piece compression type with set screw in brass barrel.
      b. Insulated by insulator cap screwed over brass barrel.
      c. Manufacturers:
         1) 3M Co.
         2) Thomas & Betts.
         3) Marrette.
D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Manufacturers and Products:
      1) Thomas & Betts; Color-Keyed.
      2) Burndy; Hydent.
      3) ILSCO.
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
   a. Manufacturers and Products:
      1) Thomas & Betts; Locktite.
      2) Burndy; Quiklug.
      3) ILSCO.

E. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Single wall for insulation and strain relief.
3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
   a. Thomas & Betts; SHRINK-KON.
   b. Raychem; RNF-100 and ES-2000.

2.06 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer.

D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.
E. Manufacturers:

1. Ideal Co.
2. Polywater, Inc.
3. Cable Grip Co.

2.07 WARNING TAPE

A. As specified in Section 26 05 33, Raceway and Boxes.

2.08 SOURCE QUALITY CONTROL

A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

PART 3 EXECUTION

3.01 GENERAL

A. Conductor installation shall be in accordance with manufacturer’s recommendations.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer’s recommendations for maximum pulling tensions and minimum bending radii.

D. Terminate conductors and cables, unless otherwise indicated.

E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors and aluminum conductors.

F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.

H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.
I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. 8 AWG and Smaller: Provide colored conductors.
3. Colors:

<table>
<thead>
<tr>
<th>System</th>
<th>Conductor</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Systems</td>
<td>Equipment Grounding</td>
<td>Green</td>
</tr>
<tr>
<td>240/120 Volts, Single-Phase, Three-Wire</td>
<td>Grounded Neutral One Hot Leg Other Hot Leg</td>
<td>White Black Red</td>
</tr>
<tr>
<td>208Y/120 Volts, Three-Phase, Four-Wire</td>
<td>Grounded Neutral Phase A Phase B Phase C</td>
<td>White Black Red Blue</td>
</tr>
<tr>
<td>240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase</td>
<td>Grounded Neutral Phase A High (wild) Leg Phase C</td>
<td>White Black Orange Blue</td>
</tr>
<tr>
<td>480Y/277 Volts, Three-Phase, Four-Wire</td>
<td>Grounded Neutral Phase A Phase B Phase C</td>
<td>White Brown Orange Yellow</td>
</tr>
</tbody>
</table>

Note: Phase A, B, C implies direction of positive phase rotation.

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.
3.03 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuit Names:

C. Circuits Not Appearing in Circuit Schedules:
   1. Assign circuit name based on device or equipment at load end of circuit.
   2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method:
   1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
   2. Cables and Conductors 2 AWG and Larger:
      a. Identify with marker plates or tie-on cable marker tags.
      b. Attach with nylon tie cord.
   3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.

C. Connections and Terminations:
   1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
   2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.

5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.

6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.

7. Place no more than one conductor in any single-barrel pressure connection.

8. Install crimp connectors with tools approved by connector manufacturer.

9. Install terminals and connectors acceptable for type of material used.

10. Compression Lugs:
   a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
   b. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Conductor Splices: Not permitted unless specifically noted on Drawings.

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:
   1. Remove surplus wire, bridle and secure.
   2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:
   1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
   2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer’s instructions.
   3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
   4. Where connections of cables installed under this section are to be made under Section 40 90 01, Instrumentation and Control for Process Systems, leave pigtails of adequate length for bundled connections.
5. **Cable Protection:**
   a. Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
   b. Maintain integrity of shielding of instrumentation cables.
   c. Ensure grounds do not occur because of damage to jacket over shield.

I. **Extra Conductor Length:** For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

**END OF SECTION**
PART 1     GENERAL

1.01    REFERENCES

A.   The following is a list of standards which may be referenced in this section:

1.   Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).

1.02    SUBMITTALS

A.   Action Submittals:

1.   Shop Drawings:
   a.   Product data for the following:
        1)   Exothermic weld connectors.
        2)   Mechanical connectors.
        3)   Compression connectors.
        4)   Ground rods.
        5)   Specialty tools.

1.03    QUALITY ASSURANCE

A.   Authority Having Jurisdiction (AHJ):

1.   Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2.   Materials and equipment manufactured within the scope of standards published by UL shall conform to those Standards and shall have an applied NRTL Listing or Labeling mark.

PART 2     PRODUCTS

2.01    GROUND ROD

A.   Material: Copper-clad.

C. Length: 20 feet.

2.02 GROUND CONDUCTORS

A. As specified in Section 26 05 05, Conductors.

2.03 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Use low-smoke, low-emission process.

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers and Products:
   a. Burndy Corp.; Hyground Irreversible Compression.
   b. Thomas and Betts Co.

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
   a. Burndy Corp.
   b. Thomas and Betts Co.

2.04 GROUNDING WELLS

A. H20 Traffic-rated ground box complete with cast-iron riser ring and traffic cover marked “GROUND ROD”.

B. Manufacturers and Products:

PART 3  EXECUTION

3.01  GENERAL

A.  Grounding: In compliance with NFPA 70 and IEEE C2.

B.  Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.

C.  Ground each separately derived system neutral with common grounding electrode conductor to grounding electrode system.

D.  Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.

E.  Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

F.  Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

G.  Shielded Instrumentation Cables:

1.  Ground shield to ground bus at power supply for analog signal.

2.  Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.

3.  Do not ground instrumentation cable shield at more than one point.

3.02  WIRE CONNECTIONS

A.  Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B.  Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C.  Connect ground conductors to raceway grounding bushings.

D.  Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E.  Connect enclosure of equipment containing ground bus to that bus.

F.  Bolt connections to equipment ground bus.
G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

3.03 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Motors Less Than 10 hp: Use furnished ground lug in motor connection box. If none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: Use furnished ground lug in motor connection box. If none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing. Install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

C. Space multiple ground rods by one rod length.

D. Install to 8 feet below local frost depth, minimum.

3.05 GROUNDING WELLS

A. Install for ground rods located where indicated on Drawings.

B. Install riser ring and cover flush with surface.
C. Place 6 inches of crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:
   1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
   2. Belowgrade Connections: Install exothermic weld or compression type connectors.
   3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
   4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:
   1. Wire brush or file contact point to bare metal surface.
   2. Use welding cartridges and molds in accordance with manufacturer’s recommendations.
   3. Avoid using badly worn molds.
   4. Mold to be completely filled with metal when making welds.
   5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:
   1. Install in accordance with connector manufacturer’s recommendations.
   2. Install connectors of proper size for grounding conductors and ground rods specified.
   3. Install using connector manufacturer’s compression tool having proper sized dies and operate per manufacturer’s instructions.

D. Mechanical Type:
   1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
   2. Install in accordance with connector manufacturer’s recommendations.
   3. Do not conceal mechanical connections.

3.07 METAL STRUCTURE GROUNDING

A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.
C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.08 MANHOLE AND HANDHOLE GROUNDING

A. Install one ground rod inside each manhole and handhole larger than 24-inch by 24-inch inside dimensions.

B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all noncurrent-carrying metal parts and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

3.09 TRANSFORMER GROUNDING

A. Bond neutrals of stepdown transformers to grounding electrode system.

3.10 LIGHTNING PROTECTION SYSTEMS

A. Bond lightning protection system ground terminals to building or structure grounding electrode system.

3.11 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

END OF SECTION
PART 1    GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:


2. ASTM International (ASTM):


4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. C80.1, Electrical Rigid Steel Conduit (ERSC).
   c. C80.3, Steel Electrical Metallic Tubing (EMT).
   d. C80.5, Electrical Rigid Aluminum Conduit (ERAC).
   e. C80.6, Electrical Intermediate Metal Conduit (EIMC).
   f. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
   g. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
   h. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   i. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
   j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
   k. VE 1, Metallic Cable Tray Systems.


7. UL:
   a. 1, Standard for Safety for Flexible Metal Conduit.
   b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
   c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
   d. 6A, Standard for Safety for Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless.
   e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
   f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
   g. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
   h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
   i. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
   j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
   k. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
   l. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
   m. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
   n. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s Literature:
   a. Rigid galvanized steel conduit.
   b. Rigid aluminum conduit.
   c. PVC Schedule 40 conduit.
   d. PVC Schedule 80 conduit.
   e. PVC-coated rigid steel conduit.
   f. Flexible metal, liquid-tight conduit.
   g. Flexible, nonmetallic, liquid-tight conduit.
   h. Conduit fittings.
   i. Wireways.
   j. Device boxes for use in hazardous areas.
   k. Junction and pull boxes used at or belowgrade.
   l. Large junction and pull boxes.
   m. Terminal junction boxes.
2. Precast Manholes and Handholes:
   a. Dimensional drawings and descriptive literature.
   b. Traffic loading calculations.
   c. Accessory information.
3. Equipment and machinery proposed for bending metal conduit.
4. Method for bending PVC conduit less than 30 degrees.

B. Informational Submittals: Component and attachment testing seismic certificate of compliance as required by Section 26 05 02, Basic Electrical Requirements.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):
   1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
   2. Materials and equipment manufactured within scope of standards published by UL shall conform to those standards and shall have an applied NRTL Listing or Labeling mark.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):
   1. Meet requirements of NEMA C80.1 and UL 6.

B. Rigid Aluminum Conduit:
   1. Meet requirements of NEMA C80.5 and UL 6A.
   2. Material: Type 6063, copper-free aluminum alloy.

C. PVC Schedule 40 Conduit:
   1. Meet requirements of NEMA TC 2 and UL 651.
   2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.
   3. Furnish without factory-formed bell.
D. PVC Schedule 80 Conduit:
   1. Meet requirements of NEMA TC 2 and UL 651.
   2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

E. PVC-Coated Rigid Steel Conduit:
   1. Meet requirements of NEMA RN 1.
   2. Material:
      a. Meet requirements of NEMA C80.1 and UL 6.
      b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
   3. Threads: Hot-dipped galvanized and factory coated with urethane.
   4. Bendable without damage to interior or exterior coating.

F. Flexible Metal, Liquid-Tight Conduit:
   1. UL 360 listed for 105 degrees C insulated conductors.

G. Flexible, Nonmetallic, Liquid-Tight Conduit:
   1. Material: PVC core with fused flexible PVC jacket.
   2. UL 1660 listed for:
      a. Dry Conditions: 80 degrees C insulated conductors.
      b. Wet Conditions: 60 degrees C insulated conductors.
   3. Manufacturers and Products:
      a. Carlon; Carflex or X-Flex.
      b. T & B; Xtraflex LTC or EFC.

2.02 FITTINGS

A. Rigid Galvanized Steel Conduit:
   1. General:
      a. Meet requirements of UL 514B.
      b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
   2. Bushing:
      a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
      b. Manufacturers and Products:
         1) Appleton; Series BU-I.
         2) O-Z/Gedney; Type HB.
3. Grounding Bushing:
   a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
   b. Manufacturers and Products:
      1) Appleton; Series GIB.
      2) O-Z/Gedney; Type HBLG.

4. Conduit Hub:
   a. Material: Malleable iron with insulated throat with bonding screw.
   b. UL listed for use in wet locations.
   c. Manufacturers and Products:
      1) Appleton; Series HUB-B.
      2) O-Z/Gedney; Series CH.
      3) Meyers; ST Series.

5. Conduit Bodies:
   a. Sized as required by NFPA 70.
   b. Manufacturers and Products (For Normal Conditions):
      1) Appleton; Form 35 threaded unilets.
      2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
      3) Killark; Series O electrolets.
      4) Thomas & Betts; Form 7 or Form 8.
   c. Manufacturers (For Hazardous Locations):
      1) Appleton.
      2) Crouse-Hinds.
      3) Killark.

6. Couplings: As supplied by conduit manufacturer.

7. Unions:
   a. Concrete tight, hot-dip galvanized malleable iron.
   b. Manufacturers and Products:
      1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
      2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.

8. Drain Seal:
   a. Manufacturers and Products:
      1) Appleton; Type EYD.
      2) Crouse-Hinds; Type EYD or Type EZD.

9. Drain/Breather Fitting:
   a. Manufacturers and Products:
      1) Appleton; Type ECDB.
      2) Crouse-Hinds; ECD.

10. Expansion Fitting:
    a. Manufacturers and Products:
        1) Deflection/Expansion Movement:
           a) Appleton; Type DF.
           b) Crouse-Hinds; Type XD.
2) Expansion Movement Only:
   a) Appleton; Type XJ.
   b) Crouse-Hinds; Type XJ.
   c) Thomas & Betts; XJG-TP.

11. Cable Sealing Fitting:
   a. To form watertight nonslip cord or cable connection to conduit.
   b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
   c. Manufacturers and Products:
      1) Appleton; CG-S.
      2) Crouse-Hinds; CGBS.

B. Rigid Aluminum Conduit:

1. General:
   a. Meet requirements of UL 514B.
   b. Type: Threaded, copper-free. Set screw fittings not permitted.

2. Insulated Bushing:
   a. Material: Cast aluminum, with integral insulated throat, rated for 150 degrees C.
   b. Manufacturer and Product: O-Z/Gedney; Type AB.

3. Grounding Bushing:
   a. Material: Cast aluminum with integral insulated throat, rated for 150 degrees, with solderless lugs.
   b. Manufacturer and Product: O-Z/Gedney; Type ABLG.

4. Conduit Hub:
   a. Material: Cast aluminum, with insulated throat.
   b. UL listed for use in wet locations.
   c. Manufacturers and Products:
      1) O-Z/Gedney; Type CHA.
      2) Thomas & Betts; Series 370AL.
      3) Meyers; Series SA.

5. Conduit Bodies:
   a. Manufacturers and Products (For Normal Conditions):
      1) Appleton; Form 85 threaded unilets.
      2) Crouse-Hinds; Mark 9 or Form 7-SA threaded condulets.
      3) Killark; Series O electrolets.
   b. Manufacturers (For Hazardous Locations):
      1) Appleton.
      2) Crouse-Hinds.
      3) Killark.

6. Couplings: As supplied by conduit manufacturer.
7. Conduit Sealing Fitting:
   a. Manufacturers and Products:
      1) Appleton; Type EYF-AL or Type EYM-AL.
      2) Crouse-Hinds; Type EYS-SA or Type EZS-SA.
      3) Killark; Type EY or Type EYS.

8. Drain Seal:
   a. Manufacturers and Products:
      1) Appleton; Type EYDM-A.
      2) Crouse-Hinds; Type EYD-SA or Type EZD-SA.

9. Drain/Breather Fitting:
   a. Manufacturers and Products:
      1) Appleton; Type ECDB.
      2) Crouse-Hinds; ECD.

10. Expansion Fitting:
    a. Manufacturers and Products:
       1) Deflection/Expansion Movement: Steel City; Type DF-A.
       2) Expansion Movement Only: Steel City; Type AF-A.

11. Cable Sealing Fittings:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. Bushing: Neoprene at connector entry.
    c. Manufacturer and Product: Appleton; CG-S.

C. PVC Conduit:
    1. Meet requirements of NEMA TC 3.
    2. Type: PVC, slip-on.

D. PVC-Coated Rigid Steel Conduit:
    1. Meet requirements of UL 514B.
    2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
    3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
    5. Overlapping pressure-sealing sleeves.
    7. Manufacturers:
       a. Robroy Industries.
       b. Ocal.
    8. Expansion Fitting:
       a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.
E. Flexible Metal, Liquid-Tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
2. Insulated throat and sealing O-rings.
3. Manufacturers and Products:
   a. Thomas & Betts; Series 5331.
   b. O-Z/Gedney; Series 4Q.

F. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
3. Body/compression nut (gland) design to ensure high mechanical pullout strength and watertight seal.
4. Manufacturers and Products:
   a. Carlon; Type LT.
   b. O-Z/Gedney; Type 4Q-P.
   c. Thomas & Betts; Series 6300.

G. Watertight Entrance Seal Device:

1. New Construction:
   a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
   b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK, as required.
2. Cored-Hole Application:
   b. Manufacturer and Product: O-Z/Gedney; Series CSM.

2.03 OUTLET AND DEVICE BOXES

A. Cast Aluminum:

1. Material:
   a. Box: Cast, copper-free aluminum.
   b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
2. Hubs: Threaded.
3. Lugs: Cast mounting.
4. Manufacturers and Products, Nonhazardous Locations:
   a. Crouse-Hinds; Type FS-SA or Type FD-SA.
   b. Appleton; Type FS or Type FD.
5. Manufacturers and Products, Hazardous Locations:
   a. Crouse-Hinds; Type GUA-SA.
   b. Appleton; Type GR.

2.04 JUNCTION AND PULL BOXES

A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

C. Large Cast Aluminum Box:
   1. NEMA 250 Type 4.
   2. Box: Cast copper-free aluminum, with drilled and tapped conduit entrances and exterior mounting lugs.
   3. Cover: Nonhinged.
   5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   6. Manufacturers and Products, Surface Mounted Type:
      a. Crouse-Hinds; Series W-SA.
      b. O-Z/Gedney; Series YS-A, YL-A.

D. Large Stainless Steel Box:
   1. NEMA 250 Type 4X.
   2. Box: 14-gauge, ASTM A240/A240M, Type 304 stainless steel.
   3. Cover: Hinged with clamps.
   5. Manufacturers:
      b. Robroy Industries.
      c. Wiegman.

E. Large Nonmetallic Box:
   1. NEMA 250 Type 4X.
   2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
   3. Cover: Hinged with clamps.
   5. Conduit hubs and mounting lugs.
   6. Manufacturers and Products:
      a. Crouse-Hinds; Type NJB.
      b. Carlon; Series N, C, or H.
      c. Robroy Industries.
F. Concrete Box, All Areas:
   1. Box: Reinforced, cast concrete with extension and bottom slab.
   2. Cover: Steel checked plate; H/20 loading with screw down.
   3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
   4. Manufacturers and Products:
      a. Christy, Concrete Products, Inc.; B1017BOX.
      b. Utility Vault Co.; 3030 SB.

2.05 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Interior Finish: Paint with white enamel or lacquer.

C. Terminal Blocks:
   1. Separate connection point for each conductor entering or leaving box.
   2. Spare Terminal Points: 25 percent, minimum.

2.06 METAL WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, lay-in type.

C. Cover: Hinged with friction latch.

D. Rating: Outdoor raintight.

E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.

F. Hardware: Plated to prevent corrosion; screws installed toward the inside
   protected by spring nuts or otherwise guarded to prevent wire insulation
   damage.

G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:
   1. Circle AW.
   2. Hoffman.
   3. Square D.
2.07 PRECAST MANHOLES AND HANDBOLES

A. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.

B. Loading: AASHTO, H-20 in accordance with ASTM C857.

C. Access: Provide cast concrete 6-inch or 12-inch risers and access hole adapters between top of manhole and finished grade at required elevations.

D. Drainage:
   1. Slope floors toward drain points, leaving no pockets or other nondraining areas.
   2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe.

E. Raceway Entrances:
   1. Provide on all four sides.
   2. Provide knockout panels or precast individual raceway openings.
   3. At entrances where raceways are to be installed by others, provide minimum 12-inch-high by 24-inch-wide knockout panels for future raceway installation.

F. Embedded Pulling Iron:
   1. Material: 3/4-inch-diameter stock, fastened to overall steel reinforcement before concrete is placed.
   2. Location:
      a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
      b. Floor: Centered below manhole or handhole cover.

G. Cable Racks:
   1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
   2. Wall Attachment:
      a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
      b. Insert Spacing: Maximum 3 feet on center for inside perimeter of manhole.
      c. Arrange in order that spare raceway ends are clear for future cable installation.
H. Manhole Frames and Covers:
   1. Material: Machined cast iron.
   2. Diameter: 36-1/2 inch.
   3. Cover Type: Indented, solid top design, with two drop handles each.
   5. Cover Designation: Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
      a. 600 Volts and Below: ELECTRIC LV.

I. Handhole Frames and Covers:
   1. Material: Steel, hot-dipped galvanized.
   2. Cover Type: Solid, bolt-on, of checkered nonskid design.
   4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
      a. 600 Volts and Below: ELECTRIC LV.

J. Hardware: Steel, hot-dip galvanized.

K. Furnish knockout for ground rod in each handhole and manhole.

L. Manufacturers:
   1. Utility Vault Co.
   2. Penn-Cast Products, Inc.
   3. Concrete Conduit Co.
   4. Associated Concrete Products, Inc.
   5. Pipe, Inc.

2.08 ACCESSORIES

A. Duct Bank Spacers:
   1. Modular Type:
      a. Nonmetallic, interlocking, for multiple conduit sizes.
      b. Suitable for all types of conduit.
      c. Manufacturers:
         1) Underground Device, Inc.
         2) Carlon.
B. Identification Devices:

1. Raceway Tags:
   b. Shape: Round.
   c. Raceway Designation: Pressure stamped, embossed, or engraved.
   d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
   a. Material: Polyethylene, 4-mil gauge with detectable strip.
   b. Color: Red.
   c. Width: Minimum 6 inches.
   d. Designation: Warning on tape that electric circuit is located below tape.
   e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
   f. Manufacturers and Products:
      1) Panduit; Type HTDU.
      2) Reef Industries; Terra Tape.
3. Buried Raceway Marker:
   a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
   b. Designation: Engrave to depth of 3/32 inch; ELECTRIC CABLES, in letters 1/4-inch high.
   c. Minimum Dimension: 1/4 inch thick, 10 inches long, and 3/4 inch wide.

C. Heat Shrinkable Tubing:

2. Semi-flexible with meltable adhesive inner liner.
4. Manufacturers:
   a. Raychem.
   b. 3M.

D. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.
3. Manufacturer and Product: Raychem; Type TWDB.
PART 3 EXECUTION

3.01 GENERAL

A. Conduit and tubing sizes shown are based on use of copper conductors.

B. Comply with NECA Installation Standards.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.

M. Install watertight fittings in outdoor, underground, or wet locations.

N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

P. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.
Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

S. Install conduits for fiber optic cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.02 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum Cover: 2 inches, including fittings.

B. Conduit placement shall not require changes in reinforcing steel location or configuration.

C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.

D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless approved by Engineer.

E. Slabs and Walls (Requires Engineer Approval):
   1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
   2. Install within middle two-fourths of slab or wall.
   3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
   4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
   5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
   6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
   7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams (Requires Engineer Approval):
   1. Trade size of conduit not to exceed one-fourth of beam thickness.
   2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.
3.03 CONDUIT APPLICATION

A. Diameter: As indicated on Drawings, minimum 3/4 inch.

B. Exterior, Exposed:
   1. Rigid aluminum.
   2. PVC-coated rigid galvanized steel.

C. Interior, Exposed:
   1. Rigid galvanized steel (areas classified as “Dry”).
   2. Rigid aluminum (areas classified as “Wet” or “Damp”).

D. Interior, Concealed (Not Embedded in Concrete): Rigid galvanized steel.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: Rigid galvanized steel.

F. Direct Earth Burial:
   1. PVC Schedule 80 for ac circuits.
   2. PVC-coated rigid steel for dc and analog circuits.

G. Concrete-Encased Ductbank:
   1. PVC Schedule 80 for ac circuits.
   2. Rigid galvanized steel for afd, dc and analog circuits.

H. Under Slabs-On-Grade:
   1. PVC Schedule 40 for ac circuits.
   2. PVC-coated rigid steel for afd, dc and analog circuits.

I. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel.

3.04 FLEXIBLE CONNECTIONS

A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:

1. Conduit Size 4 Inches or Less: Flexible, nonmetallic liquid-tight, Type LNFC-B.
3. Wet or Corrosive Areas: Flexible, nonmetallic liquid-tight, Type LNFC-B.
4. Dry Areas: Flexible, nonmetallic liquid-tight, Type LNFC-B.

B. Suspended Luminaires in Dry Areas: Flexible steel, liquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment. Conduit to be supported at intervals as indicated on Drawings, but at spacings no greater than allowed by the NEC.

3.05 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire Rated Walls: Firestop openings around penetrations to maintain existing fire rating of the structure being penetrated.

D. Apply heat shrinkable tubing or single layer of wraparound duct band to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.

1. PVC-coated rigid conduit shall extend through concrete slabs to a minimum of 6-inches above concrete surface.
F. Entering Structures:

1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.

2. Concrete Roof or Membrane Waterproofed Wall or Floor:
   a. Provide a watertight seal.
   b. Without Concrete Encasement: Install watertight entrance seal device on each side.
   c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
   d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
   e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.

3. Heating, Ventilating, and Air Conditioning Equipment:
   a. Penetrate equipment in area established by manufacturer.
   b. Terminate conduit with flexible metal conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.
   c. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
   d. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.

4. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
   a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
   b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.

5. Manholes and Handholes:
   c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.06 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 10 feet in any application. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 20 percent extra space for future conduit.
C. Application/Type of Conduit Strap:

1. Aluminum Conduit: Aluminum or stainless steel.
2. Rigid Steel Conduit: Zinc coated steel or pre-galvanized steel.
3. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
4. Nonmetallic Conduit: Nonmetallic, PVC-coated metal or stainless steel.

D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:

1. Wood: Wood screws.
2. Hollow Masonry Units: Toggle bolts.
3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
5. Location/Type of Hardware:
   a. Dry, Noncorrosive Areas: Galvanized.
   b. Wet, Noncorrosive Areas: Stainless steel.
   c. Corrosive Areas: Stainless steel.

E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

F. Support aluminum conduit on concrete surfaces with stainless steel or nonmetallic spacers, or aluminum or nonmetallic framing channel.

3.07 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.
ZINK DAM IMPROVEMENT

G. PVC Conduit:
   2. 90-Degree Bends: Provide rigid steel elbows.
   3. Use manufacturer’s recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.08 EXPANSION/DEFLECTION FITTINGS
   A. Provide on raceways at structural expansion joints and in long tangential runs.
   B. Provide expansion/deflection joints for 25 degrees F maximum temperature variation.
   C. Install in accordance with manufacturer’s instructions.

3.09 PVC CONDUIT
   A. Solvent Welding:
      1. Apply manufacturer recommended solvent to joints.
      2. Install in order that joint is watertight.
   B. Adapters:
      1. PVC to Metallic Fittings: PVC terminal type.
      2. PVC to Rigid Metal Conduit: PVC female adapter.
   C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.10 PVC-COATED RIGID STEEL CONDUIT
   A. Install in accordance with manufacturer’s instructions.
   B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.
   C. Provide PVC boot to cover exposed threading.
3.11 WIREWAYS

A. Install in accordance with manufacturer’s instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:
   1. Metal wireway in indoor dry locations.
   2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

3.12 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Install manufacturer’s premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:
   1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
   2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

C. Sheet Metal Boxes, Cabinets, and Enclosures:
   1. General:
      a. Install insulated bushing on ends of conduit where grounding is not required.
      b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
      c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
      d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
      e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
   2. Rigid Galvanized Conduit:
      a. Provide one lock nut each on inside and outside of enclosure.
      b. Install grounding bushing at source enclosure.
      c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
   3. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
5. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

D. Motor Control Center, Switchgear, and Free-Standing Enclosures:
   1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
   2. Terminate PVC conduit entering bottom with bell end fittings.

3.13 UNDERGROUND RACEWAYS

A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.

B. Cover: Maintain minimum 2-foot cover above conduit unless otherwise shown.

C. Make routing changes as necessary to avoid obstructions or conflicts.

D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.

E. Union type fittings not permitted.

F. Spacers:
   1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
   2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.

G. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.

H. Transition from Underground to Exposed: PVC-coated rigid steel conduit.

I. Installation with Other Piping Systems:
   1. Crossings: Maintain minimum 12-inch vertical separation.
   2. Parallel Runs: Maintain minimum 12-inch separation.
   3. Installation over valves or couplings not permitted.

J. Metallic Raceway Coating: At couplings and joints, apply wraparound duct band with one-half tape width overlap to obtain two complete layers.
K. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.

L. Provide expansion/deflection fittings in conduit runs that exit building or structure belowgrade.

M. Concrete Encasement: As specified in Section 03 30 00, Cast-in-Place Concrete.

N. Backfill:
   1. As specified in Section 31 23 23.15, Trench Backfill.
   2. Do not backfill until inspected by Engineer.

3.14 UNDER SLAB RACEWAYS

A. Make routing changes as necessary to avoid obstructions or conflicts.

B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.

C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.

D. Raceway spacing, in a single layer or multiple layers:
   1. 3 inches clear between adjacent 2-inch or larger raceway.
   2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.

E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in Section 31 23 23.15, Trench Backfill.

F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.

G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.
H. Fittings:

1. Union type fittings are not permitted.
2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.15 OUTLET AND DEVICE BOXES

A. General:

1. Install plumb and level.
2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
4. Install galvanized mounting hardware in industrial areas.

B. Size:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
   a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
3. Luminaires: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. General:
   a. Dimensions given to centerline of box.
   b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
   c. Do not straddle CMU block or other construction joints.
2. Light Switch:
   a. 48 inches above floor.
   b. When located next to door, install on lock side of door.

3. Thermostat: 54 inches above floor.

4. Convenience Receptacle:
   a. General Interior Areas: 24 inches above floor.
   b. Outdoor Areas: 24 inches above finished grade.

5. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.

E. Flush Mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

F. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Provide plaster rings where necessary.
5. Boxes embedded in concrete or masonry need not be additionally supported.

G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.16 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush Mounted:
   1. Install with concealed conduit.
   2. Holes in surrounding surface shall be no larger than required to receive box.
   3. Make edges of boxes flush with final surface.

C. Mounting Hardware:
   1. Noncorrosive Wet or Dry Areas: Stainless steel.
   2. Corrosive Areas: Stainless steel.

D. Supports:
   1. Support boxes independently of conduit by attachment to building structure or structural member.
   2. Install bar hangers in frame construction or fasten boxes directly as follows:
      a. Wood: Wood screws.
      b. Concrete or Brick: Bolts and expansion shields.
      c. Hollow Masonry Units: Toggle bolts.
   3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
   4. Boxes embedded in concrete or masonry need not be additionally supported.

E. At or Belowgrade:
   1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
   2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
3. Obtain Engineer’s written acceptance prior to installation in paved areas, roadways, or walkways.
4. Use boxes and covers suitable to support anticipated weights.

F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.17 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and final grade in accordance with Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

B. Do not install until final raceway grading has been determined.

C. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.

D. Grounding: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.

E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.18 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide nylon pull cord.

D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.19 IDENTIFICATION DEVICES

A. Raceway Tags:

1. Identify origin and destination.
2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
3. Install tags at each terminus for concealed raceways.
4. Provide noncorrosive wire or nylon strap for attachment.

B. Warning Tape: Install approximately 12 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of run.
ZINK DAM IMPROVEMENT

C. Buried Raceway Marker:
   1. Install at grade to indicate direction of underground raceway.
   2. Install at bends and at intervals not exceeding 100 feet in straight runs.
   3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.20 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers’ instructions until time of use.

END OF SECTION
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   b. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
   c. 399, Recommended Practice for Industrial and Commercial Power System Analysis.
   d. 1584, Guide for Performing Arc Flash Hazard Calculations.
   a. 70, National Electrical Code (NEC).
   b. 70E, Standard for Electrical Safety in the Workplace.

1.02 SUBMITTALS

A. Action Submittals:

1. Short circuit study.
2. Protective Device Coordination Study: Submit along with Short Circuit Study.
3. Arc Flash Study: Submit along with Protective Device Coordination Study. Submit final study prior to equipment energization.
4. Arc Flash Warning Labels: Submit sample with initial study.
5. Electronic files on thumb drive of final studies including all engineering software input files, output reports, and libraries.

1.03 QUALITY ASSURANCE

A. Short circuit, protective device coordination, and arc flash studies shall be prepared either by manufacturer furnishing power distribution equipment, or by a professional electrical engineer registered in the State of Oklahoma.
1.04 SEQUENCING AND SCHEDULING

A. Initial complete short circuit study, protective device coordination study, and arc flash study shall be submitted and reviewed before Engineer will review Shop Drawings for any power distribution equipment.

B. Revised short circuit, protective device coordination, and arc flash studies, and arc flash labels shall be submitted 10 days before energizing electrical equipment.

C. Final short circuit, protective device coordination, and arc flash studies shall be completed prior to Project Substantial Completion. Final version of study shall include as-installed equipment, materials, and parameter data or settings entered into equipment based on study.

D. Submit final arc flash labels described herein and in compliance with NEMA Z535.4 prior to Project Substantial Completion.

1.05 GENERAL STUDY REQUIREMENTS

A. Equipment and component titles used in the studies shall be identical to equipment and component titles shown on Drawings.

B. Perform studies using one of the following electrical engineering software packages:

2. ETAP.
3. Paladin.
4. Easy Power.

C. Perform complete fault calculations for each proposed source combination.

1. Source combination may include present and future power company supply circuits, large motors, or generators.

D. Utilize proposed load data for study from Contract Documents.

E. Device coordination time-current curves for low-voltage distribution system; include individual protective device time-current characteristics.
1.06 SHORT CIRCUIT STUDY

A. General:

1. Prepare in accordance with IEEE 399.
2. Use cable impedances based on copper conductors, except where aluminum conductors are specified or shown.
3. Use bus impedances based on copper bus bars, except where aluminum bus bars are specified or shown.
4. Use cable and bus resistances calculated at 25 degrees C.
5. Use 600-volt cable reactances based on use of typical dimensions of XHHW-2 conductors.
6. Use transformer impedances 92.5 percent of “nominal” impedance based on tolerances specified in IEEE C57.12.00.

B. Provide:

1. Calculation methods and assumptions.
2. Typical calculation.
3. Tabulations of calculated quantities.
4. Results, conclusions, and recommendations.
5. Selected base per unit quantities.
6. One-line diagrams.
7. Source impedance data, including electric utility system and motor fault contribution characteristics.
8. Impedance diagrams.

C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault at each:

1. Electric utility’s supply termination point.
2. Main (service-entrance) switchboard or panelboard.
3. Low-voltage switchboards.
5. Standby generators.
7. Future load contributions as shown on one-line diagram.

D. Provide bolted line-to-ground fault current study for areas as defined for three-phase bolted fault short circuit study.

E. Provide bolted line-to-line fault current study for areas as defined for three-phase bolted fault short circuit study.
F. Verify:

1. Equipment and protective devices are applied within their ratings.
2. Adequacy of switchboard and motor control centers bus bars to withstand short circuit stresses.
3. Adequacy of transformer windings to withstand short circuit stresses.
4. Cable and busway sizes for ability to withstand short circuit heating, in addition to normal load currents.

G. Tabulations:

1. General Data:
   a. Short circuit reactances of rotating machines.
   b. Cable and conduit material data.
   c. Bus data.
   d. Transformer data.
   e. Circuit resistance and reactance values.
2. Short Circuit Data (for each source combination):
   a. Fault impedances.
   b. X to R ratios.
   c. Asymmetry factors.
   d. Motor contributions.
   e. Short circuit kVA.
   f. Symmetrical and asymmetrical fault currents.
3. Equipment Evaluation:
   a. Equipment bus bracing, equipment short circuit rating, transformer, cable, busway.
   b. Maximum fault current available.

H. Written Summary:

1. Scope of studies performed.
2. Explanation of bus and branch numbering system.
3. Prevailing conditions.
4. Selected equipment deficiencies.
5. Results of short circuit study.
6. Comments or suggestions.

I. Suggest changes and additions to equipment rating and/or characteristics.

J. Notify Engineer in writing of existing circuit protective devices improperly rated for new fault conditions.

K. Revise data for “as-installed” condition.
1.07 PROTECTIVE DEVICE COORDINATION STUDY

A. General:

1. Prepare in accordance with IEEE 242.
2. Proposed protective device coordination time-current curves for distribution system, graphically displayed on conventional log-log curve sheets.
   a. Provide separate curve sheets for phase and ground fault coordination for each scenario.
   b. Each curve sheet to have title and one-line diagram that applies to specific portion of system associated with time-current curves on that sheet. Limit number of devices shown to four to six.
   c. Identify device associated with each curve by manufacturer type, function, and, if applicable, recommended tap, time delay, instantaneous and other settings recommended.
   d. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
   e. Apply motor protection methods that comply with NFPA 70.

B. Plot Characteristics on Curve Sheets:

1. Electric utility’s relays.
2. Electric utility’s fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands.
3. Low-voltage fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands.
4. Low-voltage equipment circuit breaker trip devices, including manufacturers tolerance bands.
5. Pertinent transformer full-load currents at 100 percent.
6. Transformer magnetizing inrush currents.
7. Transformer damage curves; appropriate for system operation and location.
8. ANSI transformer withstand parameters.
10. Motor overload relay settings for motors greater than 50 hp.
12. Other system load protective devices for largest branch circuit and feeder circuit breaker in each motor control center.
C. Primary Protective Device Settings for Delta-Wye Connected Transformer:

1. Secondary Line-to-Ground Fault Protection: Primary protective device operating band within transformer’s characteristics curve, including a point equal to 58 percent of IEEE C57.12.00 withstand point.

D. Tabulate Recommended Protective Device Settings:

1. Relays:
   a. Current tap.
   b. Time dial.
   c. Instantaneous pickup.
2. Circuit Breakers:
   a. Adjustable pickups.
   b. Adjustable time-current characteristics.
   c. Adjustable time delays.
   d. Adjustable instantaneous pickups.
   e. I^2t In/Out.
   f. Zone interlocking.
   g. Electronic settings data file.

E. Written Summary:

1. Scope of studies performed.
2. Summary of protective device coordination methodology.
3. Prevailing conditions.
4. Selected equipment deficiencies.
5. Results of coordination study.
6. Appendix of complete relay and circuit breaker electronic setting files, submit electronic data files from manufacturer’s software.
7. Comments or suggestions.

1.08 ARC FLASH STUDY

A. Perform arc flash hazard study after short circuit and protective device coordination study has been completed, reviewed and accepted.

B. Perform arc flash study in accordance with NFPA 70E, OSHA 29 CFR, Part 1910 Subpart S, and IEEE 1584.
C. Base Calculation:

1. For each major part of electrical power system, determine the following:
   a. Flash hazard protection boundary.
   b. Limited approach boundary.
   c. Restricted approach boundary.
   d. Incident energy level.
   e. Glove class required.

D. Produce arc flash warning labels that list items in Paragraph Base Calculation and the following additional items:

1. Bus name.
2. Bus voltage.

E. Produce bus detail sheets that list items in Paragraph Base Calculation and the following additional items:

1. Bus name.
2. Upstream protective device name, type, and settings.

F. Produce arc flash evaluation summary sheet listing the following additional items:

1. Bus name.
2. Upstream protective device name, type, settings.
5. Protective device bolted fault current.
6. Arcing fault current.
7. Protective device trip/delay time.
8. Breaker opening time.
9. Solidly grounded column.
10. Equipment type.

G. Analyze short circuit, protective device coordination, and arc flash calculations and highlight equipment that is determined to be underrated or causes incident energy values greater than 8 cal/cm². Propose approaches to reduce energy levels.
H. Prepare report summarizing arc flash study with conclusions and recommendations which may affect integrity of electric power distribution system. As a minimum, include the following:

1. Equipment manufacturer’s information used to prepare study.
2. Assumptions made during study.
3. Reduced copy of one-line drawing; 11 inches by 17 inches maximum.
4. Arc flash evaluations summary spreadsheet.
5. Bus detail sheets.
6. Arc flash warning labels printed in color on thermally bonded adhesive backed UV and weather-resistant labels.

PART 2 PRODUCTS

2.01 ARC FLASH WARNING LABELS

A. Arc flash warning labels printed in color on thermally bonded adhesive backed, UV- and weather-resistant labels.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust relay and protective device settings according to values established by coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Engineer in writing of required major equipment modifications.

D. Provide laminated one-line diagrams (minimum size 11 inches by 17 inches) to post on interior of electrical room doors.

E. Provide arc flash warning labels on equipment as specified in this section.

END OF SECTION
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   e. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.

2. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulation Resistance of Electric Machinery.
   b. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
   d. C37.20.1, Standard for Metal-Enclosed Low-Voltage (1000V ac and below, 3200V dc and below) Power Circuit Breaker Switchgear.

4. National Electrical Manufacturers Association (NEMA):
   a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2, Deadfront Distribution Switchboards.

5. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70B, Recommended Practice for Electrical Equipment Maintenance.
   c. 70E, Standard for Electrical Safety in the Workplace.


1.02 SUBMITTALS

A. Informational Submittals:

1. Submit 30 days prior to performing inspections or tests:
   a. Schedule for performing inspection and tests.
   b. List of references to be used for each test.
   c. Sample copy of equipment and materials inspection form(s).
   d. Sample copy of individual device test form.
   e. Sample copy of individual system test form.

2. Energization Plan:
   a. Prior to initial energization of electrical distribution equipment; include the following:
      1) Owner’s representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
      2) Staged sequence of initial energization of electrical equipment.
      3) Lock-Out-Tag-Out plan for each stage of the progressive energization.
      4) Barricading, signage, and communication plan notifying personnel of newly energized equipment.

3. Submit test or inspection reports and certificates for each electrical item tested within 15 days after completion of test.
4. Operation and Maintenance Data:
   a. In accordance with Section 01 78 23, Operation and Maintenance Data.
   b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.

5. Programmable Settings:
   a. At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left setpoints, programs, and device configuration files for:
      1) Protective relays.
      2) Intelligent overload relays.
      3) Adjustable frequency drives.
      4) Power metering devices.
      5) Uninterruptible power supplies.
      6) Electrical communications modules.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:
   1. Corporately and financially independent organization functioning as an unbiased testing authority.
   2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
   3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
   4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years’ testing experience on similar projects.
   5. Technicians certified by NICET or NETA.
   6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
   7. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
   8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test Instrument Calibration: In accordance with NETA ATS.
1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment listed herein has been installed.

B. Perform tests with apparatus de-energized whenever feasible.
   1. Scheduled with Engineer prior to de-energization.
   2. Minimized to avoid extended period of interruption to the operating plant equipment.

C. Notify Engineer at least 72 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Perform tests in accordance with requirements of Section 01 91 14, Equipment Testing and Facility Startup.

B. Tests and inspections shall establish:
   1. Electrical equipment is operational within industry and manufacturer’s tolerances and standards.
   2. Installation operates properly.
   3. Equipment is suitable for energization.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer’s recommendations.

D. Set, test, and calibrate protective relays, circuit breakers, fuses, power monitoring systems, and other applicable devices in accordance with values established by short circuit, coordination, and harmonics studies as specified in Section 26 05 70, Electrical Systems Analysis.

E. Adjust mechanisms and moving parts of equipment for free mechanical movement.

F. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.
G. Verify nameplate data for conformance to Contract Documents and approved Submittals.

H. Realign equipment not properly aligned and correct unlevelness.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer’s recommendations, or as otherwise specified in NETA ATS.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of applicable moving parts.

M. Inform Engineer of working clearances not in accordance with NFPA 70.

N. Investigate and repair or replace:
   1. Electrical items that fail tests.
   2. Active components not operating in accordance with manufacturer’s instructions.
   3. Damaged electrical equipment.

O. Electrical Enclosures:
   1. Remove foreign material and moisture from enclosure interior.
   2. Vacuum and wipe clean enclosure interior.
   3. Remove corrosion found on metal surfaces.
   4. Repair or replace, as determined by Engineer, door and panel sections having dented surfaces.
   5. Repair or replace, as determined by Engineer, poor fitting doors and panel sections.
   6. Repair or replace improperly operating latching, locking, or interlocking devices.
   7. Replace missing or damaged hardware.
   8. Finish:
      a. Provide matching paint and touch up scratches and mars.
      b. If required because of extensive damage, as determined by Engineer refinish entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.
3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:
   1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
   2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
   3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day.
      a. Submit Voltage Field Test Report within 5 days of test.
   4. Unbalance Corrections:
      a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
      b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:
   1. Check line current in each phase for each piece of equipment.
   2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
   3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.03 SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:
   1. Insulator damage and contaminated surfaces.
   2. Proper barrier and shutter installation and operation.
   3. Proper operation of indicating devices.
   4. Improper blockage of air-cooling passages.
   5. Proper operation of drawout elements.
   6. Integrity and contamination of bus insulation system.
   7. Check door and device interlocking system by:
      a. Closure attempt of device when door is in OFF or OPEN position.
      b. Opening attempt of door when device is in ON or CLOSED position.
   8. Check key interlocking systems for:
      a. Key captivity when device is in ON or CLOSED position.
      b. Key removal when device is in ON or CLOSED position.
c. Closure attempt of device when key has been removed.
d. Correct number of keys in relationship to number of lock cylinders.
e. Existence of Other Keys Capable of Operating Lock Cylinders: Destroy duplicate sets of keys.

9. Check nameplates for proper identification of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbutton.
   c. Control switch.
   d. Pilot light.
   e. Control relay.
   f. Circuit breaker.
   g. Indicating meter.

10. Verify fuse and circuit breaker ratings, sizes, and types conform to those specified.

11. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints.
   a. Ohmic value to be zero.
   b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.

12. Check operation and sequencing of electrical and mechanical interlock systems by:
   a. Closure attempt for locked open devices.
   b. Opening attempt for locked closed devices.
   c. Key exchange to operate devices in OFF-NORMAL positions.

13. Verify performance of each control device and feature.

14. Control Wiring:
   a. Compare wiring to local and remote control and protective devices with elementary diagrams.
   b. Proper conductor lacing and bundling.
   c. Proper conductor identification.
   d. Proper conductor lugs and connections.

15. Exercise active components.

16. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With breakers open.
   e. With breakers closed.
f. Control wiring except that connected to solid state components.
g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Overpotential Tests:
   a. Applied ac voltage and test procedure in accordance with IEEE C37.20.1. Alternatively use NETA ATS, Table 100.2.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. Test results evaluated on a pass/fail basis.

3. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.

4. Control Wiring:
   a. Apply secondary voltage to control power and potential circuits.
   b. Check voltage levels at each point on terminal boards and each device terminal.

5. Operational Test:
   a. Initiate control devices.
   b. Check proper operation of control system in each section.

3.04 PANELBOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

   1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
   2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer’s instruction manual.
   3. Check panelboard mounting, area clearances, and alignment and fit of components.
   4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer’s instructions for proper torque values.
   5. Perform visual and mechanical inspection for overcurrent protective devices.
B. Electrical Tests: Include the following items performed in accordance with manufacturer’s instruction:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With breakers open.
   e. With breakers closed.
   f. Control wiring except that connected to solid state components.
   g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Ground continuity test ground bus to system ground.

3.05 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.
9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
   c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
d. Temperature corrected insulation resistance values equal to, or
greater than, ohmic values established by manufacturer.
e. Insulation resistance test results to compare within 1 percent of
adjacent windings.

2. Perform tests and adjustments for fans, controls, and alarm functions as
suggested by manufacturer.

3.06 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 6 AWG and larger for:
a. Physical damage.
b. Proper connections in accordance with single-line diagram.
c. Cable bends not in conformance with manufacturer’s minimum
allowable bending radius where applicable.
d. Color coding conformance with specification.
e. Proper circuit identification.

2. Mechanical Connections for:
a. Proper lug type for conductor material.
b. Proper lug installation.
c. Bolt torque level in accordance with NETA ATS, Table 100.12,
unless otherwise specified by manufacturer.

3. Shielded Instrumentation Cables for:
a. Proper shield grounding.
b. Proper terminations.
c. Proper circuit identification.

4. Control Cables for:
a. Proper termination.
b. Proper circuit identification.

5. Cables Terminated Through Window Type CTs: Verify neutrals and
grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 AWG and Larger:

1. Insulation Resistance Tests:
a. Utilize 1,000V dc megohmmeter for 600-volt insulated
conductors.
b. Test each conductor with respect to ground and to adjacent
conductors for 1 minute.
c. Evaluate ohmic values by comparison with conductors of same
length and type.
d. Investigate values less than 50 megohms.

2. Continuity test by ohmmeter method to ensure proper cable
connections.
C. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.07 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.
5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Proper phase barrier material and installation.
7. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.
8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each switch blade and fuse holder.
   b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.08 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 70 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000V dc megohmmeter for 480-volt and 600-volt circuit breakers and 500V dc megohmmeter for 240-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.

2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.

3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristics of adjustable trip breakers shall be within manufacturer’s published time-current characteristic tolerance band, including adjustment factors.
   f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
   g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.09 LOW-VOLTAGE POWER CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Proper mounting, cell fit, and element alignment.
2. Proper operation of racking interlocks.
3. Check for damaged arc chutes.
4. Proper contact condition.
5. Bolt torque level in accordance with NETA ATS, Table 100.12.
6. Perform mechanical operational and contact alignment tests in accordance with manufacturer’s instructions.
7. Check operation of closing and tripping functions of trip devices by activating ground fault relays, undervoltage shunt relays, and other auxiliary protective devices.
8. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operation are correct.
9. Check charging motor, motor brushes, associated mechanism, and limit switches for proper operation and condition.
10. Check operation of electrically operated breakers in accordance with manufacturer’s instructions.
11. Check for adequate lubrication on contact, moving, and sliding surfaces.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000V dc megohmmeter for 480-volt and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristic when adjusted to setting sheet parameters shall be within manufacturer’s published time-current tolerance band.

3.10 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.
3.11 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:
   1. Equipment and circuit grounds in motor control center, panelboard, and switchboard assemblies for proper connection and tightness.
   2. Ground bus connections in motor control center, panelboard, and switchboard assemblies for proper termination and tightness.
   3. Effective transformer core and equipment grounding.
   4. Accessible connections to grounding electrodes for proper fit and tightness.
   5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:
   1. Clamp-On Ground Meter Test:
      a. In accordance with manufacturer’s testing requirements.
      b. Performed on grounding electrode conductor of service-entrance equipment.
      c. Ground electrode system resistance to not exceed 5 ohms to remote earth.

3.12 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 hp and larger.

B. Visual and Mechanical Inspection:
   1. Proper electrical and grounding connections.
   2. Shaft alignment.
   4. Operate motor and check for:
      a. Excessive mechanical and electrical noise.
      b. Overheating.
      c. Correct rotation.
      d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
      e. Excessive vibration, in excess of values in NETA ATS, Table 100.10.
   5. Check operation of space heaters.
C. Electrical Tests:

1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
      1) Motors above 200 hp for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      2) Motors 200 hp and less for 1-minute duration with resistances tabulated at 30 seconds and 60 seconds.
   b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.

2. Calculate polarization index ratios for motors above 200 hp. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.

3. Insulation resistance test on insulated bearings in accordance with manufacturer’s instructions.

4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.

3.13 LOW-VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
   a. Closure attempt of device when door is in OFF or OPEN position.
   b. Opening attempt of door when device is in ON or CLOSED position.
8. Check key interlocking systems for:
   a. Key captivity when device is in ON or CLOSED position.
   b. Key removal when device is in OFF or OPEN position.
   c. Closure attempt of device when key has been removed.
   d. Correct number of keys in relationship to number of lock cylinders.
   e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbuttons.
c. Control switches.
d. Pilot lights.
e. Control relays.
f. Circuit breakers.
g. Indicating meters.

10. Verify fuse and circuit breaker sizes and types conform to Contract Documents.


12. Check bus connections for high resistance by low-resistance ohmmeter and calibrated torque wrench applied to bolted joints:
   a. Ohmic value to be zero.
   b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.

13. Check operation and sequencing of electrical and mechanical interlock systems by:
   a. Closure attempt for locked open devices.
   b. Opening attempt for locked closed devices.
   c. Key exchange to operate devices in OFF-NORMAL positions.

14. Verify performance of each control device and feature furnished as part of motor control center.

15. Control Wiring:
   a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
   b. Check for proper conductor lacing and bundling.
   c. Check for proper conductor identification.
   d. Check for proper conductor lugs and connections.

16. Exercise active components.

17. Inspect contactors for:
   a. Correct mechanical operations.
   b. Correct contact gap, wipe, alignment, and pressure.
   c. Correct torque of connections.

18. Compare overload heater rating with full-load current for proper size.

19. Compare motor circuit protector and circuit breaker with motor characteristics for proper size.

20. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.

d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.

e. Test values to comply with NETA ATS, Table 100.1.

2. Current Injection through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:

a. Trip time in accordance with manufacturer’s published data.

b. Investigate values in excess of 120 seconds.

3. Control Wiring Tests:

a. Apply secondary voltage to control power and potential circuits.

b. Check voltage levels at each point on terminal board and each device terminal.

c. Insulation resistance test at 1,000V dc on control wiring, except that connected to solid state components; 1 megohm minimum insulation resistance.

4. Operational test by initiating control devices to affect proper operation.

3.14 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:

1. Check doors and panels for proper interlocking.

2. Check connections for high resistance by low-resistance ohmmeter and calibrated torque wrench applied to bolted joints.

3. Check positive mechanical and electrical interlock between normal and alternate sources.

4. Check for Proper Operation:


   b. Generator under load and nonload conditions.

   c. Auto-exerciser of generator under load and no-load conditions.

5. Verify settings and operation of control devices.

B. Electrical Tests:

1. Insulation Resistance Tests:

   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1, for each phase with switch CLOSED in both source positions.

   b. Phase-to-phase and phase-to-ground for 1 minute.

   c. Test values in accordance with manufacturer’s published data.

2. Contact Resistance Test:

   a. Contact resistance in microhms across each switch blade for both source positions.

   b. Investigate values exceeding 500 micro-ohms.
3. Investigate values deviating from adjacent pole by more than 50 percent.

3. Set and calibrate in accordance with Specifications, manufacturer’s recommendations, and Coordination Study.
   a. Voltage and frequency sensing relays.
   b. Time delay relays.
   c. Engine start and shutdown relays.

4. Perform automatic transfer tests by:
   a. Simulating loss of normal power.
   b. Return to normal power.
   c. Simulating loss of alternate power.
   d. Simulating single-phase conditions for normal and alternate sources.

5. Monitor and verify operation and timing of:
   a. Normal and alternate voltage sensing relays.
   b. Engine-start sequence.
   c. Timing delay upon transfer and retransfer.
   d. Engine cool down and shutdown.
   e. Interlocks and limit switch functions.
   f. Engine cool down and shutdown feature.

3.15 STANDBY GENERATOR SYSTEMS

A. Visual and Mechanical Inspection:

   1. Proper grounding.
   2. Blockage of ventilating passageways.
   3. Proper operation of jack water heaters.
   4. Integrity of engine cooling and fuel supply systems.
   5. Excessive mechanical and electrical noise.
   6. Overheating of engine or generator.
   7. Proper installation of vibration isolators.
   8. Proper cooling liquid type and level.
   9. Operate engine-generator and check for:
      a. Excessive mechanical and electrical noise.
      b. Overheating.
      c. Correct rotation.
      d. Check resistance temperature detectors or generator inherent thermal protectors for functionability and proper operation.
      e. Excessive vibration.
   10. Verify voltage regulator and governor operation will cause unit speed and output voltage to stabilize at proper values within reasonable length of time.
   11. Proper operation of meters and instruments.
12. Compare generator nameplate rating and connection with one-line diagram or approved Submittal.

B. Electrical and Mechanical Tests:

1. Cold start test by interrupting normal power source with test load consisting of connected building load to verify:
   a. Transfer switch operation.
   b. Automatic starting operation.
   c. Operating ability of engine-generator.
   d. Overcurrent devices capability to withstand inrush currents.

2. Phase rotation tests.

3. Test engine protective shutdown features for:
   a. Low oil pressure.
   b. Overtemperature.
   c. Overspeed.

4. Load bank test with resistors for each load step. Record voltage, frequency, load current, oil pressure, and engine coolant temperature at 15-minute intervals:
   a. 25 percent applied load for 30 minutes.
   b. 50 percent applied load for 30 minutes.
   c. 75 percent applied load for 30 minutes.
   d. 100 percent applied load for 3 hours.
   e. Load test results to demonstrate ability of unit to deliver rated load for test period.

5. One-Step Rated kW Load Pickup Test:
   a. Perform test immediately after performing load bank test.
   b. Apply rated load, minus largest rated hp motor, to generator.
   c. Start largest rated horsepower motor and record voltage drop for 20 cycles minimum with high-speed chart recorder or digital storage oscilloscope.
   d. Compare voltage drop with maximum allowable voltage dip for specified starting situation.

END OF SECTION
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

2. National Electrical Manufacturers Association (NEMA):
   b. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).

1.02 DEFINITIONS

A. CT: Current Transformer.
C. LCD: Liquid Crystal Display.
D. LED: Light Emitting Diode.
E. MPR: Motor Protection Relay.
F. PLC: Programmable Logic Controller.
G. PT: Potential Transformer.
H. RTD: Resistance Temperature Detectors.
I. UCA: Utility Communications Architecture.

1.03 SUBMITTALS

A. Action Submittals:

1. Instruction manuals for each type of device.
2. Special features, licensed programming software.
3. Potential and current schematic diagrams.
4. Control and metering schematic diagrams.
5. Interconnection wiring diagrams.
6. Installation and mounting requirements.
7. Complete descriptive literature and renewal parts data.
B. Informational Submittals:

1. Programming software used to configure devices, along with settings files necessary to reload or revise settings as left by Contractor.
2. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 POWER METER (PM)

A. General:

1. Solid state device with LED displays.
2. Direct voltage input up to 600V ac.
3. Current input via current transformer with 5-ampere secondary.
4. Programmable current and potential transformer ratios.
5. Programmable limits to activate up to four alarms.
6. Selectable Voltage Measurements: Line-to-line or line-to-neutral and wye or delta.
7. Ethernet capable.

B. Simultaneous Display:

1. Volts, three-phase.
2. Amperes, three-phase.
4. Kilowatt hours.
5. Ethernet/IP communications network capable.
6. Frequency.
7. kW Demand with programmable period intervals.
8. kVA.
9. kVAR.
10. kVARh.
11. Manufacturers: Same as power distribution equipment supplied specified under other Sections of these Specifications.

2.02 INSTRUMENT TRANSFORMERS

A. Current Transformer (CT), 600 Volts and Below:

1. Type: Molded bar or donut.
2. Accuracy: 0.6 percent for metering.
3. Shorting type terminal boards for current transformer leads.
B. Potential Transformer (PT), 600 Volts and Below:

1. Type: Molded.
2. Accuracy Classification: 0.3 at burden imposed by meters and instruments, including future.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer’s written instructions.

B. As defined in Section 26 08 00, Commissioning of Electrical Systems.

3.02 MANUFACTURER’S SERVICES

A. See Section 01 43 33, Manufacturers’ Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION
SECTION 26 14 13
LOW-VOLTAGE SWITCHBOARDS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Manufacturers Association (NEMA):
   a. PB 2, Deadfront Distribution Switchboards.
   b. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).


3. UL:
   b. 891, Standard for Safety for Switchboards.
   c. 1561, Standard for Safety for Dry-Type General Purpose and Power Transformers.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Itemized Bill of Material.
3. Dimensional drawings.
4. Operational description.
5. One-line, three-line, and control schematic drawings.
6. Connection and interconnection drawings.
10. Incoming line section equipment data.
11. Conduit entrance locations.
12. Anchoring instructions and details.
13. Seismic anchorage and bracing drawings and cut sheets, as required by Section 26 05 02, Basic Electrical Requirements.
B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 26 05 02, Basic Electrical Requirements.
2. Manufacturer’s installation instructions.
4. Component and attachment testing seismic certificate of compliance.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
6. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by UL shall conform to those standards and shall have an applied NRTL Listing or Labeling mark.

1.04 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage and deliver prior to 90 percent Project completion the following spare parts:

1. Fuses: One complete set of spare fuses of each current rating, both power and control.
2. Lights: One complete set of spare indicating lights.
3. Paint: One pint, to match enclosure exterior finish in color and quality.
4. Indicating Lamp Pullers: Two each.
5. Indicating Lamp Resistors and Sockets: Two each.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. General Electric.
3. Siemens.
4. Square D.

2.02 GENERAL REQUIREMENTS

A. Equipment suitable for 480Y/277 or 208Y/120-volt, three-phase, four-wire solidly grounded-wye electrical system (as indicated on Drawings) having the available short-circuit current as shown on Drawings.

B. Comply with NEMA PB 2 and UL 891.

C. Switchboard and its major components to be manufactured and assembled by single manufacturer in order to achieve standardization for appearance, operation and maintenance, spare parts replacement, and manufacturer’s services.

D. Lifting lugs on equipment and devices weighing over 100 pounds.

E. Operating Conditions:
   1. Ambient Temperature: Maximum 40 degrees C.
   2. Equipment shall be fully rated without derating for the above operating conditions.

2.03 STATIONARY STRUCTURE

A. Type: NEMA PB 2 construction, dead front, completely metal enclosed, self-supporting, front access only.

B. Sections bolted together to form one rigid assembly capable of being moved into position and bolted directly to floor without use of floor sills.

2.04 ENCLOSURE

A. Equipment Finish: Baked enamel applied over rust-inhibiting phosphated base coating.

   1. Color:
      a. Exterior: ANSI No. 61, Sky Blue Grey finish as approved by Engineer.
      c. Unpainted Parts: Plated for corrosion resistance.
B. Indoor Enclosure: NEMA 250, Type 1 Gasketed:
   1. Rear, full-height, bolt-on panels for each enclosure section.
   3. Front Access:
      a. Service line and load terminations, internal devices, device and bolted bus connections, and protective device removal, serviceable from front only.
      b. Sections aligned across back to permit placement flush against wall.
      c. Working Space: As required by NFPA 70.
   4. Transition sections as required or shown.
   5. Side and Top Covers: Removable, captive, screw-on plates with formed edges on each side.
   6. Front Cover: Hinged door with formed edges.

2.05 BUSWORK
A. Material: Phase noninsulated, tin-plated copper throughout entire length of sufficient cross section to limit temperature rise at rated current to 55 degrees C.
B. Bus Arrangement: A-B-C, left-to-right, top-to-bottom, and front-to-rear, as viewed from front.
C. Brace for short-circuit currents as indicated on Drawings.
D. Main Horizontal Bus: Nontapered, continuous current rating as indicated on Drawings.
E. Neutral Bus: Continuous current rating to be 50 percent of main horizontal bus rating.
F. Ground Bus:
   1. Copper.
   2. Rating: 300 amperes.
   3. Bolted to each vertical section.
G. Extend each bus entire length of switchboard.
2.06 PROTECTIVE DEVICES

A. Molded-Case Circuit Breakers:
   1. Main and Branch Feeder Protective Devices: Individually mounted, suitable for use with 75 degree C wire at full 75 degree C ampacity when mounted in switchboard.
   3. Breakers 225-Ampere Frame and Above: Continuously adjustable magnetic pickups five to ten times trip rating.
   5. Interrupting Rating: As shown on Drawings.
   6. Mechanical interlock to prevent opening compartment door while breaker is in closed position.

B. Ground Fault Protection:
   1. Ground sensor encircling phase conductors and neutral conductor, where used.
   2. Solid-state sensing relay and monitor/test panel.
   3. Zero sequence current detection, adjustable over range shown.
   4. Monitor panel with fault detection indicating light, test, and reset buttons.
   5. Control Power Source: Suitable to operate circuit protective device when connected to faulted phase conductor.

C. Arc Flash Reduction Maintenance System:
   1. Trip units for circuit breakers 600-amp frame or greater shall be equipped with an arc flash reduction maintenance system.
   2. System to allow operator to enable a maintenance mode, implementing a preset accelerated instantaneous override trip to reduce arc flash energy.
   3. An LED lamp and indicator flag on the trip unit shall indicate when the trip unit is in maintenance mode.

D. Breaker Accessories:
   1. Arc Flash Reduction Maintenance System (ARMS), indicating light and flag.
   2. Portable breaker lifter.

2.07 SOLID-STATE TRIP UNIT

A. Flux-shift trip and current sensors.
B. Protective Programmers:

2. No external relays or accessories.
3. Printed circuit cards with gold-plated contacts.
4. Programmable Controls:
   a. Fixed-point, with repetitive accuracy and precise unit settings.
   b. Trip adjustments made by nonremovable, discrete step switching.
5. Field-Installable Rating Plugs:
   a. Long-time pickup LED indicator and test receptacle.
   b. Matching load and cable requirements.
   c. Interlocked with tripping mechanism.
   d. Breaker to remain trip-free with plug removed.
   e. Keyed rating plugs to prevent incorrect application.
7. Selective Coordination Time/Current Curve Shaping Adjustable Functions:
   a. Current setting.
   b. Long-time pickup.
   c. Long-time delay.
   d. Instantaneous pickup with short-time.
   e. Short-time pickup.
   f. Short-time delay for with I2T function, and IN-OUT switch.
   g. Ground fault pickup.
   h. Ground fault delay with I2T function.
   i. High instantaneous pickup with short-time delay.
   j. Fixed, instantaneous pickup.
8. Fault Trip Indicators: Mechanical push-to-reset type for overload and short-circuit overload plus ground fault trip.
9. Rejection Pins: For each programmer frame size.

C. Phase Current Sensors:

1. Multi-ratio type.
2. Fixed, mounted on breaker frame.
4. One toroidal type for each phase.
5. Wired to shorting terminal blocks.

D. Ground Fault Sensor:

1. Neutral bar single-ratio CT mounted in cable compartment.
3. Shorting bar.
2.08 CONTROL WIRING

A. Control, Instrumentation, and Power/Current Circuits: NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts.

B. Transducer Output/Analog Circuits: Shielded cable rated 600 volts, 90 degrees C minimum.

C. Conductor Lugs: Preinsulated, self-locking, spade-type, with reinforced sleeves.

D. Identification: Individually, with permanent wire markers at each end.

E. Enclose in top and vertical steel wiring troughs, and front-to-rear in nonmetallic wiring troughs.

F. Splices: Not permitted in switchboard wiring.

2.09 TERMINAL BLOCKS

A. Enclosed in steel wiring troughs.

B. Rated 600 volts, 30 amperes minimum, one-piece barrier type with strap screws.

C. Shorting type for current transformer leads.

D. Provide terminal blocks for:
   1. Conductors connecting to circuits external to switchboard.
   2. Internal circuits crossing shipping splits.
   3. Equipment parts requiring replacement and maintenance.

E. Spare Terminals: Not less than 20 percent.

F. Group terminal blocks for external circuit wiring leads.

G. Maintain 6-inch minimum space between columns of terminal blocks.

H. Identification: Permanent, for each terminal and columns of terminal blocks.

I. Manufacturer and Product: General Electric; Type EB-5.

2.10 POWER METER

A. As specified in Section 26 09 13, Power Measurement and Control.
2.11 KEY INTERLOCK
A. Mechanical lock cylinder within as shown on Drawings.
B. Keys to be captive when breakers are closed.

2.12 SURGE PROTECTIVE DEVICES
A. As indicated on Drawings.
B. Provide factory mounted within motor control center utilizing NRTL-recognized mounting device.
C. SPD shall be as manufactured by Surge Suppression, Inc. (SSI). No exceptions or substitutions.

2.13 IDENTIFICATION
A. Nameplates:
   1. Master:
      a. Deep-etched aluminum, with manufacturer’s name and model number.
      b. Riveted to main vertical section.
   2. Circuit Breaker Cubicle and Door-Mounted Device:
      a. Engraved, phenolic.
      b. Color: White, engraved to a black core.
      c. Characters: Block-type, 1/4-inch high.
      d. Size: Manufacturer’s standard.
      e. Inscription: As shown on one-line diagram.
      g. Attachment Screws: Stainless steel panhead.

B. Section Identification:
   1. Stamped metallic, riveted to each vertical section.
   2. Serial number, bus rating, and section reference number.
   3. Size: Manufacturer’s standard.

C. Cubicle Labels:
   1. Nonmetallic, applied inside each cubicle compartment.
   2. Device serial number, rating, and description.

D. Metering Instruments: Meter type identified on meter face below pointer or dial.
E. Control Switches: Deep etched, aluminum escutcheon plate.

F. Relays and Devices:
   1. Stamped metallic, riveted to instrument case.
   2. Manufacturer’s name, model number, relay type, and rating data.

G. Switchboard Sign:
   1. Two signs each on front of switchboard.
   2. Engraved, phenolic.
   3. Size: Manufacturer’s standard.
   5. Characters: Gothic-type, 1 inch high.
   6. Inscription: DANGER/HIGH VOLTAGE/KEEP OUT.
   7. Attachment: Four rivets each sign.

2.14 FACTORY TESTING

A. Performance tests in accordance with UL 891 and production tests in accordance with NEMA PB-2.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions and recommendations.

B. Secure to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.

C. Install plumb and in longitudinal alignment with pad or wall.

D. Coordinate terminal connections with installation of secondary feeders.

3.02 MANUFACTURER’S SERVICES

A. Furnish manufacturer’s representative in accordance with Section 01 43 33, Manufacturers’ Field Services, for the following services at Site, for minimum person-days listed below, travel time excluded:
   1. 1 person-day for installation assistance, final adjustment, and initial energization of equipment.
   2. 1 person-day for functional and performance testing.
   3. 1 person-day for adjustment of relay settings.
B. Furnish startup services and training of Owner’s personnel at such times as requested by Owner.

END OF SECTION
PART 1  GENERAL

1.01  RELATED SECTIONS

A. This Section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and deviations from this Section will be listed in the specific motor-driven equipment specification, and on the accompanying motor data sheet. Where such deviations occur, they shall take precedence over this Section.

1.02  REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.

2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 620, Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines.
   c. 841, Standard for Petroleum and Chemical Industry—Premium Efficiency Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 kW (500 hp).

3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. C50.41, Polyphase Induction Motors for Power Generating Stations.
   c. MG 1, Motors and Generators.


5. UL:
   b. 674, Standard for Safety for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.
   c. 2111, Standard for Safety for Overheating Protection for Motors.
DEFINITIONS

A. Inverter Duty Motor: Motor meeting applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.

B. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

C. ODP: Open drip-proof enclosure.

D. TEFC: Totally enclosed, fan-cooled enclosure.

E. TENV: Totally enclosed, nonventilated enclosure.

F. WPI: Open weather protected enclosure, Type I.

SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Nameplate data in accordance with NEMA MG 1.
3. Additional Rating Information:
   a. Service factor.
   b. Locked rotor current.
   c. No load current.
   d. Safe stall time for motors 200 hp and larger.
   e. Adjustable frequency drive motor load classification (for example, variable torque) and minimum allowable motor speed for that load classification.
   f. Guaranteed minimum full load efficiency and power factor.
4. Enclosure type and mounting (such as, horizontal, vertical).
5. Dimensions and total weight.
6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
7. Bearing type.
8. Bearing lubrication.
10. Space heater voltage and watts.
11. Description, ratings, and wiring diagram of motor thermal protection.
12. Motor sound power level in accordance with NEMA MG 1.
13. Maximum brake horsepower required by the equipment driven by the motor.
14. Description and rating of submersible motor moisture sensing system.
15. Anchorage and bracing data sheets and Drawings as required by Section 26 05 02, Basic Electrical Requirements.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 26 05 02, Basic Electrical Requirements.
2. Factory test reports, certified.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
4. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. General Electric.
2. Baldor.
4. TECO-Westinghouse Motor Co.
5. Toshiba International Corp., Industrial Division.

2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, use a single supplier to provide drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1 for premium efficiency, constant speed, and across-the-line start motors. Inclusive of Section IV, Parts 31 and 32, for premium efficiency, variable speed motors.

D. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

E. Lifting lugs on motors weighing 100 pounds or more.
F. Operating Conditions:

1. Maximum ambient temperature not greater than 40 degrees C.
2. Motors shall be suitable for operating conditions without reduction being required in nameplate rated horsepower or exceeding rated temperature rise.
3. Overspeed in either direction in accordance with NEMA MG 1.

2.03 HORSEPOWER RATING

A. As designated in motor-driven equipment specification, and as shown on Drawings.

B. Constant Speed Applications: Brake horsepower of driven equipment at any operating condition not to exceed motor nameplate horsepower rating, excluding service factor.

C. Adjustable Frequency and Adjustable Speed Applications (Inverter Duty Motor):
   1. Driven equipment brake horsepower at any operating condition not to exceed motor nameplate horsepower rating, excluding service factor.
   2. Full speed range inverter duty, variable torque application.

2.04 SERVICE FACTOR

A. Inverter-Duty Motors: Dual rated 1.15 for constant speed operation, and 1.0 for variable speed operation, at rated ambient temperature.

B. Other Motors: 1.15 at rated ambient temperature.

2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60 Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specification:

<table>
<thead>
<tr>
<th>Size</th>
<th>Voltage</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 hp and smaller</td>
<td>115</td>
<td>1</td>
</tr>
<tr>
<td>3/4 hp through 400 hp</td>
<td>460</td>
<td>3</td>
</tr>
</tbody>
</table>

C. Suitable for full voltage starting.
D. 40 hp and larger suitable for reduced voltage starting with 65 percent or 80 percent voltage tap settings on reduced inrush motor starters.

E. 40 hp and larger suitable for adjustable speed, 0 Hz to 60 Hz, with 6-, 12- and 18-pulse inverter drive, variable torque application.

F. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

2.06 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 hp, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:

1. Efficiency:
   a. Tested in accordance with NEMA MG 1, Paragraph 12.59.
   b. Guaranteed minimum at full load in accordance with NEMA MG 1 Table 12-12, Full-load Efficiencies for NEMA Premium Efficiency Electric Motors Rated 600 Volts or Less (Random Wound), or as indicated in motor-driven equipment specification.

2. Power Factor: Guaranteed minimum at full load shall be manufacturer’s standard or as indicated in motor-driven equipment specification.

2.07 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code F or lower, if motor horsepower not covered by NEMA MG 1 tables.

B. Safe Stall Time: 12 seconds or greater.

2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer’s standard winding insulation system.

B. Three-phase and Integral Horsepower Motors: Unless otherwise indicated in motor-driven equipment specification, Class F with Class B rise at nameplate horsepower and designated operating conditions.

2.09 ENCLOSURES

A. Conform to NEMA MG 1.

B. TEFC and TENV: Furnish with drain hole with porous drain/weather plug.
C. Submersible: In accordance with Article Special Motors.

2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for motors.
   1. 40-hp Motors and Larger: 3-inch conduit opening in the bottom.
   3. Fan Motors: Manufacturer’s standard conduit opening.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Except ODP, furnish gaskets between box halves and between box and motor frame.

D. Minimum usable volume in percentage of that specified in NEMA MG 1, Section 1, Paragraph 4.19 and NFPA 70, Article 430:

<table>
<thead>
<tr>
<th>Terminal Box Usable Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Below 600</td>
</tr>
<tr>
<td>Below 600</td>
</tr>
</tbody>
</table>

E. Terminal for connection of equipment grounding wire in each terminal box.

F. Coordinate motor terminal box conduit entries versus size and quantity of conduits shown on Drawings.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:
   1. 3/4 hp and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
   2. 1 hp through 400 hp: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
   3. For Direct Drive Equipment: Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and ABMA 11.
   4. For Belt Driven Equipment: Minimum 30,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and ABMA 11.
B. Vertical Motors:

1. Thrust Bearings:
   a. Antifriction bearing.
   b. Manufacturer’s standard lubrication 100 hp and smaller.
   c. Oil lubricated 125 hp and larger.
   d. Minimum 50,000 hours L-10 bearing life.

2. Guide Bearings:
   a. Manufacturer’s standard bearing type.
   b. Manufacturer’s standard lubrication 200 hp and smaller.
   c. Oil lubricated 250 hp and larger.
   d. Minimum 100,000 hours L-10 bearing life.

C. Regreaseable Antifriction Bearings:

1. Readily accessible, grease injection fittings.
2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:

1. Oil reservoirs with sight level gauge.
2. Oil fill and drain openings with opening plugs.

E. Inverter Duty Rated Motors, Bearing Isolation: Motors larger than 50 hp shall have electrically isolated bearings to prevent stray current damage.

2.12 NOISE

A. Measured in accordance with NEMA MG 1.

B. Motors Controlled by Adjustable Frequency Drive Systems: Shall not exceed 3 dBA higher than NEMA MG 1 across the entire operating range of 0 Hz to 60 Hz.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1, Part 7.

2.14 EQUIPMENT FINISH

A. Protect Motor for Service Conditions:

1. ODP Enclosures: Indoor, nonconditioned, ventilated only atmospheres.
2. Other Enclosures: Outdoor atmospheres, including moisture and direct sunlight exposure.
B. External Finish: Prime and finish coat manufacturer’s standard. Finish color manufacturer’s standard.

C. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL FEATURES AND ACCESSORIES

A. Screen Over Air Openings: Stainless steel on motors with ODP and WPI enclosures meeting requirements for guarded machine in NEMA MG 1, and attached with stainless steel screws.

B. Winding Thermal Protection:

1. Thermostats:
   a. Motors for constant speed application 10 hp up to 100 hp.
   b. Motors for adjustable speed application 40 hp up to 100 hp.
   c. Bi-metal disk or rod type thermostats embedded in stator windings.
   d. Automatic reset contacts rated 120V ac, 5 amps minimum, opening on excessive temperature. (Provide manual reset at motor controller.)

2. Thermistors:
   a. Motors for constant speed application 100 hp and larger.
   b. Motors for adjustable speed application 100 hp and larger.
   c. Thermistor embedded in each stator phase winding before winding dip and bake process.
   d. In intimate contact with winding conductors.
   e. Solid-state thermistor control module for mounting in motor controller cabinet located in a remote location. Control module supplied by motor manufacturer.
   f. Control module rated for 120V ac power supply.
   g. Control module automatically reset contact for external use rated 120V ac, 5 amps minimum, opening on abnormally high winding temperature. Provide manual reset at motor controller. Leads brought to separate motor terminal box.

C. Space Heaters:

1. Provide winding space heaters with leads wired out to same motor terminal box as winding thermal protection.
2. Unless shown otherwise, heater shall be suitable for 120V ac supply, with wattage suitable for motor frame size.
D. Nameplates:
   1. Raised or stamped letters on stainless steel or aluminum.
   2. Display motor data required by NEMA MG 1, Paragraph 10.39 and Paragraph 10.40 in addition to bearing numbers for both bearings.
   3. Premium efficiency motor nameplates to display NEMA nominal efficiency, guaranteed minimum efficiency, full load power factor, and maximum allowable kVAR for power factor correction capacitors.
   4. Separate nameplate indicating motor is Inverter Duty Rated.

E. Anchor Bolts: Provide meeting manufacturer’s recommendations and of sufficient size and number for specified seismic condition.

2.16 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Inverter Duty Motor:
   1. Motor supplied power by adjustable voltage and adjustable frequency drives shall be inverter duty rated in accordance with NEMA MG 1, Parts 30 and 31.
   2. Provide winding insulation rated 1,600 peak volts, minimum.
   3. Meet or exceed NEMA MG 1 corona inception voltage rating.
   4. Suitable for operation over entire speed range indicated.
   5. Provide forced ventilation where speed ratio is greater than published range for motor provided.
   6. Shaft grounding device, motors larger than 50 hp shall be provided with shaft grounding brush or conductive micro fiber shaft grounding ring solidly bonded to grounded motor frame in accordance with manufacturer’s recommendations.
      a. Manufacturers:
         1) Grounding Brush: Sohre Turbomachinery, Inc.
         2) Grounding Ring: EST-Aegis.

C. Submersible Pump Motor:
   1. Manufacturers:
      a. Reliance Electric.
      b. Xylem Flygt Corp.
   2. At 100 Percent Load:
      a. Motors with Speeds Less than 1,200 rpm: Manufacturer’s standard.
b. Motors with Speeds 1,200 rpm and Greater:

<table>
<thead>
<tr>
<th>Horsepower</th>
<th>Guaranteed Minimum Efficiency</th>
<th>Guaranteed Minimum Power Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 through 10</td>
<td>80</td>
<td>82</td>
</tr>
<tr>
<td>10.1 through 50</td>
<td>85</td>
<td>82</td>
</tr>
<tr>
<td>50.1 through 100</td>
<td>87</td>
<td>82</td>
</tr>
<tr>
<td>Over 100</td>
<td>89</td>
<td>82</td>
</tr>
</tbody>
</table>

3. Insulation System: Manufacturer’s standard Class B or Class F.

4. Motor capable of running dry continuously.

5. Enclosure:
   a. Hermetically sealed, watertight, for continuous submergence up to 65-foot depth.
   b. Listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous atmosphere.
   c. Seals: Tandem mechanical.

6. Bearing and Lubrication:
   a. Permanently sealed and lubricated, replaceable antifriction guide and thrust bearings.
   b. Minimum 15,000 hours L-10 bearing life.

7. Inrush kVA/horsepower no greater than NEMA MG 1 and NFPA 70, Code F.

8. Winding Thermal Protection:
   a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
   b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
   c. Switch contacts rated at 5 amps, 120V ac.

9. Motor Seal Failure Moisture Detection:
   a. Probes or sensors to detect moisture beyond seals.
   b. Probe or sensor monitoring module for mounting in motor controller, suitable for operation from 120V ac supply.
   c. Monitoring module with control power transformer, probe test switch and test light, and two independent 120V ac contacts, one opening and one closing when flux of moisture is detected.
10. Bearing Overtemperature Protection for Motors Larger than 100 hp:
   a. Sensor on lower bearing housing monitoring bearing temperature.
   b. Any monitoring relay necessary to provide 120V ac contact opening on bearing overtemperature.
11. Winding thermal protection, moisture detection, and bearing overtemperature specified above may be monitored by single device providing two independent 120V ac contacts, one closing and one opening on malfunction.
12. Connecting Cables:
   a. One cable containing power, control, and grounding conductors.
   b. Cable suitable for hard service, submersible duty with watertight seal where cable enters motor.
   c. Length: 30 feet minimum.
   d. UL 83 listed and sized in accordance with NFPA 70.

2.17 FACTORY TESTING

A. Tests:
   1. In accordance with IEEE 112 for polyphase motors.
   2. Routine (production) tests in accordance with NEMA MG 1. Test multispeed motors at all speeds.
   3. For energy efficient motors, test efficiency and power factor at 50 percent, 75 percent, and 100 percent of rated horsepower:
      b. On motors of 100 hp and smaller, furnish certified copy of motor efficiency test report on an identical motor.
   4. Provide certified test reports for all polyphase motors 100 hp and larger.

B. Test Report Forms:
   2. Efficiency and power factor by Test Method B, IEEE 112, Form A-2, and NEMA MG 1, Table 12-12.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer’s instructions and recommendations.

B. Align motor carefully and properly with driven equipment.
C. Secure equipment to mounting surface with anchor bolts.

3.02 MANUFACTURER’S SERVICES

A. Furnish manufacturer’s representative at Site in accordance with Section 01 43 33, Manufacturers’ Field Services, for installation assistance, inspection, equipment testing, and startup assistance for motors larger than 100 hp.

B. Manufacturer’s Certificate of Proper Installation.

END OF SECTION
SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

2. Institute of Electrical and Electronics Engineers (IEEE): C57.96, Guide for Loading Dry Type Transformers.
3. National Electrical Contractor’s Association (NECA): 409, Recommended Practice for Installing and Maintaining Dry-Type Transformers.
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ST 20, Dry-Type Transformers for General Applications.
6. UL:
   a. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   b. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 1561, Standard for Dry-Type, General Purpose, and Power Transformers.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensions and weight.
3. Transformer nameplate data, including efficiency.
4. Schematic and connection diagrams.
5. Anchorage and bracing drawings and cut sheets as required by Section 26 05 02, Basic Electrical Requirements.
B. Informational Submittals:

1. Test Report: Sound test certification for dry type power transformers (0 volt to 600 volt, primary).
2. Anchorage and bracing calculations as required by Section 26 05 02, Basic Electrical Requirements
3. Component and attachment testing seismic certificate of compliance.

PART 2 PRODUCTS

2.01 GENERAL

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Dry-type, self-cooled, two-winding, with copper windings.

C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Efficiency: Meet or exceed DOE 2016 efficiency requirements.

E. Maximum Sound Level per NEMA ST 20:

1. 40 decibels for 0 kVA to 9 kVA.
2. 45 decibels for 10 kVA to 50 kVA.
3. 50 decibels for 51 kVA to 150 kVA.
4. 55 decibels for 151 kVA to 300 kVA.
5. 60 decibels for 301 kVA to 500 kVA.

F. Overload Capability: Short-term overload per IEEE C57.96.

G. Wall Bracket: For single-phase units, 15 kVA to 37-1/2 kVA, and for three-phase units, 15 kVA to 30 kVA.

H. Vibration Isolators:

1. Rated for transformer’s weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.
I. Manufacturers:
   1. General Electric Co.
   2. Square D Co.

2.02 MINI-POWER CENTER (MPC)
A. General: Transformer, primary, and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 4X, Type 316 stainless steel enclosure.

B. Transformer:
   1. Insulation Class and Temperature Rise: Manufacturer’s standard.
   2. Efficiency: Manufacturer’s standard (DOE 2016 efficiency).
   3. Core and Coil: Encapsulated.
   4. Full capacity, 5 percent voltage taps, two below normal voltage.
   5. Primary Voltage: 480, three-phase.

C. Panelboard: Full, UL 489, short-circuit current rated.
   1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
   2. Number and Breaker Ampere Ratings: Refer to Panel Schedule.

2.03 GENERAL PURPOSE TRANSFORMER
A. Insulation Class and Temperature Rise: Manufacturer’s standard.

B. Core and Coil:
   1. Fully encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
   2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

C. Enclosure:
   1. Single-Phase, 3 kVA to 25 kVA: NEMA 250, Type 3R, nonventilated.
   2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
   3. Three-Phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
   4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
   5. Outdoor Locations: NEMA 250, Type 3R.
D. Voltage Taps:

1. Single-Phase, 3 kVA to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
3. Three-Phase, 3 kVA to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

E. Impedance: 3 percent minimum on units 75 kVA and larger.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with NECA and manufacturer’s instructions.

B. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

C. Provide moisture-proof, flexible conduit for electrical connections.

D. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

E. Provide wall brackets for single-phase units, 15 kVA to 167-1/2 kVA, and three-phase units, 15 kVA to 30 kVA.

END OF SECTION
PART 1    GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   c. KS 1, Enclosed Switches.
   d. PB 1, Panelboards.
   e. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
4. UL:
   a. 67, Standard for Panelboards.
   b. 98, Standard for Enclosed and Dead-Front Switches.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
   g. 943, Ground-Fault Circuit-Interrupters.
   h. 1699, Standard for Arc-Fault Circuit-Interrupters.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s data sheets for each type of panelboard, protective device, accessory item, and component.
2. Manufacturer’s shop drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.
3. Tabulation of features for each panelboard to include the following:
   a. Protective devices with factory settings.
   c. Space for future protective devices.
   d. Voltage, frequency, and phase ratings.
e. Enclosure type.
f. Bus and terminal bar configurations and current ratings.
g. Provisions for circuit terminations with wire range.
h. Short circuit current rating of assembled panelboard at system voltage.
i. Features, characteristics, ratings, and factory settings of auxiliary components.
j. Anchorage and bracing drawings and cut sheets, as required by Section 26 05 02, Basic Electrical Requirements.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 26 05 02, Basic Electrical Requirements.
2. Manufacturer’s recommended installation instructions.
3. Component and attachment testing seismic certificate of compliance.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by UL shall conform to those standards and shall have an applied NRTL Listing or Labeling mark.

1.04 EXTRA MATERIALS

A. Extra Materials: Furnish, tag, and box for shipment and storage the following special tools and material:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch-up paint for panelboards</td>
<td>One half-pint container</td>
</tr>
<tr>
<td>Special tools required to maintain</td>
<td>One complete set</td>
</tr>
<tr>
<td>or dismantle</td>
<td></td>
</tr>
</tbody>
</table>
PART 2  PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

2. General Electric Co.
3. Square D Co.
4. Siemens.

B. Panelboards shall be of the same manufacturer as equipment furnished under Section 26 14 13, Low-Voltage Switchboards, and Section 26 24 19, Low-Voltage Motor Control.

2.02 GENERAL

A. Provide low-voltage panelboards for application at 600V or less in accordance with this section.

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. Wire Terminations:

1. Provide panelboard assemblies, including protective devices, suitable for use with 75 degrees C or greater wire insulation systems at NFPA 70, 75 degrees C conductor ampacity, and in accordance with UL 486E.
2. Lugs for termination of copper feeder phase and neutral conductors shall be replaceable, bolted mechanical or crimp compression type.

D. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated “continuous” or “100 percent”, selected components and protective devices shall be rated for continuous load current at value shown.
E. Short Circuit Current Rating (SCCR): Fully rated short circuit rating for each panelboard assembly shall be no less than the following:

1. Minimum SCCR at 208Y/120 or 120/240 volts shall be 10,000 amperes rms symmetrical.
2. Minimum SCCR at 480Y/277 volts shall be 14,000 amperes rms symmetrical.
3. As indicated on Drawings and in the Panelboard Schedules.

F. Series-Connected Short Circuit Current Ratings: Panelboards shall be fully rated; application of series-connected device ratings is unacceptable.

### 2.03 OVERCURRENT PROTECTIVE DEVICES

A. Overcurrent Device Mounting and Arrangement: Design panelboards to accommodate device installation and replacement without disturbing adjacent devices and without removing main bus.

B. Overcurrent Protective Devices: In accordance with NEMA KS 1, UL 98, and UL 489. Protective devices shall be adapted to panelboard installation.

C. Provisions for Future Overcurrent Device:

1. Provide space, mountings and bus connections such that like device may be installed without additional hardware.
2. Panel openings shall be closed with individual removable cover for each provision for future device.
3. Unless otherwise indicated, “spaces” in panelboards shall be fully equipped provision for future like devices.
4. Provisions for future devices shall be suitable devices rated no less than 60 amperes.

D. Protective Device Locking: Furnish provisions for handle padlocking for main, subfeed, and branch devices in all cases.

E. Branch Protective Devices:

1. Provide Wire Lug Load Connections: Mechanical or crimp compression type, removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch nor conductor ampacity.
2. Provide a nameplate for each circuit, blanks for spares.
2.04 CIRCUIT BREAKERS

A. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle. Circuit breakers shall comply with Section 26 05 04, Basic Electrical Materials and Methods.

B. Bus Connection: Bolt-on circuit breakers in all panelboards.

C. Trip Mechanism:
   1. Individual permanent thermal and magnetic trip elements in each pole.
   2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
   3. Two and three pole, common trip.
   4. Automatically opens all poles when overcurrent occurs on one pole.
   5. Test button on cover.
   6. Calibrated for 40 degrees C ambient, unless shown otherwise.

D. Unacceptable Substitution:
   1. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
   2. Do not use tandem or dual circuit breakers in normal single-pole spaces.
   3. Do not use three-pole devices for the protection of two-pole or single-pole circuits.

E. Specialty Breakers: Where indicated, provide breakers with the following features:
   1. Ground Fault Circuit Interrupter (GFCI): Rated to trip on 4 mA to 6 mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel). Ground fault sensor shall be rated same as circuit breaker. Breaker shall include push-to-test and reset buttons.
   2. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).
   3. Arc Fault Circuit Interrupter (AFCI): Where indicated, equip breaker with arc fault sensor to detect and trip the circuit breakers when an arcing fault occurs (UL 1699 listed).
   4. Heating and Air Conditioning Rated (HACR): Where indicated, provide breaker UL listed for the protection of such equipment.
   5. Switching Duty (SWD) Rated: Where indicated, provide breaker UL listed for frequent switching of lighting and other branch circuit loads.
F. Solid State Trip Units: Where indicated, equip breakers with solid state trip units in accordance with Section 26 14 13, Low-Voltage Switchboards.
   1. Long (Time) Short (Time) Instantaneous (LSI): Electronic trip unit with fixed long-time trip, adjustable short-time trip and delay, and adjustable instantaneous trip settings.
   2. Long (Time) Short (Time) Instantaneous Ground (Fault) (LSIG): Electronic trip unit as above and also with adjustable ground fault trip and delay settings.

2.05 ENCLOSURES

A. General:
   1. Provide as specified in Section 26 05 04, Basic Electrical Materials and Methods.
   2. Type 1 Gasketed, Type 3R, and Type 3S material code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
   3. Type 4 and Type 4X material to be Type 304 stainless steel.
   4. Provide surface-mount panelboard from trim with same dimensions as box front.

B. Finish: Rust inhibitor prime followed by manufacturer’s standard gray baked enamel or lacquer. NEMA Type 1 gasketed enclosure box may be unfinished galvanized sheet steel.

C. NEMA 250 Type 1 Branch Panelboard Enclosure:
   1. Secure front trim to box with concealed trim clamps.
   2. Overlap flush panelboards front trims with box nominal 3/4 inch on all sides.
   3. Provide door in panelboard front trim, with concealed hinges, to access protective device operating handles.
   4. Provide multi-point latching for doors over 30 inches in height.
   5. Door Lock: Secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
   6. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.
2.06 BUSSING AND TERMINAL BARS

A. Bus:
   1. Material: Tin-plated copper full sized throughout length.
   2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.

B. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors and bonded to box.
   1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
   2. Provide individual termination points for all other grounding conductors such as feeder, grounding electrode, etc.
   3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.

C. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.
   1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
   2. Provide individual termination points for all other neutral conductors.
   3. Termination Points: Bolted crimp compression lugs for conductors 6 AWG and larger.

D. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

2.07 SPECIAL FEATURES

A. General: Where indicated on Drawings or schedules, provide special features as specified.

B. Service Equipment Approval: Listed for use as service equipment for panelboards having service disconnecting means. Include separate panel label indicated ‘SE Rated’.

C. Subfeed Lugs: Protective device or lugs indicated, with additional terminals on neutral and ground bus to accommodate feeder.
D. Feed-Through Lugs: At opposite end of phase bus from mains, with additional terminals on neutral and ground buses, sized to accommodate feeders indicated.

E. Surge Protective Devices:
   1. As indicated on Drawings.
   2. Provide factory mounted within panelboard utilizing UL-recognized mounting device.
   3. SPD shall be as manufactured by Surge Suppression, Inc. (SSI). No exceptions or substitutions.

F. Fire Alarm Circuits: Identify all branch circuits feeding fire detection and alarm panels and equipment with a red, engraved to white core, plastic nameplate attached to the individual branch circuit breakers. Engrave nameplates with “FIRE ALARM CIRCUIT”.

PART 3 EXECUTION

3.01 GENERAL

A. Install in accordance with NECA 407, NEMA PB 1.1, and manufacturers’ written installation instructions.

B. Install securely, plumb, in-line and square with walls.

C. Install top of cabinet trim 78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.

D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

E. Install filler plates in unused spaces.

F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle and wrap with nylon wire ties.

G. Mount flush panels uniformly flush with wall finish.

H. Provide typewritten circuit directory for each panelboard.

I. Provide engraved identification for each protective device.

END OF SECTION
SECTION 26 24 19
LOW-VOLTAGE MOTOR CONTROL

PART 1   GENERAL

1.01 REFERENCES

A. The following is a list of standards which shall be followed for this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 volts maximum).
   b. ICS 1, Industrial Control and Systems: General Requirements.
   c. ICS 2, Controllers, Contactors, and Overload Relays Rated 600 Volts.
   d. ICS 2.3, Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600V.
   e. ICS 18, Motor Control Centers.
   f. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
5. UL:
   a. 98, Enclosed and Dead-Front Switches.
   b. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 845, Motor Control Centers.

1.02 DEFINITIONS

A. CT: Current Transformer.
B. FVNR: Full Voltage, Non-Reversing.
C. LCD: Liquid Crystal Display.
D. N.C.: Normally Closed.
E. N.O.: Normally Open.
F. SPD: Surge Protection Device.

G. VT: Voltage Transformer.

1.03 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Itemized Bill of Material.
3. Dimensional drawings.
4. Front Panel Elevations.
5. Conduit entrance locations.
8. Operational description.
9. Anchorage and bracing drawings and cut sheets as required by Section 26 05 02, Basic Electrical Requirements.
10. Anchoring instructions and details as required by Section 26 05 02, Basic Electrical Requirements.
11. Typed Tabulation:
   a. Motor name; tag (equipment) numbers as shown on Drawings.
   b. Motor horsepower.
   c. Nameplate full load current.
   d. Measured load current and voltage.
   e. Overload model number and setting.
   f. Protective device trip settings.
   g. Manufacturer’s solid state starter switch or dip switch or program settings.
   h. Attach above typed, tabulated data to a copy of starter manufacturer’s overload relay or setting selection tables for starters provided.
13. One-line diagrams.
15. Outline diagrams.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 26 05 02, Basic Electrical Requirements.
2. Manufacturer’s installation instructions.
3. Factory test reports, certified.
4. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
1.04 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by UL shall conform to those standards and shall have an applied NRTL Listing or Labeling mark.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping Splits: Established by Contractor to facilitate ingress of equipment to final installation location within building.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

2. GE Industrial Systems.
3. Schneider Electric/Square D.
4. Siemens.

2.02 GENERAL

A. Like Items of Equipment: End product of one manufacturer and same manufacturer as low voltage switchboard and panelboards for standardization.

B. Make adjustments necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors actually provided under this Contract.

C. Controllers: NEMA ICS 1, NEMA ICS 2, Class A.

D. Control Transformer:

1. Dedicated control power transformer for each motor controller located in each controller compartment.
2. Two winding, 120-volt secondary, primary voltage to suit.
3. Two current-limiting fuses for primary circuit.
4. One fuse in secondary circuit with blown fuse indicator.
5. Mount within starter unit.
6. Minimum size: 500VA.

E. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

F. Lifting lugs on equipment and devices weighing over 100 pounds.

G. Anchor Bolts: Type 316 stainless steel, minimum 1/2-inch diameter.

H. Seismic Zone and Importance Factor: As specified in Section 26 05 02, Basic Electrical Requirements.

I. Operating Conditions:
   1. Ambient Temperature: Maximum 40 degrees C.
   2. Altitude: 1,000 feet MSL.
   3. Equipment to be fully rated.

J. Enclosures: In accordance with NEMA 250.

K. Equipment Finish:
   1. Electrocoating process applied over rust-inhibiting phosphated base coating.
   2. Exterior Color: ANSI No. 61, Sky Blue Grey.

2.03 MOTOR CONTROL CENTERS

A. General:
   1. In accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 18, and UL 845.
   3. Short Circuit Rating: Amperes rms symmetrical at 480 volts or 208 volts for entire motor control center as a complete assembly as indicated on Drawings.
   4. Main and branch circuit breakers, controllers, wire connections, and other devices to be front mounted and accessible, unless otherwise noted.
   5. NEMA ICS 18, Part 3.
      a. Class: I.
      b. Type: B.
      c. Provide blank spaces on interconnection diagrams to add control conductor code designations during installation of equipment.
B. Enclosure:

1. Type: NEMA 250 Type 1, indoor gasketed.
2. Vertical Section Standard Indoor Dimensions for NEMA 1 Gasketed:
   a. Nominal, 90 inches high, 20 inches wide, 21 inches deep.
   b. Alternative width dimensions of 24 inches and 30 inches are acceptable for oversize devices or panels.
   c. Do not exceed space shown.
3. Construction:
   a. Sheet steel reinforced with channel or angle irons.
   b. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
   c. Removable top cover plates and bottom cover plates.
4. Section Mounting: Removable formed-steel channel sills and lifting angles to meet specified seismic requirements.
5. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
6. Vertical Wiring Compartment:
   a. Full height, isolated from unit starters with separate hinged door and tie supports.
   b. No terminal blocks allowed in vertical wireway compartment.
7. Terminal board compartment at unit space indicated with 20 percent spare terminals.
8. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.
9. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.
10. Door Interlocking: Mechanically interlock starter and feeder doors so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access and energizing at any time by qualified individual.
11. External disconnect handles with ON/OFF and trip positions showing, padlockable in OFF position with up to three-lock capability.
12. Cable Entrance: Main leads enter from bottom; control and feeder circuits enter from top.
13. Provide two permanent storage pockets on the exterior of the enclosure for the storage of drawings and manuals.

C. Bus:

1. Horizontal Power Bus:
   a. Three-phase tin-plated copper entire width of control center, rated as indicated on Drawings.
   b. Tin or silver-plated at joints.
c. Construct to allow future extension of additional sections.
d. Pressure type solderless lugs for each incoming line cable.
e. Isolated from top horizontal wireway.
f. Provide Belleville washers on bus connection bolts.

2. Vertical Power Bus:
   a. Three-phase tin-plated copper full height of section, rated 300 amperes.
   b. Tin-plated at joints.
   c. Sandwich type bus insulation providing deadfront construction with starter units removed except for bus stab openings.
   d. Insulated and isolated barrier, complete with automatic shutters over stab openings.
   e. Provide Belleville washers on bus connection bolts.

3. Neutral Bus:
   a. 50 percent neutral entire width of control center.
   b. Tin-plated copper.
   c. Provide Belleville washers on bus connection bolts.

4. Ground Bus:
   a. Copper, bare rated 300 amperes, entire width of control center and in each vertical wireway.
   b. Provide Belleville washers on bus connection bolts.

5. Bus Bracing: As indicated on Drawings.

D. Motor Controller Unit:

1. Provide indicated individual components and control devices including pushbuttons, selector switches, indicating lights, control relays, time delay relays, and elapsed time meters as specified in Section 26 05 04, Basic Electrical Materials and Methods.

2. Construction:
   a. Drawout combination type with stab connections for starters NEMA ICS, Size 5 and smaller.
   b. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 6 and larger.
   c. Readily interchangeable with starters of similar size.
   d. Pull-apart unit control wiring terminal boards capable of accepting up to two No. 14 AWG wires minimum on all units.

3. Starters, Full Voltage, Nonreversing:
   a. NEMA ICS 18, standard rating, except none smaller than NEMA ICS, Size 1.
   b. Rating: Horsepower rated at 600 volt, NRTL labeled SIC as shown on Drawings, at 480 volts or 208 volts with overload protection.
   c. Three-phase, FVNR, unless specified otherwise.
   d. Disconnect Type: Motor circuit protector.
e. Combination Full Voltage, Magnetic Starter:
   1) Control: As shown on Drawings.
   2) Pilot Lights: Red–ON and Green–OFF.

f. Combination Reduced Voltage, Solid State Starter:
   1) Control: As shown on Drawings.
   2) Eaton +S811-xxxP3S, “or-equal.”
   3) Bypass contactor.
   4) Class 10/20/30 electronic overload relay, switch, or dip switch selectable.
   5) Kick start, with adjustable torque and time settings.
   6) Ramp start, selectable current or torque, and adjustable time.
   7) Smooth stop ramp, adjustable time.
   8) Phase loss unbalance and phase reversal protection.
   9) LED display or LCD of fault, N.O. contact to communicate fault condition.

g. Combination Adjustable Frequency Drive, Solid State Starter:
   Drives as specified in Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

h. Communications: None.

i. Padlockable operating handle when de-energized with up to three-lock capability.

j. Unit door interlocked to prevent opening when disconnect is in closed position.

k. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.

l. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.

4. Disconnecting Device:
   a. As indicated on Drawings.
   b. Padlockable in OPEN position for up to three locks.

5. Circuit Breaker:
   a. Meet requirements of UL 489.
   b. Molded case with manufacturer’s recommended trip setting for maximum motor protection.
   c. Thermal-magnetic trip.
   d. Tripping indicated by operating-handle position.
   e. Interrupting capacity required for connection to system with short-circuit capacity indicated.

6. Solid State Motor Overload Protection:
   a. Inverse-time-limit characteristic.
   b. Phase loss, phase unbalance and Class II ground fault protection.
   c. Current operated electronic circuitry with adjustable trip.
   d. Class 10/20/30 relay trip, switch selectable.
   e. One N.O. auxiliary contact for remote monitoring.
g. Provide in each ungrounded phase.
h. Mount within starter unit.
i. Communications: None.


8. Ground Fault Protection: Where indicated and as specified in Paragraph Main Protective Device and Feeder Units, except provide instantaneous operation device.

E. Control Unit:

1. Disconnecting Device: Pull-apart terminal blocks capable of de-energizing external source control circuits in unit.
2. Control Devices: As indicated and as specified in Section 26 05 04, Basic Electrical Materials and Methods.
3. Control Wiring:
   a. Copper, 14 AWG, minimum.
   b. Permanent sleeve type markers with wire numbers applied to each end of wires.
   c. Terminate wires using insulated locking fork or ring type crimp terminals.
   d. Terminate current transformer leads on shorting type terminal blocks.

F. Incoming Line Terminal:

1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable and as shown on Drawings.
3. Mechanical type CU-/AL lugs for 75 degrees C cable.

G. Main Protective Device and Feeder Unit:

1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable.
3. Instantaneous Trip Mode Selector Switch: Provide switch on main circuit breaker for bypassing long and short time trip settings, and lowered instantaneous trip settings for incident energy reduction during maintenance. In addition, provide the following:
   a. Mode Status Light.
   b. Output contact, rated 5A at 120V ac, for remote Mode status to Plant Control System.
4. Solid State Trip Circuit Breaker:
   a. In accordance with UL 489.
   b. Main and feeder protective device.
c. NRTL labeled as suitable for service entrance where indicated on Drawings.
d. Insulated or molded case breakers with ambient insensitive solid-state trips and having current sensors and logic circuits integral in breaker frame.
e. Solid-state current control with adjustable ampere setting, adjustable long-time delay, adjustable short-time trip and delay band, fixed or adjustable instantaneous trip, and adjustable ground fault trip and delay band.
f. Setting adjustments to be covered by a sealable, tamper-proof, transparent cover (insulated case breakers only) or by compartment door for other breakers).
g. Locate trip button on front cover of breaker to permit mechanical simulation overcurrent tripping for test purposes and to trip breaker quickly in emergency situation.

5. Molded Case Circuit Breaker:
   a. In accordance with UL 489.
b. Main and feeder protective device where indicated on Drawings.
c. NRTL labeled as suitable for service entrance where indicated on Drawings.
d. Thermal-magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
e. Indicate tripping by operating-handle position.
f. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.

6. Ground Fault Protection:
   a. Suitable for 480-volt or 208-volt, three-phase, four-wire solidly grounded wye system.
b. Ground sensors to encircle phase conductors and neutral conductor where used, and connected to ground relays with adjustable pickup settings and time-current characteristics indicated.
c. Circuit breaker shunt trip and relay operating from fused 120V ac control source within control center.
d. Manufacturers:
   1) Cutler-Hammer.
   2) General Electric.

7. Key Interlocking:
   a. Mechanical lock cylinders within breaker compartments when indicated on Drawings.
b. Keys to be captive when breakers are closed.
c. Two main breaker arrangements.
H. Digital Instruments:

1. Digital Power Meter: As specified in Section 26 09 13, Power Measurement and Control.
2. Digital Monitoring Panel:
   a. Microprocessor-based electronic monitoring package, complete with keypad or entry keys.
   b. Monitors and Display Parameters for MCC Starters and Contactors:
      1) Status: ON, OFF, tripped, no response.
      2) Location or address.
      3) Control voltage.
      4) Overload alarm.
      5) Cause of device trip.
      6) Operations count.
      7) Run time.
      8) Set points.
      9) Starter description and identification.
   c. Alpha numeric, LED display or LCD.
   d. Communications: Interface capability to starters, power meter, and computer.
   e. Manufacturers:
      1) Cutler-Hammer.
      2) General Electric.

3. Ground Detection Lights: Heavy-duty oiltight type, with operation explanation nameplate.

I. Surge Protective Devices:

1. As indicated on Drawings.
2. Provide factory mounted within motor control center utilizing NRTL-recognized mounting device.
3. SPD shall be as manufactured by Surge Suppression, Inc. (SSI). No exceptions or substitutions.

J. Pushbuttons, Indicating Lights, Selector Switches, Elapsed Time Meters, Control Relays, Time-Delay Relays, and Reset Timers: As specified in Section 26 05 04, Basic Electrical Materials and Methods.

K. Nameplates:

1. As specified in Section 26 05 02, Basic Electrical Requirements.
2. Provide for each motor control center and each unit.
3. Engrave with inscription shown on single-line diagram.
4. Provide blank nameplates on spaces for future units.
5. Attach with stainless steel panhead screws on face of control center.

L. Space Heaters: Thermostatically controlled. Locate in bottom of each vertical section for operation from 120-volt power source derived internal to MCC.

2.04 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Applicable Standards: NEMA ICS 18, UL 845, and NEC Article 430, Part VIII.
2. Perform standard factory inspection and tests in accordance with NEMA requirements to verify components have been designed to Specification, assembled in accordance with applicable standards, and each unit functions in accordance with electrical diagrams.
3. Actual operation shall be performed wherever possible. Otherwise, inspect and perform continuity checks.
4. Verify component devices operated correctly in circuits as shown on diagrams or as called for in Specification.
5. Control Circuits and Devices:
   a. Energize circuit at rated voltage.
   b. Operate control devices.
   c. Perform continuity check.
6. Instruments, Meters, Protective Relays, and Equipment:
   a. Verify devices functioned by energizing potential to rated values with connection to devices made at outgoing terminal blocks.
   b. Verify protective relays operated for functional checks and trips manually initiated to verify functioning of operation for indicator and associated circuits.
7. Perform dielectric tests on primary circuits and equipment, except potential transformers.
   a. Tests: Phase-to-phase and phase-to-around with 60-cycle test voltages applied for 1 second at 2,640 volts.
8. Verify equipment passed tests and inspection.
9. Provide standard factory inspection and test checklists, and final certified and signed test report.
PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install equipment in accordance with NEMA ICS 2.3, IEEE C2, NECA 402, Submittals, and manufacturer’s written instructions and recommendations.
   2. Secure equipment to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.
   3. Install equipment plumb and in longitudinal alignment with pad or wall.
   4. Coordinate terminal connections with installation of secondary feeders.
   5. Grout mounting channels into floor or mounting pads.
   6. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer’s recommendations.
   7. Motor Data: Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:
      a. Motor served by tag number and equipment name.
      b. Nameplate horsepower.
      c. Motor code letter.
      d. Full load amperes.
      e. Service factor.
      f. Installed overload relay catalog number.

B. Circuit Breakers:
   1. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.
   2. Adjust to approximately 11 times motor rated current.
   3. Determine motor rated current from motor nameplate following installation.

C. Solid State Overload Relay: Select and install overload relay and apply settings based upon actual full-load current of motor.

3.02 MANUFACTURER’S SERVICES

A. Furnish manufacturer’s representative in accordance with Section 01 43 33, Manufacturers’ Field Services, for the following services at Job Site or classroom as designated by Owner for minimum person-days listed below, travel time excluded:
   1. 1 person-day for installation assistance, and inspection of installation.
   2. 1 person-day for functional and performance testing.
3. 1 person-day for plant startup.
4. 1 person-day for training of Owner’s personnel.

END OF SECTION
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

2. Federal Specifications (FS):
   b. W-S-896F, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
3. Institute of Electrical and Electronic Engineers, Inc. (IEEE):
   a. C62.41.2, Recommended Practice on Characterization of Surges in Low-Voltage (1,000V and less) AC Power Circuits.
   b. C62.45, Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1,000V and less) AC Power Circuits.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. FB 11, Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations.
   c. WD 1, General Color Requirements for Wiring Devices.
   d. WD 6, Wiring Devices – Dimensional Specifications.
7. UL:
   b. 508, Standard for Safety for Industrial Control Equipment.
   e. 1436, Standard for Safety for Outlet Circuit Testers and Similar Indicating Devices.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer’s product data for wiring devices.
PART 2      PRODUCTS

2.01      SWITCHES

A.  Switch, General Purpose:

1.  NEMA WD 1 and FS W-S-896F.
2.  Totally enclosed, ac type, with quiet tumbler switch and screw terminal.
3.  Rivetless one-piece brass or copper alloy contact arm with silver alloy contact.
4.  Capable of controlling 100 percent tungsten filament, fluorescent and LED lamp loads.
6.  Automatic grounding clip and integral grounding terminal on mounting strap.
7.  Special Features:
   a.  Provide the following features in comparable devices where indicated:
      1)  Three-way and four-way.
      2)  Locator, illuminated operator.
8.  Manufacturers and Products, Industrial Grade:
   a.  Cooper Arrow Hart; AH1220 Series.
   b.  Bryant; 4901 Series.
   c.  Hubbell; 1221 Series.
   d.  Leviton; 1221 Series.

B.  Switch, Motor Rated:

1.  Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
2.  UL 508 listed.
3.  Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts.
4.  Minimum General Purpose Rating: 30 amperes, 600V ac.
5.  Minimum Motor Ratings:
   a.  2 hp for 120V ac, single-phase, two-pole.
   b.  3 hp for 240V ac, single-phase, two-pole.
   c.  15 hp for 480V ac, three-phase, three-pole.
6.  Screw-type terminal.
7.  Manufacturers and Products:
   a.  Cooper Arrow Hart.
   b.  Hubbell Bryant; HBL78 Series.
   c.  Leviton.
2.02 RECEPTACLES

A. Receptacle, General Purpose:

1. NEMA WD 1 and FS W-C-596G.
2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
3. Impact resistant nylon cover and body, with finder grooves in face, unless otherwise indicated.
4. One-piece mounting strap with integral ground contact (rivetless construction).
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps unless otherwise indicated.
7. Size: For 2-inch by 4-inch outlet box.
8. Special Features:
   a. Provide the following features in comparable devices where indicated:
      1) Listed weather-resistant per NEC 406.8 for installation in damp or wet locations.
      2) Listed Class A, 4 mA to 6 mA GFCI. See Paragraph Receptacle, Ground Fault Circuit Interrupter below.

9. Industrial Grade Manufacturers and Products:
   a. Cooper Arrow Hart; 5362 Series.
   b. Hubbell Bryant; HBL5362 Series.
   c. Leviton; 5362 Series.

B. Receptacle, Ground Fault Circuit Interrupter:

1. Meet requirements of general-purpose receptacle.
2. Listed Class A to UL 943, tripping at 4 mA to 6 mA.
3. Rectangular smooth face with push-to-test and reset buttons.
4. Listed weather-resistant per NEC 406.8 when installed in damp or wet locations.
5. Feed-through Capability: 20 amps.
6. Manufacturers and Products:
   a. Hubbell Bryant; GFTR20 Series.
   b. Cooper Arrow Hart WRVGF20 Series.
   c. Leviton; 7899 Series.

C. Receptacle, Special-Purpose: Rating and number of poles as indicated or required for anticipated purpose. As indicated on Drawings.
2.03 TELEPHONE AND DATA JACK

A. Compatible with Category 6 cable, and backwards compatible with Category 5 and Category 5e.

   1. High-impact thermoplastic body.
   2. Termination Type:
      a. IDC with pair separation towers.
      b. Compatible with 110-style termination tool.
   3. Snap-on cap to secure connections.
   4. Listed UL 1863.
   5. Manufacturers and Products:
      a. Hubbell; HXJ6 Series.
      b. Leviton; 61110 Series.

2.04 DEVICE PLATES

A. Sectional type plate not permitted.

B. Nylon:

   1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
   2. Color: To match associated wiring device.
   3. Mounting Screw: Oval-head metal, color matched to plate.

C. Stainless Steel:

   1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
   3. Mounting Screw: Oval-head, finish matched to plate.

D. Cast Metal:

   1. Material: Copper-free aluminum.
   2. Screw: Oval-head stainless steel.

E. Weatherproof:

   1. Receptacle, Weatherproof Type 1:
      a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
      b. Mounting Screw and Cap Spring: Stainless steel.
c. Manufacturers and Products:
   1) Crouse-Hinds; Type WLRD-1.
   2) Appleton; Type FSK-WRD.

2. Receptacle, Weatherproof Type 2:
   a. UL listed for wet location while in use.
   b. Die cast metal cover.
   c. Locking type.
   d. Manufacturer and Product: TayMac; Type Multi-Mac.

3. Switch:
   a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
   b. Mounting Screw: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; DS-181 or DS-185.
      2) Appleton; FSK-1VTS or FSK-1VS.

2.05 FINISHES

A. Wiring device catalog numbers specified in this section do not designate device color. Unless otherwise indicated, or required by code, provide colors as specified below, or as required by Drawings.

B. Wiring Device:

   1. All Areas: Grey.

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

A. Comply with NECA 1.

B. Coordination with Other Trades:

   1. Ensure device and its box are protected. Do not place wall finish materials over device box and do not cut holes for box with router that is guided by riding against outside of box.
   2. Keep outlet box free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate raceway system, conductors, and cables.
   3. Install device box in brick or block wall such that cover plate does not cross a joint, unless otherwise indicated. Where indicated or directed to cross joint, trowel joint flush with face of wall.
   4. Install wiring device after wall preparation, including painting, is complete.
C. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

D. Device Installation:
   1. Replace devices that have been in temporary use during construction or that show signs they were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches (150 mm) in length.
   5. Use torque screwdriver when a torque is recommended or required by manufacturer.
   6. When conductors larger than 12 AWG are installed on 15-amp or 20-amp circuits, splice 12 AWG pigtails for device connections.
   7. Tighten unused terminal screws on device.
   8. Device Plates:
      a. Do not use oversized or extra deep plate.
      b. Repair wall finishes and remount outlet box when standard device plate does not fit flush or does not cover rough wall opening.

3.02 SWITCH INSTALLATION

A. Switch, General Purpose:
   1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
   2. Install with switch operation in vertical position.
   3. Install single-pole, two-way switch such that toggle is in up position when switch is on.

B. Switch, Motor Rated:
   1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
   2. Install with switch operation in vertical position such that toggle is in up position when ON.
   3. Install within sight of motor when used as disconnect switch.
3.03 RECEPTACLE INSTALLATION

A. Duplex Receptacle:

1. Install with grounding slot up, except where horizontal mounting is shown, in which case install with neutral slot up.
2. Ground receptacle to box with grounding wire only.
3. Weatherproof Receptacle:
   a. Install in cast metal box.
   b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.
5. Special-Purpose Receptacle: Install in accordance with manufacturer’s instructions.

3.04 DEVICE PLATE INSTALLATION

A. Securely fasten to wiring device; ensure tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surface without use of mat or similar material. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plate has no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Label with Designated Title:

1. Printed:
   a. Character Height: 1/8-inch.
   b. Text: Black.
   c. Background: White.

F. Type (Exterior):

2. Receptacle in Damp Location: Weatherproof Type 1.
3. Receptacle in Wet Location: Weatherproof Type 2.
G. Type (Interior):
   1. Flush Mounted Box: Nylon or stainless steel.
   2. Surface Mounted, Metal Box:
      a. General Purpose Areas (Dry): Cast metal.
      b. Other Areas: Cast metal.
   3. Surface Mounted, Aluminum Box:
      a. General Purpose Areas: Stamped.
      b. Other Areas: Cast metal.
   4. Surface Mounted, Cast Box: Cast.
   5. Surface Mounted, Nonmetallic Box: Manufacturer’s standard.
   6. Receptacle Shown as Weatherproof on Drawings: Weatherproof Type 1.

3.05 IDENTIFICATION

A. Use tape labels for identification of individual wall switches and receptacles in dry indoor locations.
   1. Degrease and clean device plate surface to receive tape labels.
   2. Use 3/16-inch Kroy black letters on white background, unless otherwise indicated.
   3. Identify panelboard and circuit number from which item is served on face of plate.

B. Identify conductors with durable wire markers or tags inside outlet boxes where more than one circuit is present.

3.06 FIELD QUALITY CONTROL

A. Perform tests and inspections, and prepare test reports.

B. Test Instrument for 125-Volt 20-Amp Receptacle: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

C. Using test plug, verify device and its outlet box are securely mounted.

D. Line Voltage Range: 105 volts to 132 volts.

E. Percent Voltage Drop under 15-Amp Load: Less than 6 percent; 6 percent or higher is not acceptable.

F. Ground Impedance: 2 ohms, maximum.

G. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
H. Tests shall be diagnostic, indicating damaged conductors, high resistance at circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION
SECTION 26 29 23
LOW-VOLTAGE ADJUSTABLE FREQUENCY DRIVE SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   c. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturer’s Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. CP 1, Shunt Capacitors.
   c. MG 1, Motors and Generators.
   d. WC 57, Standard for Control, Thermocouple Extensions, and Instrumentation Cables.

1.02 DEFINITIONS

A. Terms that may be used in this section:

1. AFD: Adjustable frequency drive.
2. CMOS: Complementary metal oxide semiconductor.
3. CSI: Current source Inverter.
4. EMU: Energy Monitoring Unit.
5. GTO: Gate turn-off thyristor.
6. MPR: Motor protection relay.
7. MTBF: Mean time between failure.
8. PWM: Pulse width modulation.
9. ROM: Read only memory.
10. RTD: Resistance temperature detector.
11. RTU: Remote Telemetry Unit.
12. Rated Load: Load specified for equipment.
13. Rated Speed: Nominal rated (100 percent) speed specified for equipment.
14. TDD: Total demand distortion.
15. THD: Total harmonic distortion.
16. TTL: Transistor transistor logic.

1.03 SYSTEM DESCRIPTION

A. General:

1. 6-pulse, 12-pulse, and 18-pulse VFDs:
   a. VFD shall be normal operation.
   b. \( \frac{dv}{dt} \) low-pass output filter.
   c. Complete system shall be housed in a NEMA-1 Gasketed enclosure.

2. Manufacturer of VFD and pump/motor system shall coordinate prior to manufacture to ensure proper operation of the combined drive/motor system.

B. Performance Requirements:

1. Rated Continuous Operation Capacity: Not less than 1.15 times full load current rating of driven motor, as indicated on motor nameplate, and suitable for continuous operation at continuous overload which may be imposed on motor by driven pump operating over specified speed range.

2. Basis for Harmonic Computations: Using the One-Line Diagram for current and voltage distortion computations, furnish harmonic filters, line reactors, isolation transformers, or higher pulse converter arrangements required to meet current/voltage distortion limits.

3. For all calculations and field measurements, the point of common coupling (PCC) is defined as the Service-Entrance Equipment.

4. The short circuit current at the point of common coupling for calculation purposes shall be determined from the Electrical Analysis studies required by Section 26 05 70, Electrical Systems Analysis.

5. Normal Source Current Harmonic Distortion:
   a. Compute normal source individual and total current harmonic distortion at location identified as PCC in accordance with IEEE 519.
b. Individual current harmonic distortion and total demand distortion expressed as percent of maximum demand load current $I_L$ shall not exceed values specified in Table 1 below:

<table>
<thead>
<tr>
<th>Individual Harmonic Order (Odd Harmonics)</th>
<th>Harmonic Current Distortion Percent of Max. Demand Load Current IL</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h \leq 11$</td>
<td>1.0</td>
</tr>
<tr>
<td>$11 \leq h &lt; 17$</td>
<td>0.5</td>
</tr>
<tr>
<td>$17 \leq h &lt; 23$</td>
<td>0.37 (2.59 for $h=17, 19$)</td>
</tr>
<tr>
<td>$23 \leq h &lt; 35$</td>
<td>0.15</td>
</tr>
<tr>
<td>$35 \leq h$</td>
<td>0.5</td>
</tr>
<tr>
<td>Total Demand Distortion (TDD)</td>
<td>5</td>
</tr>
</tbody>
</table>

c. Limits specified in Table 1 are for drives utilizing 18-pulse rectifiers.

6. Compute normal source voltage harmonic distortion at location identified as PCC. THD shall not exceed 5 percent, and individual voltage harmonic distortion shall not exceed 3 percent.

7. Furnish isolating transformers or series reactors, harmonic filters, or other devices necessary for proper system operation. Furnish necessary devices and circuits to prevent operation of one drive from adversely affecting operation of other drives supplied from same transformer or same bus.

8. When isolation transformers are used, design to meet K-factor requirements of drive(s) connected.

C. Design Requirements:

1. Drive system consisting of adjustable frequency controller, drive motor, auxiliary items, and components necessary for complete operating system.

2. Other equipment is being powered from same bus as adjustable frequency drives. Ensure proper operation of drives and other loads under normal and emergency conditions.

3. Furnish AFDs rated on basis of actual motor full load nameplate current rating times the service factor.
4. Drive System: Convert incoming three-phase, 60-Hz ac power to variable voltage, adjustable frequency output for adjustable speed operation of a standard ac induction squirrel-cage motor, using pulse-width-modulation (PWM) technique to produce adjustable frequency output.

5. System rated for continuous industrial duty and suitable for use with NEMA MG 1, Design B motors.

6. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for drive system.

7. Incoming Line Reactor: Design to minimize harmonic distortion on incoming power feeder, 3 percent.

8. Output Filter: Provide output dv/dt low-pass filter to cap peak voltage to below 1,000 Vp.

1.04 SUBMITTALS

A. Action Submittals:

1. Overall drive system operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, 100, and 110 percent of rated speed.

2. Individual and total harmonic content (voltage and current) reflected in system normal source supply at driven equipment actual load at 70 percent and 100 percent of rated speed at PCC, and with load conditions specified. Normal source system short-circuit available at drive shall be calculated from data furnished from electrical analysis required by Section 26 05 70, Electrical Systems Analysis. Use TDD and THD factors as defined in IEEE 519 to designate total harmonic content.

3. AFD output pulse maximum peak voltage, pulse rise time, and pulse rate of rise including justification for proposed deviation from specified values. Include motor manufacturer’s certification motor insulation will withstand long-term overvoltages caused at motor terminals due to specified output pulse data or proposed deviation from this data.

4. Data on shelf life of “dc link” capacitor.

5. Complete system rating, including nameplate data, continuous operation load capability throughout speed range of 0 percent to 120 percent of rated speed.

6. Complete adjustable frequency controller rating coordinated with motor full load nameplate current rating; list controller special features being supplied.
7. Controller, reactor, harmonic filter, and isolating transformer (if applicable) dimensional drawings; information on size and location of space for incoming and outgoing conduit.

8. Maximum heat dissipation from enclosure.

9. Should separate enclosures and equipment be necessary for filter elements or power factor correction equipment, provide complete dimensional information including location of space for incoming and outgoing conduit, weight, maximum heat loss, and minimum current carrying capacity and recommended wire size for required interconnecting circuits.

10. Layout of controller face showing pushbuttons, switches, instruments, and indicating lights.

11. Complete system operating description.

12. Complete system schematic (elementary) wiring diagrams.

13. Complete system interconnection diagrams between controller, drive motor, and related components or controls external to system, including wire numbers and terminal board point identification.

14. One-line diagram of system, including component ratings.

15. Description of diagnostic features being provided.

16. Descriptive literature for control devices such as relays and timers.

17. Itemized bill-of-materials listing system components.

18. Specific description of provisions, such as filtering and harmonic suppression, being made to ensure proper system operation when: power factor correction capacitors are included in system.

19. Description MPR being furnished or how these functions are accomplished within drive system.

20. Anchorage and bracing drawings and cut sheets as required by Section 26 05 02, Basic Electrical Requirements.

B. Informational Submittals:

1. Statement of Supplier qualifications.

2. Anchorage and bracing calculations as required by Section 26 05 02, Basic Electrical Requirements.

3. Special shipping, storage and protection, and handling instructions.

4. Manufacturer’s printed installation instructions.

5. Factory functional test reports.

6. Certified copy of test report for identical motor tested in accordance with NEMA MG 1-12.53a and IEEE 112, Test Method B, showing rated load, rated speed efficiency meeting or exceeding specified values; motors not as specified will be rejected.

7. Field test reports.

8. Component and attachment testing seismic certificate of compliance.
9. Suggested spare parts list to maintain equipment in service for period of 1 year and 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.

10. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.

11. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

12. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services.

13. Written statement of coordination between the manufacturers of the adjustable frequency drive and the pump/motor system.

1.05 QUALITY ASSURANCE

A. Supplier: Minimum 5 years’ experience in furnishing similar size and type adjustable frequency, controlled speed, drive systems.

1.06 EXTRA MATERIALS

A. Furnish for each drive unit:

1. Complete set of components likely to fail in normal service.
2. Plug-in subassemblies.
3. Integrated circuits.
4. One complete power bridge and one spare printed circuit card for each modular, plug-in type card in controller.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Components and accessories specified in this section shall be products of:

1. Allen-Bradley.
2. Eaton/Cutler Hammer.
4. Schneider Electric/Square D.
5. Siemens Automation.
6. Yasakawa.

2.02 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.
2.03 SERVICE CONDITIONS

A. Ambient Operating Temperature: 0 degrees C to 40 degrees C.
B. Storage Temperature: Minus 40 degrees C to 70 degrees C.
C. Humidity: 0 percent to 95 percent relative (noncondensing).
D. Altitude: 0 foot to 3,300 feet.
E. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

2.04 COMPONENTS

A. Drive Units:
   1. Incorporate switching power supply operating from dc bus, to produce PWM output waveform simulating sine wave and providing power loss ride through of 2 milliseconds at full load, full speed.
   2. Current-limiting semiconductor fuses for protection of internal power semiconductors.
   3. Employ diode bridge rectifier providing constant displacement power factor of 0.95 minimum at all operating speeds and loads.
   4. Use transistors for output section, providing a minimum 97 percent drive efficiency at full speed, full load.
   5. Employ dc power discharge circuit so that after removal of input power dc link capacitor voltage level will decay below 50 volts dc within 1 minute after de-energizing following NEMA CP 1 and NFPA 79. Design dc link capacitor for a MTBF of 5 years.
   6. Operate with open circuited output.
   7. Input Voltage: As indicated on Drawings, plus or minus 10 percent.
   8. Output Voltage: As indicated on Drawings, 0-Hz to 60-Hz, minimum.
   9. Maximum peak voltage of PWM AFD output pulse of 1,000 volts, with pulse rise time of not less than 2 microseconds, and maximum rate of rise of 500 volts per microsecond. Maximum frequency of PWM AFD output pulse (carrier) frequency of 3,000-Hz. Should magnitudes of these characteristics be more stressful to motor insulation than specified values, furnish insulation systems on motors suitable for proposed values.
   10. Motor Audible Noise Level: When operating throughout speed range of PWM AFD, no more than 3 dBA above that designated in NEMA MG 1 for same motor operated at constant speed with a 60-Hz supply voltage.
   11. Short-Time Overload Capacity: 125 percent of rated load in rms current for 1 minute following full load, full speed operation.
12. Equipment Short-Circuit Rating: Suitable for connection to system with maximum source three-phase, bolted fault, short-circuit availability as indicated on Drawings.

13. Furnish drives with output dv/dt low-pass filter mounted within equipment enclosure.

14. Diagnostics: Comprehensive for drive adjustment and troubleshooting:
   a. Memory battery backup; 100-hour minimum during power loss.
   b. Status messages will not stop drive from running but will prevent it from starting.
   c. Fault Condition Messages and History: First fault protection function to be activated, ability to store six successive fault occurrences in order. Minimum faults numerically:
      1) Overcurrent (time and instantaneous).
      2) Overvoltage.
      3) Undervoltage (dc and ac).
      4) Overtemperature (drive, motor windings, motor bearing, pump bearing).
      5) Serial communication fault.
      6) Short-circuit/ground fault (motor and drive).
      7) Motor stalled.
      8) Semiconductor fault.
      9) Microprocessor fault.
     10) Single-phase voltage condition.

15. Drive Protection:
   b. Overcurrent, instantaneous overcurrent trip.
   c. Dc undervoltage protection, 70 percent dropout.
   d. Dc overvoltage protection, 130 percent pickup.
   e. Overtemperature, drive, inverter, converter, and dc link components.
   f. Overtemperature, motor, and pump.
   g. Single-phase protection.
   h. Reset overcurrent protection (manual or automatic reset).
   i. Active current limit/torque limit protection.
   j. Semiconductor fault protection.
   k. Short-circuit/ground fault protection.
   l. Serial communication fault protection.
   m. Microprocessor fault.
   n. Surge protection for transient overvoltage (6,000 volts, 80 joule surge, tested per IEEE C62.41).
   o. Visual display of specific fault conditions.

16. Operational Features:
   a. Use manufacturer’s standard unless otherwise indicated.
   b. Sustained power loss.
   c. Momentary power loss.
d. Power interruption.
e. Power loss ride through (0.1 second).
f. Start on the fly.
g. Electronic motor overload protection.
h. Stall protection.
i. Slip compensation.
j. Automatic restart after power return (ability to enable/disable function).
k. Critical frequency lockout (three selectable points minimum, by 1.5-Hz steps in 10-Hz bands, to prevent resonance of system).
l. Drive maintenance system software for complete programming and diagnostics.
m. Ground fault protection, drive, and motor.

B. Rectifier: Three-phase 6-pulse, 12-pulse, or 18-pulse full wave diode bridge rectifier (as required on Drawings) to provide constant dc voltage to drive’s dc bus.

C. Furnish series choke and capacitors on dc bus to reduce ripple in rectifier output and to reduce harmonic distortion reflected into incoming power feeders.

D. Controller: Microprocessor-controller PWM inverter to convert to dc voltage to variable voltage, adjustable frequency, three-phase ac output. Output voltage shall vary proportionally with frequency to maintain constant ratio of volts to hertz up to 60-Hz; above 60-Hz, voltage shall remain constant with drive operating in constant horsepower output mode.

E. Enclosure:

1. NEMA 250, Type 1 Gasketed, freestanding or wall-mounted enclosure, completely front accessible, and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow).
2. Cable termination compartment door interlocked main circuit breaker, defeatable (lockable in the open position), emergency stop pushbutton, alphanumeric keypad and display, and operator’s controls.
3. Wire drive from below for power and control wiring.
4. Size forced-ventilation for periodic operation to cool each unit with maximum room ambient temperature of 95 degrees F. Furnish redundant fans such that if one fan fails remaining fans furnish adequate ventilation for drive when operating at maximum capacity. Furnish filters on ventilation intakes.
5.  Wiring:
   a. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding.
   b. Label each terminal for permanent identification of leads.
   c. Identify each wire at each end with imprinted mylar adhesive-back wire markers.
   d. Incorporate in as-installed wiring diagrams for wire and terminal numbers shown.
   e. Wiring across door hinge, use 19-strand, NEMA WC 57 Class C stranding looped for proper twist rather than bending at hinge.
   f. Wire connections internal to panels by crimp-on terminal types.
   g. For multiple enclosure systems, complete interconnection wiring with gasketed enclosure openings for wiring.
   h. Multipoint plug receptacles for control wiring crossing equipment shipping splits.

6.  Selector switches, indicating lights, potentiometers, instruments, protective devices, and major system components identified by means of mechanically attached, engraved, laminated nameplates.

F.  Operator Interface:

1. Controls: Mount drive local control on front door of enclosure and include control as shown on the motor control diagrams in the contract documents. Form front of drive provide for the following operator functions:
   a. Start (when in LOCAL mode).
   b. Stop (when in LOCAL mode).
   c. Speed increase (when in LOCAL mode).
   d. Speed decrease (when in LOCAL mode).
   e. Parameter mode selection (recall programmed parameters).
   f. LOCAL/OFF/REMOTE control selection (in remote, furnish for remote RUN command digital input and speed increase/decrease via remote 4 mA to 20 mA analog signal).
   g. Fault reset, manual for faults, except loss of ac voltage which is automatic upon return.
   h. Parameter lock, password or key switch lockout of changes to parameters.
   i. Start disable, key switch or programmed code.

2. Control circuit disconnect shall de-energize circuits in units that are not de-energized by main power disconnect device.

3. 120 volts, single-phase, 60-Hz circuits for control power and operator controls from internal control power transformer. Furnish power for motor space heaters rated 120 volts.

4. Arrange component and circuit such that failure of a single component cannot cause cascading failure(s) of other component(s).
5. Alphanumeric Display:
   a. During normal operation and routine test, the following parameters shall be available:
      1) Motor current (percent of drive rated current).
      2) Output frequency (Hertz).
      3) Output voltage.
      4) Running time.
      5) Local/remote indicator.
      6) Status of digital inputs and outputs.
      7) Analog input and output values.
      8) Output motor current per leg.
      9) All test points.

6. Adjustable Parameters: Set drive operating parameters and indicate in numeric form. Potentiometers may not be used for parameter adjustment. Minimum setup parameters available:
   a. Frequency range, minimum, maximum.
   b. Adjustable acceleration/deceleration rate.
   c. Volts per Hertz (field weakening point).
   d. Active current limit/torque limit, 0 percent to 140 percent of drive rating.
   e. Adjustable voltage boost (IR compensation).
   f. Preset speed (adjustable, preset operating point).
   g. Provision for adjustment of minimum and maximum pump speed to be furnished as function of 4 mA to 20 mA remote speed signal.

G. Signal Interface:

1. Digital Input:
   a. Accept a remote RUN command contact closure input.
   b. High temperature contact closure input from field mounted motor temperature monitoring relay.

2. Digital Output: Furnish discrete output dry contact closures rated 5 amps at 120V ac for the following:
   a. DRIVE RUNNING.
   b. DRIVE FAULT (with common contact closure for all fault conditions).
   c. DRIVE IN REMOTE MODE.
   d. High vibration alarm.
   e. High High vibration shutdown.

3. Analog Input: When LOCAL/OFF/REMOTE switch is in REMOTE, control drive speed from remote 4 mA to 20 mA dc signal.
   a. Make provisions for adjustment of minimum and maximum motor speed which shall result from this signal.
ZINK DAM IMPROVEMENTS

b. Factory set this adjustment to comply with operating speed range designated in driven equipment specifications.
c. Frequency resolution shall be 0.1 percent of base speed.

4. Analog Output: Furnish two 4 mA to 20 mA dc signals for actual frequency, actual load.

H. Accessories:

1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
2. Lifting Lugs: Equipment weighing over 100 pounds.
3. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.

2.05 FACTORY FINISHING

A. Enclosure:

1. Primer: One coat of rust-inhibiting coating.
2. Finish:
   a. Interior: One coat white enamel.
   b. Exterior: One coat ANSI No. 61, Sky Blue Grey, or as indicated on Drawings.

2.06 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.
B. Factory Tests and Adjustments: Test one control panels actually furnished.
C. Record test data for report.
D. Functional Test: Perform manufacturer’s standard:

1. Operate controller with motor throughout its specified range, and at rated power supply load for 1 hour.
2. Resonance: When harmonic filters are furnished to meet specified harmonic distortion requirements, perform analysis and furnish documentary evidence that filter elements do not resonate with remainder of system parameters at harmonic frequencies present.

E. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.
PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s printed instructions.

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each controller.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.
3. Vibration Test:
   a. Complete assembly, consisting of motor, load, and flexible shafting, connected and in normal operation shall not develop amplitudes of vibration exceeding limits recommended by HIS.
   b. Where loads and drives are separated by intermediate flexible shafting, measure vibration both at top motor bearing and at two points on top pump bearing, 90 degrees apart.
4. Record test data for report.

B. Performance Test:

1. Conduct on each controller.
2. Perform under actual or approved simulated operating conditions.
3. Test for continuous 12-hour period without malfunction.
4. Demonstrate performance by operating continuous period while varying application load, as input conditions allow, to verify system performance.
5. With plant load connected to normal utility source, measure the following to show parameters within specified limits:
   a. Total and individual current harmonic distortion, up to and including 35th harmonic, at location identified as PCC, under following load conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.
   b. Power factor at input side of each drive. Documented verification that power factor is maintained at 95 percent as speed of drive goes down from 100 percent to 33 percent.
   c. THD at location identified as PCC3 under following conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.
6. Record test data for report.
C. Test Equipment:

1. Use Dranetz, Model No. 626-PA, harmonic distortion monitor and Series 626 disturbance analyzer or equivalent instrument to document results.
2. Provide diagnostic plug-in test card complete with instructions, multiposition selector switch, and meters or built-in diagnostic control panel or ROM-based processor for monitoring ac, dc, and digital signals to assist in troubleshooting and startup of drive.

3.03 MANUFACTURERS’ SERVICES

A. Manufacturer’s Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.
   b. 1 person-day for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation.
   c. 1 person-day for prestartup classroom or Site training.
   d. 1 person-day for facility startup.
   e. 1 person-day for post-startup training of Owner’s personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Engineer.

B. See Section 01 43 33, Manufacturers’ Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION
PART 1  GENERAL

1.01  REFERENCES

A.  The following is a list of standards which may be referenced in this section:

1.  Lightning Protection Institute (LPI): 175, Standard of Practice.
2.  National Fire Protection Association (NFPA):
   a.  70, National Electrical Code (NEC).
   b.  780, Standard for the Installation of Lightning Protection Systems.
3.  UL:
   a.  96, Standard for Lightning Protection Components.
   b.  96A, Standard for Installation Requirements for Lightning Protection Systems.

1.02  DESIGN REQUIREMENTS

A.  Provide lightning protection system design for the following structures:

1.  Air Compressor/PSO Pump Room Building on the West Bank.

B.  Design lightning protection system to comply with applicable provisions of
   LPI 175, UL 96, UL 96A, and NFPA 780.

1.03  SUBMITTALS

A.  Action Submittals:

1.  Reproducible Drawings, signed and sealed by an Oklahoma
   Professional Engineer (PE):
   a.  Lightning protection system layout.
   b.  Component locations.
   c.  Detailed plans.
2.  Down conductor.
3.  Connecting conductor.
4.  Bond strap.
5.  Air terminals.
6.  Fittings.
7.  Connectors.
8.  Ground rods.
B. Informational Submittals:

1. Field test report.
2. Ground Witness Certification-Form LPI-175A.
3. Post-Installation Certification-Form LPI-175B.
4. UL 96 Master Label Certification for the complete, installed system.

1.04 QUALITY ASSURANCE

A. Designer: Lightning protection system design shall be prepared by an LPI-certified designer, or recognized lightning protection manufacturer, signed and sealed by an Oklahoma Professional Engineer (PE).

B. System components shall be the product of a manufacturer regularly engaged in the manufacturing of lightning protection components in accordance with UL 96.

C. Lightning protection system shall be installed under direct supervision of an LPI 175 Certified Master Installer.

D. Inspection of final installation and grounding connection shall be performed by an LPI-certified inspector.

E. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory (NRTL) or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

F. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied NRTL Listing or Labeling mark.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Thompson Lightning.
2. IPC Protection.
4. VFC, Inc.
2.02 GENERAL

A. Complete system shall bear UL 96 Master Label Certification.

B. Power system surge protection is provided under other sections of these Specifications.

C. System Material: Copper or high copper content, heavy-duty bronze castings, or aluminum, unless otherwise specified.

D. Material shall comply in weight, size, and composition for the class of structure to be protected as established by NFPA 780.

2.03 COMPONENTS

A. Air Terminal:
   1. Material: Solid aluminum with tapered or blunt points as required for application.
   2. Length: Sufficient to extend minimum 10 inches above object being protected.
   3. UL 96 Label B applied to each terminal.

B. Conductors:
   1. Lightning System Conductors: Bare medium hard-drawn stranded copper, or stranded aluminum as required for the application.
   3. Connecting Conductor: Concentric stranding.
   5. Main down and connecting conductors shall bear the UL 96 Label A, applied every 10 feet.

C. Cable Fastener and Accessories: Capable of withstanding minimum pull of 100 pounds.

D. Fittings:
   1. Heavy-duty.

E. Ground Rods: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.
PART 3  EXECUTION

3.01  GENERAL

A. Workmanship to comply with all applicable provisions of LPI 175, UL 96, UL 96A, and NFPA 780.

B. Aluminum materials shall be used where required to meet the galvanic corrosion requirements of UL 96A.

C. Provide pitchpockets or method compatible with roofing to waterproof roof penetrations.

D. Install system in inconspicuous manner so components blend with building aesthetics.

3.02  EXAMINATION

A. Verify conditions prior to installation. Actual conditions may require adjustments in air terminal and ground rod locations.

3.03  INSTALLATION

A. Air Terminals:

1. Supports: Brackets or braces.
2. Parapet Bracket Attachment: Lag or expansion bolts.
3. Secure base to roof surface with adhesive or pitch compatible with roofing bond.
4. Provide terminal flashing at roof penetrations.
5. Perimeter Terminals:
   a. Maximum Spacing: 20 feet.
   b. Maximum Distance From Outside Edge of Building: 2 feet.
6. Roof Ridge Terminals: Maximum spacing 20 feet.
7. Mid-Roof Terminals: Maximum spacing 50 feet.
8. Provide blunt point air terminals for applications exposed to personnel.
B. Conductors:

1. Conceal whenever practical.
2. Provide 1-inch PVC conduit in building walls or columns for main downleads and roof risers.
   a. Vertical: 3 foot.
   b. Horizontal: 4 foot.
4. Maintain horizontal and vertical conductor courses free from dips or pockets.
5. Bends: Maximum 90 degrees, with minimum 8-inch radius.
6. Install air terminal conductors on the structural roof surface before roofing composition is applied.

C. Bonding:

1. Bond to Main Conductor System:
   a. Roof-mounted ventilators, fans, air handlers, masts, flues, cooling towers, handrails, and other sizeable metal objects.
   b. Roof flashing, gravel stops, insulation vents, ridge vents, roof drains, soil pipe vents, and other small metal objects if located within 6 feet of main conductors or another grounded object.
2. Bond each steel column or major framing members to grounding system.
3. Bond each main down conductor to grounding system.

D. Grounding Electrode System: Bond all down conductors to the building’s grounding electrode system as shown on Drawings. Design of the grounding electrode system is responsibility of Owner’s Engineer and shall provide a maximum resistance to remote earth 5 ohms.

3.04 FIELD QUALITY CONTROL

A. Field Testing:

1. Coordinate with the requirements of Section 26 05 26, Grounding and Bonding for Electrical Systems.
2. Isolate lightning protection system from other ground conditions while performing tests.
3. Resistance: Test ground resistance to remote earth after power system is energized and with utility neutral connected. Testing shall utilize a clamp-on ground resistance meter such as AEMC 3711, Fluke 1630, Greenlee CMGRT-100, or equivalent device. Ground resistance meter must have a current certificate of calibration not exceeding 12 months at time of installation testing. Fall-of-Potential testing is not acceptable.
   a. Test shall be conducted on the grounding electrode conductor of the service-entrance equipment.
   b. Resistance to Remote Earth: Maximum 5 ohms.
   c. Contact Owner’s Engineer for remediation solutions should measurement exceed the maximum value allowed.

4. Test Report:
   a. Description of equipment tested.
   b. Description of test.
   c. Test results.
   d. Conclusions and recommendations.
   e. Appendix, including appropriate test forms.
   f. Identification of test equipment used.
   g. Signature of responsible test organization authority.

END OF SECTION
PART 1  GENERAL

1.01  REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   e. A595/A595M, Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use.

2. Canadian Standards Association (CSA).
3. Certified Ballast Manufacturer (CBM).
5. Illuminating Engineering Society of North America (IESNA).
   a. HB-9, Lighting Handbook.
   c. LM-80, IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources.
   d. RP (Recommended Practices) Series.
   e. TM-21, Projecting Long Term Lumen Maintenance of LED Light Sources.
6. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
8. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
13. UL:
   b. 844, Electric Lighting Fixtures for Use in Hazardous ( Classified) Locations.
   c. 924, Emergency Lighting and Power Equipment.
   d. 1598, UL Standard for Safety Luminaires.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. General:
      1) Provide catalog data sheets and pictures for all products.
      2) Proposed Luminaire Substitutions (Interior and Exterior):
         Provide an electronic photometric file in standard ‘.ies’ file format per the Illumination Engineering Society of North America (IESNA) for any proposed luminaire substitution not identified on the project Luminaire Schedule. Obtain file from the luminaire manufacturer or approved independent photometric testing laboratory. Include the proposed substitute luminaire with all options identified on the project Luminaire Schedule.
b. Interior Luminaires:
   1) Catalog data sheets with pictures.
   2) Luminaire material, finish, dimensions, and metal gauge.
   3) Lens material, pattern, and thickness.
   4) Candle power distribution curves in two or more planes.
   5) Candle power chart 0 degree to 90 degrees.
   6) Lumen output chart.
   7) Average maximum brightness data in foot lamberts.
   8) Coefficients of utilization for zonal cavity calculations.
   9) Mounting or suspension details.

c. Exterior Luminaires:
   1) Catalog data sheets with pictures. Luminaire material, finish, dimensions, and metal gauge.
   2) Lens material, pattern, and thickness. Filters.
   3) IESNA lighting classification (BUG rating).
   4) Isolux diagram.
   5) Lighting distribution data and lighting distribution classification type as defined in IESNA HB 9.
   6) Fastening details to wall, pendant, or pole.
   7) Ballast type, location, and method of fastening.
   8) For light poles, submit catalog sheet, wind loading, pole deflection with fixture attached, total weight, all accessories, complete dimensions, and finish.
   9) Brackets and supports.

d. Lamps:
   1) Voltages.
   2) Watts.
   3) Correlated Color Temperature (CCT).
   4) Color Rendering Index (CRI).
   5) Published rated life (in hours). Provide number of hours per start and operating temperature for published rated life hours indicated.
   6) Published rated initial and mean lumens.
   7) Lumen maintenance curve.
   8) Lamp type (ANSI designation, dimensions, shape, and base).

e. Ballasts:
   1) Type.
   2) Wiring diagram.
   3) Ballast factor.
   4) Nominal watts and input watts.
   5) Input voltage and power factor.
   6) Starting current, line current, and restrike current values.
   7) Sound rating.
   8) Temperature rating.
9) Efficiency ratings.
10) Low temperature characteristics.
11) Emergency Ballasts:
    a) Electrical ratings.
    b) Lamp type compatibility.
    c) Battery capacity.

f. LED Source Systems:
1) General:
    a) IESNA LM-80 test reports.
    b) IESNA TM-21 ratings.
    c) Operating temperature range. Data sheet (chart/graph) describing life as a function of temperature.
    d) Warranty: Light engine and driver.
    e) Rated life.
    f) Surge protection.
    g) Thermal control device, heat sink.
    h) Enclosure and wiring information.
    i) Operating voltage range.

2) Electronic Module/Light Engine:
    a) Correlated Color Temperature (CCT).
    b) Color Rendering Index (CRI).

3) Drivers:
    a) Input Current Total Harmonic Distortion.
    b) Power factor.
    c) Sound rating.

g. Time Switches:
1) Wiring diagram.
2) Contact ratings.
3) Functional features.
4) Programmable capabilities.
5) Enclosure type, dimensions.

h. Lighting Contactor:
1) Type (mechanically or electrically held).
2) Enclosure.
3) Contact ratings and configuration.
4) Coil operating voltage.

i. Photoelectric Switches (Photocells):
1) Voltage.
2) Power consumption.
3) Load capacity (watts).
4) Contact ratings and configuration.
5) Time delay.
6) Light operating level controls.
7) Enclosure type and dimensions.
8) Mounting type.
9) Temperature range.
10) Features and options.
j. Landscape Lighting:
   1) Luminaires.
   2) Controls.
   3) Transformers.
   4) Wiring.
k. Seismic anchorage and bracing drawings and cut sheets, as required by Section 26 05 02, Basic Electrical Requirements.

B. Informational Submittals:

   1. Anchorage and bracing calculations as required by Section 26 05 02, Basic Electrical Requirements.
   2. Manufacturer’s printed installation instructions.
   3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

   1. Provide Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
   2. Provide materials and equipment manufactured within the scope of standards published by UL in conformance with those standards and with an applied NRTL Listing or Labeling mark.

B. Standard Products:

   1. Provide materials and equipment of manufacturers regularly engaged in the production of products specified in this section and that are of equal material, design, and workmanship.
   2. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to Bid opening in similar applications under similar circumstances and of similar size. Provide products that have been on sale on the commercial market through advertisements, manufacturers’ catalogs, or brochures during the 2-year period.
   3. Material and Equipment Manufacturing Date: Do not use products manufactured more than 3 years prior to date of delivery to Site.
1.04 DELIVERY, STORAGE, AND HANDLING

A. Aluminum Poles:
   1. Provide manufacturer’s standard protection for the finish during
      shipment and installation. At minimum, spirally wrap each pole shaft
      with protective paper secured with tape, and ship small parts in boxes.
   2. Do not store poles on ground.
   3. Support poles so they are at least 1 foot above ground level and growing
      vegetation.
   4. Do not remove factory-applied pole wrappings until just before
      installing pole.
   5. Ship poles with bolt circle template, base cover, handhold cover, and
      shaft cap or tenon.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts,
   special tools, and materials:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spare ballast of each type</td>
<td>Two complete sets</td>
</tr>
<tr>
<td>Spare lamps of each type</td>
<td>One complete set</td>
</tr>
<tr>
<td>Spare LED drivers of each type</td>
<td>Two complete sets</td>
</tr>
</tbody>
</table>

PART 2 PRODUCTS

2.01 LUMINAIRES

A. Specific requirements relative to execution of the Work of this section are
   located in Luminaire Schedule as shown on Drawings.

B. Provide luminaires and components tested, listed, and labeled by a NRTL.

C. Provide luminaires with Illumination Engineering Society of North America
   (IESNA) formatted photometric files, “.ies” format, certified by the luminaire
   manufacturer for use with lighting software.

D. Luminaire Labels:
   1. External label per ANSI C136.15.
   2. Internal label per ANSI C136.22.
E. Provide luminaires rated by the manufacturer to start and operate to their full lumen capacity for rated life of the luminaire at the minimum low and maximum high ambient temperatures as defined in the Contract Documents at their installation location.

F. Feed-through type.

G. Wire Leads: Minimum 18 AWG.

H. Component Access: Accessible and replaceable without removing luminaire from ceiling, wall or pole.

I. Exterior Installations:
   1. NRTL Labeled: WET LOCATIONS.
   3. When factory-installed photocells are provided, entire assembly shall have a NRTL label.

J. Illuminated Exit Signs:
   1. Body: As scheduled.
   2. Face: Stencil.
      a. Letters:
         1) 6-inch high by 3/4-inch stroke.
         2) Color: Red.
   4. Directional Arrows: As shown on Drawings.

K. Emergency Lighting Units:
   1. Power Pack: Self-contained, 120/277-volt dual voltage transformer, inverter/charger, sealed nickel cadmium battery, and indicator switch in accordance with UL 924.
   2. Lighted, push-to-test indicator.
   3. Capable of providing full illumination for 1-1/2 hours in emergency mode.
   4. Capable of full recharge in 24 hours, automatically upon resumption of normal line voltage.
   5. Capable of protecting against excess charging and discharging.
   6. Emergency Self-Diagnostic System:
      a. Solid state device with LED display and audible alarm.
      b. Automatic and manual test unit.
      c. Test for malfunction of lamps, battery, and charger board.
2.02 LED SOURCE SYSTEMS

A. General:

1. Provide IESNA LM-80 test reports.
2. Provide Energy Star compliance for solid state luminaires.
4. Provide RoHS compliant LED light source(s) and driver(s).
5. Rated operating temperature range as indicated on the Luminaire Schedule.
6. Warranty: 5 years minimum.

B. Electronic Module/Light Engine:

1. Mount all components to a single plate and factory prewired with quick-disconnect plugs.
2. Include a driver, thermal control device, thermal protector device, and surge protector device.
   a. Provide surge protector tested in accordance with IEEE/ANSI C62.41.2 to Category C Low.
3. Provide LEDs mounted to a metal-core circuit board and aluminum heat sink for optimal thermal management and long life.
4. Light Engine Rating per TM-21: 60,000 at 65 degrees C, L84.
5. Correlated Color Temperature (CCT): As indicated on the Luminaire Schedule.

C. Drivers:

1. Expected life of 60,000 hours at 65 degrees C.
2. Provide drivers mounted in an all metal can.
3. Operating Voltage Range: 50/60-Hz input source, voltage range as indicated on the Luminaire Schedule with sustained variations of plus or minus 10 percent voltage with no damage to the driver.
4. Input Current Total Harmonic Distortion: Less than 20 percent up to 50 percent of full load rating.
5. Power Factor: Greater than 0.90 for primary application up to 50 percent of full load rating.
6. Sound rating: Class A.
7. Comply with NEMA 410 for inrush current limits.
2.03 LIGHTING CONTROL

A. Time Switch, Electronic Programmable Type:

1. Provide digital electronic time switch with number of channels shown on Drawings.
2. Programming: Each channel shall be independently programmable and include:
   a. A Form ‘C’ dry contact, output rated for 30 amps at 120V to 240V ac for operation on LED driver loads.
   b. Provide channels with four ON/OFF set points in a 24-hour period for each day or the week.
   c. 365-day capability.
   d. Holiday override capability.
   e. User-programmable daylight savings time adjustment option.
   f. Automatic daylight savings changeover.
   g. Automatic leap year compensation.
3. Time Switch Minimum Features:
   a. Selectable am/pm or 24-hour format.
   b. 1-minute time resolution.
   c. Control Inputs: Up to four control inputs capable of connection to input devices including photoelectric relays, discrete input devices, etc., for use in programming output channels.
   d. Battery backup with rechargeable batteries and 72-hour capacity.
   e. Individual manual ON/OFF override control for each channel.
4. Manufacturers:
   a. Tork.
   b. Intermatic.
   c. Paragon Electric Company.

B. Lighting Contactor:

1. Features:
   a. Electrically held contactor.
   b. Contacts Rating: 240 volts, 30 amperes, and 3-poles.
   c. Silver rating 240 volts.
   d. Rate contactor as shown on Drawings.
   e. Enclosure: As shown on Drawings.
   f. Provide contactor with HAND-OFF-AUTOMATIC selector switch.

C. Photoelectric Switch (Photocell):

1. Automatic Solid State ON/OFF Switching Photo Control:
   a. Dry Contacts: Configuration and Rating as shown on Drawings.
2. Housing: Self-contained, die-cast aluminum, unaffected by moisture, vibration, or temperature changes.
3. Mounting Type: Twist lock plug.
4. Setting: ON at dusk and OFF at dawn.
5. Time delay feature to prevent false switching.
6. Field adjustable to control operating light levels.
7. Integral surge protection.
8. Manufacturers:
   a. Tork.
   b. Intermatic.
   c. Paragon Electric Company.

2.04 POLES

A. General: As shown on Drawings.

B. Aluminum Poles:

1. Manufactured of corrosion-resistant aluminum alloys. Seamless extruded or spun seamless type with minimum 0.188-inch wall thickness.
2. Shape: Round.
3. Provide pole grounding connection designed to prevent electrolysis when used with copper ground wire.
4. Shaft Top: Fitted with round tenon.
5. Base:
   a. Anchor bolt mounted and machined to receive lower end of shaft.
   b. Welded joint between shaft and base.
   c. Base Cover: Cast aluminum alloy.
   d. Hardware, Except Anchor Bolts: Either anodized aluminum alloy or stainless steel.
   e. Handhole.
6. Provide pole cast-in-place foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end.
7. Provide base covers to match pole and galvanized nuts and washers for anchor bolts.
8. Pole and Bracket Finish: As shown on Drawings.

2.05 BRACKETS AND SUPPORTS

A. Features:

1. Not less than 1-1/4-inch aluminum secured to pole.
2. Slip-fitter or pipe-threaded brackets may be used, but coordinate brackets to luminaires provided. Provide identical brackets for use with one type of luminaire unless otherwise approved by Engineer.
3. Select brackets for pole-mounted street lights to correctly position luminaire no lower than mounting height indicated.

4. Mount brackets not less than 24 feet above street.

5. Provide special mountings or brackets as shown on Drawings fabricated of metal which will not promote galvanic reaction with luminaire head.

2.06 POLE FOUNDATIONS

A. Anchor Bolts: Steel rod having a minimum yield strength of 50,000 psi; at minimum, galvanize the top 12 inches of the rod.

B. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 EMERGENCY BALLAST

A. In accordance with UL 924.

B. Nickel cadmium battery, charger, and electronic circuitry in metal case.

C. Solid state charging indicator monitoring light and double-pole test switch.

D. Manufacturers and Products:
   1. MagneTek Lighting Products.
   2. Philips-Bodine.
   3. Hubbell Lighting; Dual-Lite.
   4. Lithonia.

2.08 LANDSCAPE LIGHTING

A. Materials:
   1. Fixtures shall meet UL standards and be suitable for outdoor installation.
   2. Types of lamps used, but not limited to:
      a. Fluorescent.
      b. High pressure sodium.
      c. Incandescent.
      d. LED.
      e. Halogen.
      f. Metal halide.
      g. Neon.
   3. Wire Type:
      a. Low Voltage: 12-gauge, two-wire, UV-rated coating.
      b. Line Voltage: 12 AWG, XHHW-2.
      c. NRTL Listed.
4. Wire Fastening: Hardware shall be composed of corrosion resistant materials.
5. Transformers:
   a. NRTL Listed in addition to meeting NEC codes.
   b. Overcurrent protection in accordance with NEC.
6. Conduit: In accordance with Section 26 05 33, Raceway and Boxes.
7. Pull Boxes and Junction Boxes: Suitable for outdoor installation per Section 26 05 33, Raceway and Boxes.

2.09 EQUIPMENT IDENTIFICATION

A. Manufacturer’s Nameplate: Provide each item of equipment with a nameplate bearing manufacturer’s name, address, model number, and serial number securely affixed in a conspicuous place; nameplate of distributing agent will not be acceptable.

B. Provide clear markings located to be readily visible to service personnel.

2.10 FACTORY FINISH

A. Provide electrical equipment with factory-applied painting systems that, at minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.01 LUMINAIRES

A. General:
   1. Install in accordance with manufacturer’s recommendations.
   2. Provide proper hangers, pendants, and canopies as necessary for complete installation.
   3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building required to safely mount.
   4. Install plumb and level.
   5. Install each luminaire outlet box with galvanized stud.

B. Mounting:
   1. General: Coordinate mounting, fastening, and environmental conditions with Section 26 05 02, Basic Electrical Requirements.
   2. Wall Mounted: Measure mounting heights from center of mounting plate to finished floor or finished grade, whichever is applicable.
3. Pendant Mounted:
   a. Provide swivel type hangers and canopies to match luminaires, unless otherwise noted.
   b. Space single-stem hangers on continuous-row fluorescent luminaires nominally 48 inches apart.
   c. Provide twin-stem hangers on single luminaires.
   d. Measure mounting heights from bottom of luminaire to finished floor or finished grade, whichever is applicable.


C. Finished Areas:

   1. Install symmetrically with tile pattern.
   2. Locate with centerlines either on centerline of tile or on joint between adjacent tile runs.
   3. Install recessed luminaires tight to finished surface such that no spill light will show between ceilings and sealing rings.
   4. Combustible Low Density Cellulose Fiberboard: Provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use fixtures suitable for mounting on low density ceilings.
   5. Junction Boxes:
      a. Flush and Recessed Luminaires: Locate minimum 1-foot from luminaire.
      b. In concealed locations, install junction boxes to be accessible by removing luminaire.

6. Wiring and Conduit:
   a. Provide wiring of temperature rating required by luminaire.
   b. Provide flexible steel conduit.

7. Provide plaster frames when required by ceiling construction.

8. Independent Supports:
   a. Provide each recessed fluorescent luminaire with two safety chains or two No. 12 soft-annealed galvanized steel wires of length needed to secure luminaire to building structure independent of ceiling structure.
   b. Select chain or wire with tensile strength and method of fastening to structure adequate to support luminaire weight.
   c. Fasten chain or wire to each end of luminaire.

D. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.

   1. Fixture Suspension: Provide 1/4-inch threaded steel hanger rods. Scissor type hangers not permitted.
   2. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.
E. Building Exterior: Flush-mounted back box and concealed conduit, unless otherwise indicated.

3.02 LIGHTING CONTROL

A. Outdoor Luminaires: Photocells switch time clock ON at dusk with time clock switching lights OFF at preset time.

3.03 EMERGENCY BALLAST

A. Install battery, charger, and electronic circuitry metal case inside fluorescent fixture housing.
B. Install monitoring light and double-pole switch adjacent to light fixture.
C. Wire in accordance with manufacturer’s wiring diagrams.

3.04 EMERGENCY LIGHTING UNIT

A. Install in accordance with manufacturer’s recommendations.
B. Provide permanent circuit connections with conduit and wire.
C. Connect to branch circuit feeding normal lighting in area ahead of all local switches.
D. Provide separate circuit wiring to luminaire.

3.05 POLES

A. Electrical Installations: Conform to IEEE C2 and requirements specified herein.
B. Pole Setting:
   1. Depth: As shown on Drawings or footing detail.
   2. Install poles in straight runs in a straight line.
C. Aluminum Poles: Install according to pole manufacturer's instructions.
   1. Provide cast-in-place concrete base.
D. Grounding: Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, Grounding and Bonding for Electrical Systems. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.
3.06 LANDSCAPE LIGHTING

A. General: Electrical work and installation shall be in accordance with Article 411 of the NEC.

B. Installation:
   1. Aboveground:
      a. Locate wire, hardware, and fixtures so as to allow for “normal” unobstructed plant growth with attention paid to the following:
         1) Hardware or fixtures should not be mounted in such a way that wire needs to be routed through a tree branch or trunk union.
         2) Branches or trunks should not be encircled with wire or other hardware.
         3) Maintain 10 inches minimum between new and existing installations of tree hardware.
      b. Protect wire by PVC conduit or water-resistant flexible conduit to a minimum of 8 feet abovegrade.
      c. Make connections in approved junction boxes.
      d. Secure conduit to tree with appropriate approved clips and hardware.
         1) Wire is to be fastened only with galvanized wire staples which have standoff nubs.
         2) Do not drive staples into tree past the standoff nubs to avoid pinching wire. Leave wire loose to allow for tree sway, tree growth, and wire expansion and contraction.
      e. Leave 10-inch slack or service loop at each end junction or fixture to allow:
         1) Wire contraction.
         2) Servicing.
         3) Relocation.
   2. Belowgrade Wiring:
      a. Excavating and Backfill:
         1) Excavate trenches for electrical conduit and wiring of sufficient width to permit proper handling and installation of pipe and fittings.
         2) Trenches containing conduit for line voltage wiring must have a minimum cover of at least 15 inches wherever possible and 18 inches minimum in vehicle areas.
         3) Trenches containing conduit for low voltage wiring must have a minimum cover of at least 6 inches wherever possible.
         4) Compact backfill up to original grade level to 90 percent of the modified Proctor density.
b. Pulling:
   1) Size pull boxes in accordance with Section 26 05 33, Raceway and Boxes.
   2) Keep interior of conduit free from dirt and debris.

c. Underground Conduit: Install per Section 26 05 33, Raceway and Boxes.

d. Pull Boxes and Junction Boxes:
   1) Install in accordance with Section 26 05 33, Raceway and Boxes.
   2) Boxes shall remain accessible at all times.

3.07 FIELD FINISHES

A. Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Paint as specified on Drawings.

3.08 FIELD QUALITY CONTROL

A. Upon completion of installation, verify equipment is properly installed, connected, and adjusted. Conduct an operating test to show equipment operates in accordance with the requirements of this section.

B. Coordinate lighting and controls installation and testing with commissioning as specified in Section 01 91 14, Equipment Testing and Facility Startup.

3.09 CLEANING

A. Remove labels and markings, except NRTL Listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touch up painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace defective lamps at time of Substantial Completion.

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, General Requirements Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes light fixtures, lamps and ballasts requirements for the following:

1. Exterior Lighting Fixtures, with Lamps, and Ballasts: Light Emitting Diodes (LEDs).
2. Lighting fixture supports.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color-rendering index.
C. LER: Luminaire efficacy rating.
D. Lumen: Measured output of lamp and luminaire, or both.
E. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.04 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

4. EPACT:
8. IL 844, Electric Lighting Fixtures for use in hazardous (classified) locations.
10. National Equipment Manufacturers Association (NEMA):
    a. WD6, Wiring devices – Dimensional requirements.
    b. LE4, Recessed luminaires: ceiling compatibility.
    c. FA 1, Outdoor floodlighting equipment.
    d. OD 3, Physical and electrical interchangeability of photo control devices and mating receptacles.
    e. SH 5, Tubular steel poles.
    a. 70, National Electric Code.
12. Occupation Safety and Health Administration (OSHA).
13. UL:
    a. 57, Electric Lighting Fixtures.
    b. 924, Emergency Lighting and Power Equipment.
    c. 1598, Luminaires.
14. WDMA:
    a. T.M. 1, Soil Block Test.
    b. T.M. 2, Swellometer Test, Test Method to Determine the Water-Repellent Effectiveness of Treating Formulations.

1.05 SUBMITTALS

A. Product Data:

1. For each luminaire and support component, arranged in order of lighting unit designation. Submit manufacturer’s data on features, accessories, finishes, and the following, in reproducible form:
   a. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters. Submit dimensioned drawings of lighting fixtures.
   b. Details of attaching luminaires and accessories.
   c. Details of installation and construction.
   d. Luminaire materials.
e. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.

f. Poles and standards dimensions details of hand holes and wire entries, mast or bracket arms and connection to poles, wind load and deflection, and finishes.

g. Steel, power installed type of pole, foundation dimensions, corrosion resistance, pullout and overturning resistance for the soil conditions of the site and bolt circle data.

B. Photometric Data:

1. Supply complete photometric data for each fixture, photometric reports shall be rendered by an independent testing laboratory developed according to methods of the Illuminating Engineering Society of North America (IESNA) as follows:
   a. Luminaire description and dimensions.
   b. Candela distribution data, presented graphically and numerically in no more than 5-degree increments (5, 10, 15, etc.). Data developed for up and down quadrants normal, parallel and at 22.5, 45, 167.5 degrees to fixture axis if light output is asymmetric. Photoelectric relays.
   c. Zonal lumens stated numerically in 10-degree increments (5, 15, etc.) and fixture efficiency.
   d. Luminance table with data presented numerically, showing maximum luminance of the fixture at the shielding angles. Readings should be taken both crosswise and lengthwise in the case of LED fixtures or fixtures with asymmetric distribution.
   e. Coefficients of utilization table.
   f. Photometric Data for LED Luminaire: See also Article Solid State Lighting (LED) Fixtures.
   g. Driver UL listing, volts, lamp and line amperes, input watts and minimum lamp starting temperature.
   h. Lamp ANSI designation, initial and mean lumen output, average rated hours of lamp life and lamp mortality curve, color temperature and color rendering index.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
3. Wiring Diagrams: For power, signal, and control wiring.
4. Warranty: Sample of special warranty (see Article Warranty).

D. Submittals or shop drawings lacking sufficient detail to indicate clear and complete compliance with contract documents shall be rejected. Include plans, elevations, sections, details, and attachments to other work.

E. Installation instructions.

F. Coordination Drawings:

1. Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   a. Lighting fixtures.
   b. Suspended ceiling components.
   c. Structural members to which suspension systems for lighting fixtures will be attached.
   d. Other items in finished ceiling may include the following:
      1) Air outlets and inlets.
      2) Speakers.
      3) Sprinklers.
      4) Smoke and fire detectors.
      5) Occupancy sensors.

G. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

H. Field quality-control reports.

I. Operation and Maintenance Data:

1. For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals. Provide a collection of manufacturer recommended maintenance practices for each lighting fixture type including, but not limited to:
   a. Tools required.
   b. Acceptable cleaners and recommended cleaning practices.
   c. Replacement parts list.
   d. Manufacturer service department contact information/Qualified Service Agencies.
   e. Submittal Data.
   f. Operation Data.
   g. Intended Operation Narrative.

J. Warranty: Sample of special warranty.
K. "Approved Equal" specification status does not and shall not exempt the
identified manufacturers from full and complete compliance with all criteria
identified either in the specifications or as attributed to "prime specification"
equipment with regards to photometric performance, brightness control,
nominal size, finishes, credentials or experience, etc. Consideration,
acceptance or rejection of any proposed submittal at any time shall rest solely
upon the evaluation of the Lighting Designer/Engineer for those areas within
the Project scope.

1.06 QUALITY ASSURANCE

A. All lighting fixtures shall be manufactured, furnished, and installed in
compliance with all government agencies having jurisdiction. All fixtures
shall bear the appropriate UL (or ETL) identifications.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by
an independent agency, with the experience and capability to conduct the
testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910,
complying with the IESNA Lighting Measurements Testing and Calculation
Guides.

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

D. Manufacturers: Provide products of firms regularly engaged in the
manufacture of interior and exterior lighting equipment of the types and
ratings whose products have been in satisfactory use in similar service for not
less than 5 years.

E. Mockups: Provide lighting fixtures for location or module mockups complete
with power and control connections.

1. Obtain Owner’s approval of fixtures for mockups before starting
installations.
2. Maintain mockups during construction in an undisturbed condition as a
standard for judging the completed Work.
3. Approved fixtures in mockups may become part of the completed Work
if undisturbed at time of final written acceptance by the Owner.
4. The Contractor shall make every effort to install all mockups to be
viewed during the course of one review session. Should mockups not be
ready for viewing on the scheduled mockup date, the Contractor shall be
responsible for all travel rebooking fees, upcharges, and other additional
fees that may occur as a result of rescheduling the mockup date.
5. Refer to Article Mockups.
F. National Electrical Manufacturers Association (NEMA): Comply with applicable requirements of NEMA LE 4, “Recessed Luminaires, Ceiling Compatibility” pertaining to recessed luminaires.

G. UL: Comply with applicable UL standards pertaining to interior and exterior lighting equipment.

H. Manufacturers listed as “prime spec,” “or-equal,” in the lighting fixture schedule shall be assumed capable of supplying the listed fixtures unless clearly written exceptions are set forth in their quotations. Any such exceptions shall immediately be brought to the attention of the Landscape Architect and the Lighting Designer. Manufacturers not listed (as prime or approved equal) must comply with the following:

1. Experience: Manufacturers shall have not less than 5 years’ experience in design and manufacturing of lighting fixtures of the type and quality shown. Submission must include a list of completed projects and dated catalogue pages or Drawings indicating length of experience.

2. Samples: Manufacturers shall submit a prototype sample of each fixture for review by the Lighting Designer. Prototype samples shall be sufficiently detailed and operational to allow evaluation of compliance with the salient features of the specification. Preliminary design or Shop Drawings shall not be accepted in place of prototype samples (see Article Samples).

1.07 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1. Conform to approved Coordination Drawings.

1.08 WARRANTY

A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

B. LED luminaires shall carry a minimum 5 years’ warranty from the date of final written acceptance by the Owner.

C. All drivers shall carry a minimum 5-year warranty from the date of final written acceptance by the Owner.
1.09 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. LED Modules/Boards: 10 for every 100 of each type and rating installed. Furnish at least two of each type.
2. Plastic/Glass Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least two of each type.
3. Drivers: One for every 10 of each type and rating installed. Furnish at least five of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least five of each type.
5. Complete Luminaires: One for every 20 or each type that does not have field-replaceable LEDs and/or drivers. Furnish at least one of each type that does not have field-replaceable LEDs and/or drivers.

1.10 SAMPLES

A. Upon request, the Contractor shall submit for review one representative sample for each or any lighting fixture required under this Contract. After sample acceptance, the fixture shall be sent to the project for use as a standard. In the event the submission is rejected, the fixture will be returned to the manufacturer who shall immediately make a new submission which meets the contract requirements.

B. All substitutions shall be provided as samples for review and approval.

C. Shipping: The samples must be actual working unit of fixtures to be supplied and shall be submitted complete with specified lamp(s), 120-volt driver/transformer complete with cord and plug set and ready for hanging, energizing, and examining sample shall be shipped (prepaid) by Contractor to the Lighting Designer or as otherwise specified or directed.

1.11 MOCKUPS

A. The specific design requirements of several building conditions will mandate the necessity of full scale on site mockups prior to final authorization (release) to fabricate. The Contractor shall include as part of his bid provision for complete on site mockups of the following conditions:

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>Magnitude (Extent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Walkway</td>
<td>1 pole + fixtures and brackets</td>
</tr>
<tr>
<td>L1A</td>
<td>Walkway</td>
<td>1 pole + fixtures and brackets</td>
</tr>
</tbody>
</table>
B. The Contractor shall make every effort to install all mockups to be viewed during the course of one review session. Should mockups not be ready for viewing on the scheduled mockup date, the Contractor shall be responsible for all travel rebooking fees, upcharges, and other additional fees that may occur as a result of rescheduling the mockup date.

1.12 DELIVERY, STORAGE AND HANDLING

A. Lighting fixtures shall be wrapped for protection during delivery, storage, and handling. Wet or damp wrapping shall be removed, and disposed of, to prevent staining finish.

B. Deliver materials in manufacturer’s original, unopened, protective packaging.

C. Store materials in original packaging in a manner to prevent soiling and physical damage, prior to installation.

D. Handle in a manner to prevent damage to finished surfaces.

E. Where possible, maintain protective covering until installation is complete and remove such coverings as part of final cleanup.

1.13 TECHNICAL AND ADMINISTRATIVE REQUIREMENTS

A. All information identified in the Contract Documents Schedules, Details, Layouts and Specifications shall be considered to form a complete and integrated Specification for Lighting Fixtures and Control Systems in the agreed upon Scope Areas. The Contractor shall be responsible for contacting the Landscape Architect/Engineer regarding the proper interpretation of all information indicated on the Lighting Fixture Schedules, Fixture Cuts, Details and Specifications.

B. The submission of a proposal by the Contractor will be construed as evidence that a careful, complete and thorough examination of the premises, existing job conditions and Contract Documents has been made and later claims for labor, materials or equipment required or for difficulties encountered, which could have been foreseen had such an examination been made, will not be recognized. It shall also constitute a representation that the Contractor has checked and verified all quantities, work and materials involved and shall take complete responsibility for any deficiencies encountered thereafter.

C. The Contractor shall be solely responsible for verifying all fixture quantities, lengths and clearances required and shall inform the Landscape Architect/Engineer of job conditions at variance with fixtures as specified or detailed which affect installation or location at the time bid submission is made.
D. The Contractor shall insure that the lighting fixture manufacturer shall keep on file and make available for review by the Landscape Architect/Engineer and the Owner complete Quality Control and Quality Assurance records for all phases of production for all lighting fixtures to be supplied under this project.

E. Upon request the Contractor shall submit for review by the Landscape Architect/Engineer and the Owner verification that he has solicited pricing from all manufacturers which have been listed as "prime spec" and "approved equal." Upon request the Contractor shall submit for review itemized (line item) unit equipment costs for all fixtures to be provided under the Scope of this Contract.

F. The Contractor shall be solely responsible for coordinating and expediting the timely procurement and delivery for all lighting equipment, lamps, drivers, and related components for the Project.

G. Specifications and Drawings are intended to convey the salient features, function and character of the fixtures only, and do not undertake to illustrate or set forth every item or detail necessary for the work. Minor details not usually indicated on Drawings nor specified, but that are necessary or normally required for the proper execution, completion, installation and operation of the fixtures, shall be included, the same as if they were herein specified or indicated on Drawings.

H. Omissions: The Owner shall not be held responsible for the omission or absence of any detail, construction feature, etc. which may be normally required in the production of the lighting fixtures. The full and complete responsibility for accurately purchasing, fabricating and installing the lighting fixtures described herein to the fulfillment of those specifications including compliance with all regulatory bodies (i.e. UL) shall rest solely with the Contractor.

1.14 INDUSTRY STANDARDS

A. Applicability of Standards: Except where more explicit or stringent requirements are written into the Contract Documents, applicable construction industry standards have the same force and effect as if found in or copied directly into the Contract Documents. Such industry standards are made a part of the Contract Documents by reference.

1. Referenced standards (standards referenced directly in the contract documents) take precedence over standards that are not referenced but generally recognized in the industry for applicability to the work.
2. Unreferenced standards are not directly applicable to the work, except as a general requirement of whether the work complies with recognized construction industry standards.

B. Publication Dates: Except as otherwise indicated, where compliance with an industry standard is required, comply with the latest standard in effect as of date of Contract Documents.

C. Conflicting Requirements: Where compliance with two or more standards or criteria is specified, and where these standards establish different or conflicting requirements for minimum quantities or performance quality levels, the most stringent requirement will be enforced, and henceforth provided by the Contractor unless the Contract Documents or the Owner specifically indicates otherwise. Refer requirements that are different, but apparently equal, and uncertainties as to which quality level is more stringent, to the Landscape Architect for a decision before proceeding.

D. Minimum Quantities or Quality Levels: In every instance the quantity or quality level shown or specified is intended to be the minimum to be provided or performed. Unless otherwise indicated, the actual work may either comply exactly, within specified tolerances, with the minimum quantity or quality specified, or may exceed that minimum within reasonable limits. In complying with these requirements, the indicated numeric values are minimum or maximum values, as noted or as appropriate for the context of the requirements. Refer instances of uncertainty to the Landscape Architect/Engineer for a decision before proceeding.

E. Copies of Standards: The Contract Documents require that each entity performing work be experienced in that part of the work being performed. Each entity is also required to be familiar with industry standards applicable to that part of the work. Copies of applicable standards are not bound with the Contract Documents.

1. Where copies of standards are needed for proper performance of the work the Contractor is required to obtain such copies directly from the publication source.
2. Although copies of standards needed for enforcement of requirements may be required submittals, the Landscape Architect/Engineer reserves the right to require the Contractor to submit additional copies as necessary for enforcement of requirements.

F. Abbreviations and Names:

1. Trade association names and titles of general standards are frequently abbreviated. The following acronyms of abbreviations, as referenced in Contract Documents, are defined to mean the association names. Both
names and addresses are subject to change, and are believed to be, but are not assured to be, accurate and up-to-date, as of the date of Contract Documents:


c. ANSI, American National Standards Institute, 25 W 43rd Street, 4th Floor, New York, NY 10036, Telephone: (212) 354-3300, www ANSI.org, Fax: (212) 398-0023, in-o@ansi.org.

d. ASTM, American Society for Testing and Materials, 100 Barr Harbor Drive, PO Box C700, Telephone: (610) 832-9585, West Conshohocken, PA 19428, Fax: (610) 832-9555, www.astm.org, service@astm.org.

e. AWS, American Welding Society, 550 NW Jeune Road, Telephone: (305) 443-9353, Miami, FL 33135, Fax: (305) 443-7555, www.aws.org, info@aws.org.


g. IEEE, Institute of Electrical and Electronic Engineers, 3 Park Avenue, 17th Floor, New York, NY 10016, Telephone: (212) 419-7900, www.ieee.org, Fax: (212) 752-4929, webmaster@ieee.org.

h. IESNA, Illuminating Engineering Society of North America, 120 Wall Street, 17th Floor, New York, NY 10005-4001, Telephone: (212) 248-5000, www.iesna.org, Fax: (212) 248-5017, iesna@iesna.org.

i. NEC, National Electric Code (see NFPA).

j. NEMA, National Electrical Manufacturer's Association, 1300 N. 17th St., Suite 1847, Rosslyn, VA 22209, Telephone: (703) 841-3200, www.nema.org, Fax: (703) 841-5900, gmoniznema@verizon.net.

k. NFPA, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169, Telephone: (617) 770-3000, www.nfpa.org, Fax: (617) 770-0700, publicfire@nfpa.org.

G. Federal Government Agencies: Names and titles of federal government standard or specification producing agencies are frequently abbreviated. The following acronyms or abbreviations as may be referenced in the Contract Documents indicate names of standard specification producing agencies of the federal government. Names and addresses are subject to change but are believed to be, but are not assured to be, accurate and up-to-date as of the date of the Contract Documents.


PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

B. Basis-of-Design Product: The design for each lighting fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.02 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
B. Lighting fixtures shall be of rigid construction, dimensionally stable, and shall be assembled with secure fastenings. Ferrous parts shall be protected from corrosion by plating or shall be finished with high reflectance enamel with non-yellowing binder and high pigment to binder ratio, with semi-gloss finish. Ferrous parts shall be prepared for finish by industry standard finishing process (see Finishes). Nonferrous metals (i.e. aluminum) unless otherwise noted be treated with a semi-gloss polyester powder coat enamel finish.

C. Recessed, surface or pendant lighting fixtures shall be suspended from structural members or ceiling structure members of minimum 1-1/2-inch channels, by standard bar hangers, or other approved means. Fixture locations shall be coordinated with ceiling patterns. Refer to architectural reflected ceiling plan for exact location of fixtures and architectural rooms finish schedule for ceiling construction details and mounting heights. Provide all structural steel and related supports as required or necessary to properly and safely install and support the fixtures. Conform to coordination drawings as described in Article Submittals, Paragraph Coordination Drawings.

D. Fixture wiring shall be suitable for the temperature rating of the fixture; wiring through fixture channels shall be done with Type SFF2 wire. Where a junction box is required, to change from branch circuit to fixture wiring, use approved feed through, prewired fixture wiring, and install a separate junction box. The junction box shall be fully accessible after installation of covering materials. Where flexible conduit or portable cord is used, a grounding jumper shall be installed. All fixtures shall be grounded. Housings shall be so constructed that all electrical components are easily accessible and replaceable without removing fixtures from their mountings, or disassembling adjacent construction.

E. All recessed, pendant and surface mounted lighting fixtures unless otherwise noted or directed shall be UL listed for through-wiring and shall be furnished complete with all required integral wiring and all required flexible conditions, pigtails and related accessories necessary for suitable operation and installation.

F. All materials, accessories, and other related fixture parts shall be new and free from defects which in any manner may impair their character, appearance, strength, durability and function, and be effectively protected from any damage or injury from the time of fabrication to the time of delivery and until final written acceptance of the work by the Owner.

G. Where surface mounted junction boxes are called for, the lighting manufacturer shall provide a canopy cover which completely covers the entire junction box.
H. Castings: All aluminum, iron or composite casting shall be exact replicas of the approved patterns and shall be free of sand pits, blemishes, scales and rust, and shall be smoothly furnished. Tolerance shall be provided for any shrinkage of the metal castings in order that the finished casting will accurately fit in their designated locations. Unless otherwise noted, for cast aluminum components use copper-free 319 or 443 aluminum alloy only. For cast iron components use ASTM A48-83 Class 30 gray iron.

I. Mounting Frames and Rings: If ceiling system requires, each recessed fixture shall be furnished with a mounting frame or ring compatible with the ceiling in which they are to be installed. The frames and rings shall be one piece or constructed with electrically welded butt joints and of sufficient size and strength to sustain the weight of the fixture.

J. Yokes, brackets and supplementary supporting members needed to mount lighting fixtures to carrier channels, suitable ceiling members, or other structure shall be furnished and installed by the Contractor.

K. Metal Parts: Free of burrs and sharp corners and edges. All sheet metal work shall be free from tool marks and dents.

L. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

M. Housings: Rigidly formed, minimum No. 20 gauge cold rolled steel weather- and light-tight enclosures that will not warp, sag, or deform in use.

N. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

O. For steel and aluminum fixtures all screws, bolts, nuts and other fastening and latching hardware shall be cadmium or equivalent plated. For stainless steel fixtures, all hardware shall be stainless steel. Whenever possible all fasteners shall be captive type. Where indicated provide tamper resistant fasteners.

P. Welding shall be in accordance with recommendations of the American Welding Society and shall be done with electrodes and/or methods recommended by the manufacturers of the metals being welded. Welds shall be continuous, except where spot welding is specifically permitted. Welds exposed to view shall be ground flush and dressed smooth. All welds on or behind surfaces which will be exposed to view shall be done so that finished surfaces will be free of imperfections such as pits, runs, splatter, cracks,
warping, dimpling, depressions or other forms of distortion or discoloration. All welded surfaces shall be free of weld splatter and welding oxides.

Q. Extruded aluminum frame and trim shall be rigid and manufactured from 6063-T3 aluminum alloy without blemish or warpage in the installed product. Miter cuts shall be accurate. Joints shall be flush and without burrs. Cuts shall maintain alignment with the light fixture located in its final position.

R. All extruded aluminum fixtures shall be fabricated of 6063-T3 alloy (min. wall thickness 0.120) and in all cases shall be provided with heavy gauge internal alignment brackets in order to assure tight joints and a clean level and continuous appearance after installation. Unless otherwise noted, all end plates shall be continuously welded, filled and ground prior to application of final paint finishes so as to present a clean, seamless and monolithic appearance. Exposed fasteners on end plates shall be absolutely prohibited.

S. All fixtures with removable louvers, lenses, reflectors, refractors, cones or other shielding devices shall be supplied with integral safety chains. Contractor shall be responsible for insuring that all safety chains are securely fastened to shielding device and fixture housing.

T. Exposed Fasteners: All fasteners at every product and assembly exposed to view or accessible within the public’s reach shall be tamper resistant and stainless steel.

U. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

V. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 92 percent.
2. Specular Surfaces: 87 percent.
3. Diffusing Specular Surfaces: 83 percent.

W. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

X. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and drivers. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and driver characteristics:
   a. "USE ONLY" and include specific lamp type.
b. CCT and CRI for all luminaires.

Y. All recessed fixtures, which are to be installed in insulated ceilings, shall be provided with UL listed thermocouple protection.

Z. Hinged door closure frames shall operate smoothly without binding. Where possible fabricate frames to allow lamp installation/removal without tools. Hinge mechanism shall be designed to preclude accidental falling of hinged door closure frames during relamping operations and while secured in operating position.

AA. Enclosures: Fabricate fixture enclosures with a minimum No. 20 gauge (0.0359 inch) thick cold rolled sheet steel. Enclosures may be constructed of other metals, provided they are equivalent in mechanical strength, durability and in compliance with local codes and acceptable for the purpose.

2.03 SOLID STATE LIGHTING (LED) FIXTURES

A. General:

1. Lighting fixtures shall conform to IES LM-79-08 and LM-80-08 standards.
2. All fixtures shall be RoHS compliant.
3. All fixtures shall conform with standards prepared by CIE, IES, UL, and other standards organizations as they apply to solid state lighting technologies. Including, but not limited to:
   a. 2-46 CIE/ISO standards on LED intensity measurements.
   b. TC2-50 Measurements of the optical properties of LED clusters and arrays.
   c. TC2-58, Measurements of LED radiance and luminance.
   d. TC2-63, Optical measurement of High-Power LEDs.
   e. TC2-64, High speed testing methods for LEDs.

B. Performance: Luminaire performance claims shall be measured in accordance with the requirements of IEC/PAS 62612: Edition 1: 2009-06. The testing quantity for LED package lamps shall be a minimum of twenty. The drive current and bin reference should be clearly documented.

1. All manufacturer data to include:
   a. Luminaire lumen output.
   b. Luminaire power.
   c. Luminaire efficacy.
   d. Correlated Color Temperature, CCT, and color shift over life.
   e. Color rendering index, and shift over life.
   f. Luminaire life including lumen depreciation and failure.
   g. Luminous intensity distribution.
2. Luminaire efficacy should be calculated from the initial lumen output of the luminaire that has reached thermal stability operating in an ambient temperature of 25 degrees C and based on the total power of the LEDs and driver circuit.

3. Definition of life shall comply with Clause 10 IEC/PAS 62612. Life shall be based on lumen depreciation and failure and shall consist of an endurance test. It shall be clearly noted which part of life and lumen depreciation has been measured and what part has been calculated or extrapolated.

4. Lumen depreciation shall be clearly document the length of time a complete LED luminaire provided more than a percentage of the rated luminous flux under standard test conditions. For illuminating luminaires the percentage shall be greater than 80 percent, indicated as L80 (greater than 80 percent). For direct view luminaires the percentage should be greater than 50 percent, indicated as L50.

5. Thermal Losses: The temperature of the p-n junction of the raw LED (die) (Tj) is to be measured at an ambient temperature of 25 degrees C. In a luminaire the die will be operating at a higher temperature. All performance parameters are to measure the Junction Temperature and Board Temperature.

6. Thermal Protection: All fixtures shall be provided with appropriate heat sink to maintain lamp life. Stated lamp life and output shall be measured and identified and documented with heat sink. Any variations from stated life or output without heat sink shall be clearly identified including Junction Temperature.

7. Warranty: Entire fixture shall carry a minimum 5-year warranty with an additional $25 per fixture labor allowance for premature failure.

C. Photometry: All fixtures shall be provided with absolute photometric tests and conducted in accordance with IES LM-79-08 Photometric Measurements of Solid State Lighting Products. Any deviations such as higher or lower drive currents or dies from other bins are to be clearly identified. Correction factors are to be provided with the results.

D. Drivers:

1. Constant Current Drivers (non-dimming): All constant current drivers shall be UL 1310, Class 2, including short-circuit protection, high-power factor, with either 12V or 24V input, unless otherwise noted. The driver shall operate on the voltage they are connected to, 120V or 277V input power. Variability in output shall not exceed 5 percent in load or 1 percent line levels. Driver shall be designed for use in minus 40 degrees C environments with a high temperature tolerance of plus 60 degrees ambient, 80 degrees C case rating. Total harmonic
2. PWM Dimming Drivers: All PWM dimming drivers shall be UL 1310, Class 2, including short-circuit protection, high-power factor, with either 12V or 24V input, unless otherwise noted. The light output of the LED shall be controlled by DC voltage applied to the control input (0V to 10V) with a maximum of 500 micro-amps per driver. The control equipment must not impose a voltage greater than 11.0V peak maximum on the driver terminals and the short-term transient voltage must not exceed 14-volt. Control equipment intended to control more than one driver must be capable of sinking the current supplied to the control bus by the maximum number of drivers specified for the control device. The control terminals for the driver shall be isolated from the power lines and suitable for use as Class II terminals. Maximum voltage drop not to exceed 0.2 volts. Variability in output shall not exceed 5 percent in load or 1 percent line levels. Driver shall be designed for use in minus 40 degrees C environments with a high temperature tolerance of plus 60 degrees ambient, 80 degrees C case rating. Total harmonic distortions shall not exceed 20 percent with a current crest factor of 1.5 maximum. All drivers shall be field replaceable.

3. Electrical Basis of Design: 0.5 mA driver source current input; 25 mA max per control system dimming output. Any deviations that result from Contractor proposed fixture substitutions shall be brought to the Lighting Designer and Engineer’s attention. The IEC standard for current sink controls (Standard 60929 Annex E) must be followed.

E. Lamp Module:

1. All manufacturer data to include LED module information including, but not limited to:
   a. Manufacturer of the LED module with part number or other device identifier.
   b. LED module drive current, voltage, power.
   c. LED module lumen depreciation curves, life, CCT, CRI at an ambient temperature of 25 degrees C.
   d. Board temperature of the LED module installed in the luminaire with proper heat sink, when the luminaire is operating an ambient temperature of 25 degrees C.
   e. The color bin, CCT, and color shift variation of the LED module at the operating board temperature.
   f. Color rendering index at the operating board temperature.

2. LED lamp modules shall be minimum CRI of 80 with tolerances as identified in Clause 7 IEC/PAS 62612.

3. White LED modules shall be available in 2700K, 3000K, 3500K, and 4000K, or as identified in lighting fixture schedule.
2.04 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Section Hangers and Supports for Electrical Systems, for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.


E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12-gauge.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

2.05 FINISHES

A. Painted surfaces shall be synthetic enamel with acrylic, alkyd, epoxy, polyester or polyurethane base, light stabilized, baked on at 350 degrees F minimum, catalytically or photo chemically polymerized after application.

B. White finishes minimum 90 percent reflectance (semi-gloss).

C. Selection: Unless otherwise indicated, all external fixture finishes shall be as selected by the Landscape Architect/Engineer. Unless otherwise indicated, all fixture finishes shall be semi-gloss polyester powder coat enamel (color to be selected by Landscape Architect).

D. Undercoat: Except for stainless steel all ferrous metal surfaces shall be given a five stage phosphate treatment or other acceptable base bonding treatment before final painting and after fabrication.

E. Unpainted nonreflecting surfaces shall be satin finished and coated with a baked-on clear lacquer to preserve the finish. Where aluminum surfaces are treated with an anodic process, the clear lacquer coating may be omitted.

F. Unpainted Aluminum Surfaces: Finish interior aluminum trims with an anodized coating of not less than 7 mg per square inch, of a color and surface finish as selected by the Landscape Architect/Engineer. Finish exterior aluminum and aluminum trims with an anodized coating of not less than
35 mg per square inch of a color and surface finish as selected by the Landscape Architect/Engineer.

G. Metal Finishes:

1. Provide finishes of the color and type indicated and having the following properties:
   a. Protection of Metal from Corrosion: 5-year warranty against perforation of erosion of the finish from weathering.
   b. Color Retention: 5-year warranty against fading, staining, or chalking from weathering including solar radiation.
   c. Uniformity: Provide finish of uniform thickness and color, free from streaks, stains or orange peel texture.

2.06 REFLECTORS

A. Reflectors, cones or baffles shall be absolutely free of spinning lines, stains, ripples or any marks or indentations caused by riveting to other assembly techniques.

1. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

B. All fixtures with removable reflectors, louvers or baffles shall be supplied with safety chains.

C. Where stem/mounted pendant fixtures are indicated provide a minimum of three cable supports to minimize sway. Cable supports shall be stainless steel woven wire (or equivalent).

D. Cone flanges shall be formed as an integral part of the cone and shall have identical color and finish as the cone, except as shown. The flange's major surface shall be perpendicular to the cone axis.

E. The reflecting surface of the cone or reflector shall be tested for proper sealing. Test per ASTM B136-63T. If any stain is visible, the specimen shall not be considered to have been properly sealed. Reflector cones shall be free of manufactured defects. The reflector inner surface shall be free of water spotting and shall maintain a reflectivity ratio of not less than 83 percent on clear specular finish.

F. All Alzak parabolic cones shall be guaranteed by the manufacturer against discoloration for a minimum of 10 years and in the event of premature discoloration shall be replaced by the manufacturer (including both materials and the cost of labor) at no cost to the Owner.
2.07 LENSES, LOUVERS AND DIFFUSERS

A. All lenses, diffusers, and shielding media shall be properly and securely mounted within fixture assemblies. All shielding materials shall be tightly fitted with no loose panels or parts and shall show no visible light leaks of unintentional or unscheduled light.

B. All fixtures with removable cones, louvers or other shielding devices shall be supplied with safety chains. Contractor shall be responsible for ensuring that all safety chains are securely fastened to housing and shielding device.

C. Unless otherwise indicated, all plastic shielding, lenses and diffusers shall be white opal clear 100 percent UV stabilized virgin acrylic or in special cases high impact polycarbonate (lexan). Use of polycarbonate lenses shall be restricted to those areas outlined in the National Electric Code (latest Bulletin). Use of polystyrene components is absolutely prohibited.

D. Plastic for lenses and diffusers shall be formed of colorless 100% virgin acrylic as manufactured by Rohm & Haas, DuPont, G.E. or equally acceptable manufacturers. The quality of the raw material must meet American Society of Testing Materials (ASTM) standards, as tested by an independent test laboratory. Acrylic plastic lenses and diffusers shall be properly cast, molded or extruded as specified and shall remain free of any dimensional instability, discoloration, embrittlement or loss of light transmittance for at least 15 years.

E. Unless otherwise indicated, all glass shielding, diffusers or lenses shall be clear tempered borosilicate glass. Soda lime glass material shall not be acceptable. Submit samples of glass elements upon request.

F. Glass used for lenses, refractors and diffusers lighting fixtures shall be tempered for high impact and heat resistance. Minimum transmittance equals 92 percent. For exterior fixtures use tempered borosilicate glass, Corning No. 7740, “or-equal.” For fixtures directly exposed to the elements and aimed above the horizontal with a radiant energy of 4.16 watts per square inch or greater, use Corning Vycor glass, “or-equal.”

G. Optical lenses shall be free from spherical or chromatic aberrations and other imperfections, which may hinder the functional performance of the lenses.

H. All lenses, louvers or other light diffusing elements shall be removable but positively held so that hinging or other normal motion will not cause them to drop out. Lay-in type lenses and Louvers are not acceptable.
2.08 STEMS

A. Each stem shall have a brass or steel swivel, hang straight, or other self-aligning device.

B. Wherever a fixture or its hanger canopy is applied to a surface mounted outlet box a finishing ring shall be utilized to conceal the box.

C. Unless otherwise indicated, all stems shall match in color and finish the color of the fixture which they support.

D. Stems shall be free of clamp marks, scratches and all other visual imperfections.

E. Unless otherwise indicated, stems shall be provided in order to adequately mount and level each fixture run with proper structural support per manufacturer's recommendations.

F. Install pendant lighting fixtures plumb and at a height from the floor as specified on Drawings. In cases where conditions make this impractical, refer to the Landscape Architect/Engineer for direction. Use ball aligners and canopies on pendant fixtures unless otherwise noted.

G. Space stems equally spaced every fixture run. If field conditions or fixture construction do not allow for this condition, the installing Contractor shall immediately notify the Landscape Architect/Engineer prior to commencement of the work.

2.09 MISCELLANEOUS

A. Where (or if) indicated all remote step-down transformers and drivers shall be properly wired to fixtures to ensure that voltage drop does not exceed 5 percent, regardless of transformer's or ballast's location.

B. All remote step-down transformers and drivers shall be mounted in approved NEMA type enclosures and only located in areas previously deemed to be readily accessible by the Owner’s maintenance personnel.

C. Where indicated, all uplight or wallwash coves utilizing LED equipment shall be installed so as to produce a continuous and unbroken band of light free of visual imperfections, socket shadows, light gaps, etc. The inability to provide this appearance shall be brought immediately to the Landscape Architect's/Engineer's attention prior to installation.

D. All fixture lengths whether straight or curvilinear shall be fabricated based upon the fixture manufacturer's or contractor's field verified dimensions only.
E. Fixture manufacturer shall coordinate conduit entry locations with installing contractor.

2.10 POLES AND STANDARDS

A. General: Provide poles of the types and heights indicated. U.O.N., provide internal raceway for underground power supply, with luminaire support poles base indicated. Provide poles that will carry the indicated supports, luminaires and appurtenances, at the required heights above grade, without excessive deflection or whipping of the luminaire, when subjected to 100 mph winds with a 1.3 gust factor or local wind speeds/gusts, whichever is more stringent.


1. Provide Class 3 pressure treated Southern Yellow Pine, 0.60 CCA timber poles.
2. Installation: Bury 10 percent of total pole length plus an additional 2 feet.
3. Protect conduit from ground level to 10 feet up the pole or as designated by local electrical code.
4. All wood poles shall comply with all requirements as designated by ANSI O5.1-2002.

2.11 LUMINAIRE MOUNTING

A. General: Provide corrosion resistant metal luminaire mounting compatible with the poles and fixtures that will not cause galvanic action at contact points.

B. Mast Arms: Provide steel mast arm, fabricated from 3-inch pipe with span and rise as indicated, and continuously welded to pole attachment plate.

C. Brackets: Provide brackets, cantilevered and without underbrace of the sizes, styles and finishes indicated with straight tubular and section to accommodate the luminaire.

D. Pole-Top Tenon: Provide [corrosion resistant steel] tenon securely fastened to the top of the pole shaft fabricated to accept and rigidly support the luminaire to be mounted thereon.
PART 3 EXECUTION

3.01 INSTALLATION

A. Lighting Fixtures:

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
2. Install lamps in each luminaire.

B. Temporary Lighting: If it is necessary, and approved by Owner, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall. If permanent luminaires are damaged in any way during construction, the Contractor shall be responsible for replacing said luminaires at his own cost.

C. The Contractor shall furnish and install lighting fixtures as noted on Drawings. Fixtures shall be completely wired and lamps installed and shall be in perfect operating condition at the time of completion.

D. Setting and Securing: The Contractor shall set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved Shop Drawings. Conform to the requirements of NFPA 70.

E. Coordination: The Installing Contractor shall communicate with other trades as appropriate to properly interface, schedule and coordinate installation of lighting fixtures with other work.

F. Grounding: The Contractor shall ground noncurrent carrying parts of electrical equipment. Where the copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

G. Installation of fixture locations shall be in strict accordance with the intent of the Contract Drawings and approved shop, Specifications and Drawings.

H. Instructions: Each lighting fixture shall be packaged with complete illustration and instructions showing how to install. Install lighting fixtures in strict conformance with manufacturer's recommendations and instructions.

I. The Contractor shall support all lighting fixtures independently of ductwork or piping.
J. Splices in internal wiring shall be made with approved insulated "wire nut" type mechanical connectors, suitable for the temperature and voltage conditions to which they are subjected.

K. All wire utilized for connections to or between individual lamp sockets and lamp auxiliaries (i.e., wires which do not constitute "through circuit" wiring) shall be suitable for temperature, current, and voltage conditions to which it is subjected.

L. Mounting: Mounting heights specified or indicated are to bottom of fixture for suspended and 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 installation in commenced and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed.

M. Remote Mounting of Drivers: Distance between the driver and fixture shall not exceed that recommended by driver manufacturer. Verify, with driver manufacturers, maximum distance between driver and luminaire.

N. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.
   1. Install ceiling support system rods or wires for each fixture. Locate not more than 6 inches from lighting fixture corners.
   2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
   3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
   4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

O. Suspected Lighting Fixture Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
   4. Do not use grid ductwork or piping as support for pendant luminaires. Connect support wires or rods to building structure.
P. Connect wiring according to Section Low-Voltage Electrical Power Conductors and Cables.

Q. Fixture locations: Do not scale electrical drawings for exact location of the lighting fixtures. In general, the Landscape Architect’s plans indicate the proper locations of lighting fixtures, unless otherwise noted on Drawings.

R. Unless otherwise shown on the Contract Drawings, lighting fixtures and/or fixture outlet boxes shall be provided with hangers to adequately support the complete weight of the lighting fixture. The design of hangers and the method of fastening other than what is shown on the Contract Drawings, or herein specified, shall be submitted to the Landscape Architect/Engineer for approval.

S. The Contractor shall provide all hangers, rods, mounting brackets, supports, frames, earthquake clips and other equipment normally required for the proper, safe and distortion-free installation in the various surfaces in which they appear. Determine surface types from the architectural drawings.

T. The Contractor shall rigidly align continuous rows of lighting fixtures for true aligned appearance.

U. The Contractor shall install reflector cones, baffles, aperture plates, light controlling elements for air handling fixtures and decorative elements after completion of ceiling tiles, painting and general cleanup.

V. The Contractor shall replace blemished, damaged, or unsatisfactory fixtures as directed by the Owners’ representative.

W. All pendant mounted lighting fixtures within the same room or area shall be installed plumb, and at a uniform height from the finished floor. Adjustment of desired height (if required) shall be made during the installation phase. Unless otherwise shown on the Contract Drawings, stems and canopies shall be matched to the associated lighting fixtures.

X. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.

Y. Adjust aimable lighting fixtures to provide required light intensities.

3.02 ADJUST AND CLEAN

A. Clean: Clean lighting fixtures of dirt and debris upon completion of installation.
B. Protection: Protect installed fixtures from damage during remainder of construction period.

3.03 FIELD QUALITY CONTROL

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

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

C. Tests: Upon completion of installation of lighting fixtures, and after building circuits have been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

3.04 STARTUP SERVICE

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner.

3.05 AIMING AND ADJUSTING

A. All adjustable lighting units shall be aimed, focused, locked, etc., by the Contractor under the supervision of the Lighting Designer. The Lighting Designer shall indicate the number of crews (foreman and apprentice) required. All aiming and adjusting shall be carried out after the entire installation is complete. All ladders, scaffolds, lift equipment, safety belts, flashlights, walkie talkie equipment, etc. required shall be furnished by the Contractor at the direction of the Lighting Designer. As aiming and adjusting is completed, locking set screws and bolts and nuts shall be tightened securely.

B. Night Work: Where possible, units shall be focused during the normal working day. However, where daylight interferes with seeing, aiming shall be accomplished at night.

C. Prior to final inspection, relamp all fixtures which have failed lamps, or lamps where visible color shift has occurred, and leave all lighting fixtures, equipment, and accessories in good, uniform operating condition. The Contractor shall replace any burned-out lamp during the first 100 days after the completion of the Contract.
D. Occupancy Adjustments: When requested within 12 months of date of final written acceptance by the Owner, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.

1. Adjust aimable luminaires in the presence of Owner/Lighting Designer.
2. As/if required, aiming shall be accomplished at night.

3.06 LUMINAIRE INSTALLATION

A. General: Install luminaires at locations and heights as indicated, in accordance with the manufacturer's written instructions, applicable requirements of NFPA 70, ANSI C2, and with recognized industry practices to ensure that lighting installation fulfills requirements.

B. Support: Fasten luminaires securely to indicated structural supports; and check to ensure that the required degree of freedom is provided to allow alignment or aiming of the fixtures for indicated light distribution.

C. Condition: Clean luminaires of dirt and debris upon completion of installation. Do not damage finishes or lens or refractor surfaces.

D. Grounding: Provide equipment grounding connections using branch circuit equipment and connected sufficiently tight to assure a permanent and effective ground.

END OF SECTION
PART 1  GENERAL

1.01  DEFINITIONS

A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2-inch caliper to a depth of 6 inches below subgrade.

D. Scalping: Removal of sod without removing more than upper 3 inches of topsoil.

E. Stripping: Removal of topsoil remaining after applicable scalping is completed.

F. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.02  SUBMITTALS

A. Action Submittals: Drawings clearly showing clearing, grubbing, and stripping limits.

1.03  QUALITY ASSURANCE

A. Obtain Engineer’s approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.04  SCHEDULING AND SEQUENCING

A. Prepare Site only after adequate erosion and sediment controls are in place.
PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Clear, grub, and strip areas actually needed for waste disposal, borrow, or Site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.

3.02 LIMITS

A. As follows, but not to extend beyond Project limits.

1. Excavation: 5 feet beyond top of cut slopes.
2. Fill:
   a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.
   b. Stripping and Scalping: 2 feet beyond toe of permanent fill.
3. Waste Disposal:
   a. Clearing: 5 feet beyond perimeter.
   b. Scalping and Stripping: Not required.
   c. Grubbing: Around perimeter as necessary for neat finished appearance.
5. Overhead Utilities:
   b. Scalping and Stripping: Wherever grading is required.
6. River and Reservoir Areas:
   a. Clearing: 5 feet beyond perimeter of excavations, permanent fills, or structures.
   b. Grubbing: Not required, except within excavations, permanent fills, or structures.
7. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.03 TEMPORARY REMOVAL OF INTERFERING PLANTINGS

A. Remove and store, as specified in Section 32 93 00, Planting and Fine Grading, shrubs and trees that are not designated for removal but do interfere with construction or could be damaged by construction activities.
B. Photograph and document location, orientation, and condition of each plant prior to its removal. Record sufficient information to uniquely identify each plant removed and to assure accurate replacement.

3.04 CLEARING

A. Clear areas within limits shown or specified.
B. Fell trees so that they fall away from facilities and vegetation not designated for removal.
C. Cut stumps not designated for grubbing flush with ground surface.
D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

3.05 GRUBBING

A. Grub areas within limits shown or specified.

3.06 SCALPING

A. Do not remove sod until after clearing and grubbing is completed and resulting debris is removed.
B. Scalp areas within limits shown or specified.

3.07 STRIPPING

A. Do not remove topsoil until after scalping is completed.
B. Strip areas within limits to minimum depths shown or specified. Do not remove subsoil with topsoil.
C. Stockpile strippings, meeting requirements of Section 32 91 13, Soil Preparation, for topsoil, separately from other excavated material.

3.08 TREE REMOVAL OUTSIDE CLEARING LIMITS

A. Remove Within Project Limits:
   1. Dead, dying, leaning, or otherwise unsound trees that may strike and damage Project facilities in falling.
   2. Trees designated by the Owner.
B. Cut stumps off flush with ground, remove debris, and if disturbed, restore surrounding area to its original condition.
3.09 SALVAGE

A. Saleable log timber may be sold to Contractor’s benefit. Promptly remove from Project Site.

B. Sod with commercial value may be sold to Contractor’s benefit. Promptly remove from Project Site.

3.10 DISPOSAL

A. Clearing and Grubbing Debris:

1. Dispose of debris offsite.
2. Burning of debris onsite will not be allowed.
3. Limit offsite disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities, and that will not be visible from Project.

B. Scalpings: As specified for clearing and grubbing debris.

C. Strippings:

1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required for topsoil offsite.
2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

END OF SECTION
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft³ (600 kN-m/m³)).
   b. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft³ (2,700 kN-m/m³)).

1.02 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 31 23 23, Fill and Backfill.

B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.

C. Prepared Dam Subgrade: Bedrock surface after completion of clearing and grubbing, demolition of existing structures, removal of sediment and debris, dewater, excavation to grade.

D. Prepared Grouted Core Rock Subgrade: Bedrock surface after completion of clearing and grubbing, demolition of existing structures, removal of sediment and debris, dewatering, and excavation to grade.

E. Prepared Riprap Subgrade: Surface of existing riprap after removal of sediment and debris, vegetative growth, and other interfering or objectionable material.

F. Relative Compaction: As defined in Section 31 23 23, Fill and Backfill.

G. Relative Density: As defined in Section 31 23 23, Fill and Backfill.

H. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.
I. Proof-Rolling: Testing of subgrade by compactive effort to identify areas that will not support the future loading without excessive settlement.

1.03 SEQUENCING AND SCHEDULING
A. Complete applicable Work specified in Sections 02 41 00, Demolition; 31 10 00, Site Clearing; and 31 23 16, Excavation, prior to subgrade preparation.

1.04 QUALITY ASSURANCE
A. Notify Engineer when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

1.05 ENVIRONMENTAL REQUIREMENTS
A. Prepare subgrade when unfrozen and free of ice and snow.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL
A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.
B. Bring subgrade to proper grade and cross-section and uniformly compact surface.
C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.
D. Maintain prepared ground surface in finished condition until next course is placed.

3.02 COMPACTION
A. Under Earthfill: Compact upper 9 inches to minimum 90 percent relative compaction as determined in accordance with ASTM D698.

B. Under Pavement Structure, Floor Slabs On Grade, or Granular Fill Under Structures: Compact the upper 9 inches to minimum of 98 percent relative compaction as determined in accordance with ASTM D698 within 2 percentage points of the material’s optimum moisture content.
C. Bedrock Subgrade: Not required.

3.03 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

C. Bedrock Subgrade: Keep bedrock surface moist at all times.

3.04 TESTING

A. Proof-roll subgrade with equipment specified in Article Compaction to detect soft or loose subgrade or unsuitable material, as determined by Engineer.

B. Bedrock subgrade shall be inspected and sounded by a

3.05 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact, or
2. Over excavate as specified in Section 31 23 16, Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

B. Unsuitable Material: Over excavate as specified in Section 31 23 16, Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

3.06 DAM FOUNDATION SUBGRADE PREPARATION

A. No materials shall be placed in any portion of the dam foundation until the foundation for each section has been dewatered, stripped, excavated to grade, and suitably prepared, and has been approved by the Engineer.

B. All cavities, depressions, and irregularities, either existing or resulting from removal of loose or weathered rock fragments found within the area to be covered by concrete and which extend below or beyond the established lines of excavation for the dam shall be filled with concrete fill as specified for the overlying dam structure and/or treated by slush grouting and dental concrete.

C. All joints, shear zones, cracks, openings, and irregularities shall be adequately cleaned out and treated with slush grouting or dental concrete, or in other areas directed by the Engineer.
D. The suitability of each section of the foundation for placing dam materials thereon will be determined by the Engineer. No concrete materials shall be placed when the subgrade is frozen.

E. The bottom and side slopes of excavation upon or against which concrete is to be placed shall be excavated to the required dimensions as shown on Drawings. No material will be permitted to extend within the neatlines of the structure.

F. If, at any point in rock or foundation materials, the natural foundation material is disturbed or loosened, it shall be removed and replaced with concrete fill.

G. Immediately prior to placing the first layer of concrete, all bedrock surfaces upon or against which the concrete is to be cast against shall be cleaned of all loose and objectional materials in an approved manner by handwork, barring, picking, brooming, air jetting, or other effective means. Such surfaces shall be properly moistened and sufficiently cleaned so that the concrete will bond intimately to the surfaces. Standing water shall be removed from depressions prior to placement of concrete. All open joints, cracks, and fissures in the foundation shall be cleaned of all loose material and loose bedrock material to a depth equal to at least three times their width, or to a depth where the opening is 0.5-inch-wide or less, whichever depth is greater, but not to exceed 2 feet and backfilled as directed with either slush grout or dental concrete.

H. Vertical bedrock surfaces shall not be more than 4 feet in height, and benches of sufficient width shall be provided as necessary so that the average slope of any bedrock excavation is not steeper than one horizontal to two vertical. Resloping of bedrock surfaces shall be accomplished by the method that results in the least damage to the formation left in place.

I. Exposed finished excavated surfaces shall be kept moist at all times to prevent evaporation of the natural moisture in the material and shall be protected from freezing. Exposure of excavated bedrock foundation surface upon which concrete is to be placed shall be limited to 48 hours, which time shall commence at the completion of each portion of the excavation, and which will include the time required for final cleanup and surface treatment. Contractor shall mobilized sufficient equipment, materials, and manpower prior to the start of final excavation in order to limit the exposure time so specified. At Contractor’s option, he/she may complete the excavation to final grade without leaving temporary cover of unexcavated material provided that time of exposure of the final excavated surface is limited as described herein and a depth of 3 feet of temporary loose earthfill is placed over the surface to protect it from air slaking and freezing. The temporary loose earthfill shall be completed removed and the bedrock subgrade cleaned and treated prior to
J. Surfaces to receive concrete upon or against shall be cleaned of all loose material, dirt, dust, mud, standing water, and other foreign matter.

K. Slush Grouting Foundations:

1. Where directed by the Engineer, apply slush grouting to cracks, crevices, or broken or fractured portions of the prepared bedrock surface under the areas to receive concrete and other areas as directed. Use of slush grouting shall only be at the direction of the Engineer.

2. Materials: the slush grout shall be composed of neat cement grout or cement, sand, ad water. The ratios of the materials may vary as directed by the Engineer, but the ratio of sand to cement will not exceed 2 parts sand to 1 part cement. Adequate water shall be mixed thoroughly into the cement or cement and sand mixes to produce a workable mixture for proper placement as approved by the Engineer. The grout mixture shall be prepared with a mechanical mixer and shall be used within 30 minutes after mixing.

3. Placement: Slush grout shall be used to fill foundation surface cracks, crevices, and fractures at locations directed by the Engineer. Slush grout shall not be used to cover exposed areas of the bedrock subgrade. All joints, cracks, crevices, and fractures to be treated shall be thoroughly cleaned of all loose materials as noted above and shall be wetted immediately prior to placement of the slush grout material. Placement of slush grouting shall be by brooming into all cracks, crevices, and fractures with a stiff-bristled broom or other approved method, but grout layers shall not be left on the foundation beyond the edge of the crack, crevice, or fracture. Fished surfaces of slush grouting shall be left in a roughened, broomed finish to provide a satisfactory bonding surface for the concrete.

4. The quantity of slush grout is uncertain, and the contractor shall be entitled to no additional allowance above the bid price in the schedule by reason of increased or decreased quantities awarded.

L. Dental Concrete:

1. Where directed by the Engineer, place dental concrete in exposed areas of broken, fractured, or sheared portions of the dam foundation surface; gate structures; end walls or training walls; and at other locations as directed by the Engineer. Dental concrete shall be used in areas too large to be satisfactorily treated by slush grouting and volumes too small to be satisfactorily filled by concrete placement as determined by the Engineer.
2. Materials: Dental concrete shall be lean concrete conforming to Concrete Fill.

3. Placing Dental Concrete: Where it is not practicable to excavate local overhanging rock faces or rock faces steeper than 0.5 horizontal to 1 vertical without detrimental blasting or excessive material excavation, the rock faces shall be solidly faced with dental concrete to provide abutment contact slopes not steeper than 0.5 horizontal to 1 vertical.

4. Where soft zones or areas exist in the surface of the foundation, they shall be excavated to the extent directed and backfilled with dental concrete. Soft zones are defined as those which can be hand-excavated with a shovel or consist of loose, detached, or hollow sandstone.

5. Designated voids shall be properly excavated and cleaned of all loose materials as approved by the Engineer. Open joints, shear zones, and fractured areas shall be cleaned. Dental concrete shall be placed as required to form a tight, unfractured foundation surface against which the dam or concrete structure may be placed.

6. Finished surfaces of dental concrete shall be left in a roughened, broomed finish to provide a satisfactory bonding surface for the concrete materials.

7. The quantity of dental concrete is uncertain, and the contractor shall be entitled to no additional allowance above the bid price in the schedule by reason of increased or decreased quantities awarded.

3.07 GROUTED CORE ROCK SUBGRADE PREPARATION

A. No materials shall be placed in any portion of the grouted core rock foundation until the foundation for each section has been dewatered, stripped, excavated to grade, and suitably prepared, and has been approved by the Engineer.

B. All cavities, depressions, and irregularities, either existing or resulting from removal of loose or weathered rock fragments found within the area to be covered by concrete and which extend below or beyond the established lines of excavation for the dam shall be filled with concrete fill.

C. The suitability of each section of the foundation for placing grouted core rock materials thereon will be determined by the Engineer. No concrete materials shall be placed when the subgrade is frozen.

D. The bottom and side slopes of excavation upon or against which grouted core rock is to be placed shall be excavated intact sandstone bedrock as approved by the Engineer.

E. If, at any point in rock or foundation materials, the natural foundation material is disturbed or loosened, it shall be removed and replaced with concrete fill.
F. Immediately prior to placing the first layer of concrete, all bedrock surfaces upon or against which the concrete is to be cast against shall be cleaned of all loose and objectional materials in an approved manner by handwork, barring, picking, brooming, air jetting, or other effective means. Such surfaces shall be properly moistened and sufficiently cleaned so that the grouted riprap will bond intimately to the surfaces. Standing water shall be removed from depressions prior to placement of grouted core rock.

3.08 RIPRAPH SUBGRADE PREPARATION

A. Prior to placing riprap against existing riprap, prepare existing riprap surface. Remove and dispose of debris, interfering or objectionable material, silt, vegetative matter, wood, standing water, and damaged riprap. Modify riprap surface to stable configuration by working into a stable position. Obtain Engineer’s approval of final subgrade prior to placing riprap on riprap subgrade.

END OF SECTION
PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:
   1. Excavation Plan, Detailing:
      a. Methods and sequencing of excavation.
      b. Proposed locations of stockpiled excavated material.
      c. Proposed onsite and offsite spoil disposal sites.
      d. Numbers, types, and sizes of equipment proposed to perform excavations.
      e. Anticipated difficulties and proposed resolutions.

1.02 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

1.03 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Excavation to finish grade shall protect subgrade from freezing, desiccation, and disturbance as described in Section 31 23 13, Subgrade Preparation.

C. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.04 SEQUENCING AND SCHEDULING

A. Demolition: Complete applicable Work specified in Section 02 41 00, Demolition, prior to excavating.

B. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 31 10 00, Site Clearing, prior to excavating.

C. Dewatering: Conform to applicable requirements of Section 31 23 19.01, Dewatering, prior to initiating excavation.
D. Excavation Support: Install and maintain, as specified in Section 31 41 00, Shoring, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1 foot, except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

B. Do not overexcavate without written authorization of Engineer.

C. Remove or protect obstructions as shown and as specified in Section 01 50 00, Temporary Facilities and Controls, Article Protection of Work and Property.

D. Blasting is not allowed. Excavate all soil and bedrock using mechanical and/or non-explosive methods to lines and grades shown. Excavation methods shall protect existing bedrock subgrades and surfaces to remain from disturbance.

E. Bedrock excavation means and methods shall not impart disturbance or damage to bedrock subgrade beyond the limits of excavation. Protect existing bedrock subgrades to remain from disturbance or damage. Loose or disturbed material created by contractor’s methods shall be removed by the Contractor and disposed offsite as directed by the Engineer at Contractor’s expense.

3.02 UNCLASSIFIED EXCAVATION

A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.

B. Ground surface in the river channel varies from that shown due to natural variation in sediment river flows, seasonal variations, and dam operations. Field verify existing grades and bedrock surface conditions prior to construction.

C. Make own assessment of bedrock surface conditions, weathering profile, and excavation requirements.
3.03 TRENCH WIDTH

A. Minimum Width of Trenches:

1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
   a. Less than 4-inch Outside Diameter or Width: 18 inches.
   b. Greater than 4-inch Outside Diameter or Width: 18 inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.

2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench:
   18 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.

3. Increase trench widths by thicknesses of sheeting.

B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

3.04 EMBANKMENT AND CUT SLOPES

A. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.

B. Remove stones and rock that exceed 3-inch diameter and that are loose and may roll down slope. Remove exposed roots from cut slopes.

C. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

D. Bedrock excavation shall be no higher than 4 feet in vertical cut. Overall bedrock excavation shall be stepped to have an overall average slope of 0.5 horizontal to 1 vertical. Any undercutting of bedrock shall be trimmed to sound undisturbed bedrock with a positive slope.

3.05 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.

B. Excavated sandstone bedrock is unsuitable for reuse as riprap, grouted core rock, or other aggregate.
C. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

D. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

E. Do not stockpile excavated material adjacent to trenches and other excavations, unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

F. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.06 DISPOSAL OF SPOIL

A. Dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill, offsite.

B. Dispose of debris resulting from removal of underground facilities as specified in Section 02 41 00, Demolition, for demolition debris.

C. Dispose of debris resulting from removal of organic matter, trash, refuse, and junk as specified in Section 31 10 00, Site Clearing, for clearing and grubbing debris.

END OF SECTION
PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:
   2. Well permits.
   3. Discharge permits.
   4. Water Level Elevations Observed in Observation Wells: Submit same day measured.
   5. Settlement Benchmark Elevations: Submit weekly record.

1.02 WATER CONTROL PLAN

A. As a minimum, include:
   1. Descriptions of proposed groundwater and surface water control facilities including, but not limited to, equipment; methods; standby equipment and power supply, pollution control facilities, discharge locations to be utilized, and provisions for immediate temporary water supply as required by this section.
   2. Drawings showing locations, dimensions, and relationships of elements of each system.
   3. Design calculations demonstrating adequacy of proposed dewatering systems and components.

B. If system is modified during installation or operation revise or amend and resubmit Water Control Plan.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. For construction of project components within the Arkansas River corridor which may be damaged by flooding, continuously control water during course of construction, including weekends and holidays and during periods of work stoppages, and provide adequate backup systems to maintain control of water. Coordinate project dewatering with cofferdamming and diversion activities.
B. For Other Portions of Project: Remove and control water during periods when necessary to properly accomplish Work.

C. Contractor is responsible for making his/her own hydraulic calculations and judgements regarding the planning and execution of measures to dewater.

3.02 SURFACE WATER CONTROL

A. See Section 01 50 00, Temporary Facilities and Controls, Article Diversion and Care of Water.

B. Remove surface runoff controls when no longer needed.

3.03 DEWATERING SYSTEMS

A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain groundwater level a minimum of 2 feet below the lowest point of excavations in soil and at or below the lowest point of excavations in bedrock. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade.

B. Design and Operate Dewatering Systems:

1. To prevent loss of ground as water is removed.
2. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
3. To relieve artesian pressures and resultant uplift of excavation bottom.

C. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.

3.04 DISPOSAL OF WATER

A. Obtain discharge permit for water disposal from authorities having jurisdiction.

B. Treat water collected by dewatering operations, as required by regulatory agencies, prior to discharge.

C. Discharge water as required by discharge permit and in manner that will not cause erosion or flooding, or otherwise damage existing facilities, completed Work, or adjacent property.

D. Remove solids from treatment facilities and perform other maintenance of treatment facilities as necessary to maintain their efficiency. Dispose of solids offsite.
3.05 PROTECTION OF PROPERTY

A. Make assessment of potential for dewatering induced settlement. Provide and operate devices or systems, including but not limited to reinjection wells, infiltration trenches and cutoff walls, necessary to prevent damage to existing facilities, completed Work, and adjacent property.

B. Securely support existing facilities, completed Work, and adjacent property vulnerable to settlement due to dewatering operations. Support shall include, but not be limited to, bracing, underpinning, or compaction grouting.

END OF SECTION
PART 1      GENERAL

1.01      REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   d. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft$^3$ (600 kN-m/m$^3$)).
   e. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
   f. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2,700 kN-m/m$^3$)).
   g. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   i. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02      DEFINITIONS

A. Relative Compaction:

1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D698.
2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Engineer.
B. Optimum Moisture Content:
   1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
   2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

E. Completed Course: A course or layer that is ready for next layer or next phase of Work.

F. Lift: Loose (uncompacted) layer of material.

G. Geosynthetics: Geotextiles, geogrids, or geomembranes.

H. Well-Graded:
   1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
   2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
   3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

I. Influence Area:
   1. Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:
      a. 1 foot outside outermost edge at base of foundations or slabs.
      b. 1 foot outside outermost edge at surface of roadways or shoulder.
      c. 0.5 foot outside exterior at spring line of pipes or culverts.

J. Borrow Material: Material from required excavations or from designated borrow areas on or near Site.

K. Selected Backfill Material: Materials available onsite that Engineer determines to be suitable for specific use.
L. Imported Material: Materials obtained from sources offsite, suitable for specified use.

M. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

N. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.


1.03 SUBMITTALS

A. Action Submittals:
   1. Samples: Imported material taken at source.

B. Informational Submittals:
   1. Manufacturer’s data sheets for compaction equipment.
   2. Certified test results from independent testing agency.

1.04 QUALITY ASSURANCE

A. Notify Engineer when:
   1. Structure is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
   2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
   3. Fill material appears to be deviating from Specifications.

1.05 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 02 41 00, Demolition; Section 31 10 00, Site Clearing; Section 31 23 16, Excavation; and Section 31 23 13, Subgrade Preparation, prior to placing fill or backfill.

B. Backfill against concrete structures only after concrete has attained 95 percent of design compressive strength, specified in Section 03 30 00, Cast-in-Place Concrete. Obtain Engineer’s acceptance of concrete work and attained strength prior to placing backfill.

C. Do not place granular base, subbase, or surfacing until after subgrade has been prepared as specified in Section 31 23 13, Subgrade Preparation.
PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Gradation Tests:
   1. As necessary to locate acceptable sources of imported material.
   2. During production of imported material, test as follows:
      a. Granular Fill: Every 1,000 tons.
      b. Sand: Every 500 tons.
      c. Granular Drain Material: Every 500 tons.
      d. Base Course Rock: Every 500 tons.
      e. Foundation Stabilization Rock: Every 500 tons.

B. Samples:
   1. Collected in accordance with ASTM D75:
      a. During production of imported material, provide Samples as follows:
         1) Granular Fill: Every 1,500 tons.
         2) Sand: Every 500 tons.
         3) Granular Drain Material: Every 500 tons.
         4) Base Course Rock: Every 500 tons.
         5) Foundation Stabilization Rock: Every 500 tons.
      b. Clearly mark to show source of material and intended use.

2.02 EARTHFILL

A. Excavated material from required excavations and designated borrow sites, free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials and containing less than 20 percent fines (passing the No. 200 sieve) as determined by ASTM D1140.

B. Material containing more than 10 percent gravel, bedrock, stones, or shale particles is unacceptable.

C. Provide imported material of equivalent quality, if required to accomplish Work.
2.03 RIPRAPH FILTER MATERIAL

A. Gradation:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 inches</td>
<td>100</td>
</tr>
<tr>
<td>6 inches</td>
<td>70 to 85</td>
</tr>
<tr>
<td>2.5 inches</td>
<td>30 to 50</td>
</tr>
<tr>
<td>1.5 inches</td>
<td>5 to 15</td>
</tr>
</tbody>
</table>

B. Bulk specific gravity greater than 2.25 and absorption less than 6.0 percent as measured by ASTM D6473.

C. Loss of soundness less than or equal to 15 percent after 20 cycles when tested in accordance with U.S. Army Corps of Engineers test method CRD-C144.

D. Width and thickness of individual pieces shall be at least one-third the length.

E. No compaction required. Work material manually in thin lifts to create a dense configuration with smaller particles distributed through the mass and occupying the void space between larger particles.

F. Where placed upon larger size riprap, work material into voids in large riprap to choke off material against movement into larger riprap.

2.04 UPPER COURSE FILTER BLANKET MATERIAL

A. Conforming to Filter Blanket Material-Upper Course as described in Section 713.02 of the Standard Specifications.

B. Placed in maximum 10 inch loose lifts and compacted to minimum 95 percent relative compaction in accordance with ASTM D698.

2.05 LOWER COURSE FILTER BLANKET MATERIAL

A. Conforming to Filter Blanket Material-Lower Course as described in Section 713.02 of the Standard Specifications.

B. Placed in maximum 8-inch loose lifts and compacted to minimum 95 percent relative compaction in accordance with ASTM D698.
2.06 GRANULAR FILL
A. 1-inch minus crushed gravel or crushed rock.
B. Free from dirt, clay balls, and organic material.
C. Well-graded from coarse to fine and containing sufficient fines to bind material when compacted, but with maximum 8 percent by weight passing No. 200 sieve.

2.07 SAND
A. Free from clay, organic matter, or other deleterious material.
B. Gradation as determined in accordance with ASTM C117 and ASTM C136:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>95 - 100</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 8</td>
</tr>
</tbody>
</table>

2.08 GRANULAR DRAIN MATERIAL
A. As specified in Section 31 23 23.15, Trench Backfill.

2.09 WATER FOR MOISTURE CONDITIONING
A. Free of hazardous or toxic contaminants, or contaminants deleterious to proper compaction.

2.10 BASE COURSE ROCK
A. As specified in Section 32 11 23, Aggregate Base Courses.

2.11 FOUNDATION STABILIZATION ROCK
A. Crushed rock or pit run rock.
B. Uniformly graded from coarse to fine.
C. Free from excessive dirt and other organic material.
D. Maximum 2-1/2-inch particle size.
2.12 SOIL COVER OVER GEOTEXTILES

A. Particle Size: Maximum 0.75-inch.

B. Free of sharp angular pieces that may damage geotextile.

2.13 CONCRETE FILL

A. As specified in Section 31 23 23.15, Trench Backfill.

PART 3 EXECUTION

3.01 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:
   1. Fill or backfill to an elevation 2 feet above top of item to be laid.
   2. Excavate trench for installation of item.
   3. Install bedding, if applicable, as specified in Section 31 23 23.15, Trench Backfill.
   4. Install item.
   5. Backfill envelope zone and remaining trench, as specified in Section 31 23 23.15, Trench Backfill, before resuming filling or backfilling specified in this section.

F. Tolerances:
   1. Final Lines and Grades: Within a tolerance of 0.1 foot unless dimensions or grades are shown or specified otherwise.
   2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.
G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

3.02 BACKFILL UNDER AND AROUND STRUCTURES

A. Under Concrete Structures Bearing on Bedrock: Concrete Fill as specified in Section 31 23 23.15, Trench Backfill. Do not place granular materials between structures and bedrock unless directed by the Engineer.

B. Under Grouted Core Rock: Concrete Fill as specified in Section 31 23 23.15, Trench Backfill. Do not place granular materials between Grouted Core Rock and bedrock unless directed by the Engineer.

C. Under Facilities Bearing on Soil: Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with granular fill, unless otherwise shown. Place granular fill in lifts of 6-inch maximum thickness and compact each lift to minimum of 98 percent relative compaction as determined in accordance with ASTM D698.

D. Subsurface Drainage: Backfill with granular drain material, where shown. Place granular drain material in lifts of 6-inch maximum thickness and compact. Incorporate and protect geotextile fabric where shown.

E. Other Areas: Backfill with granular fill to lines and grades shown, with proper allowance for topsoil thickness where shown. Place in lifts of 6-inch maximum thickness and compact each lift to minimum 98 percent relative compaction as determined in accordance with ASTM D698.

3.03 FILL

A. Outside Influence Areas beneath Structures, Tanks, Pavements, Curbs, Slabs, Piping, and Other Facilities:

1. Unless otherwise shown, place earthfill as follows:
   a. Allow for 6-inch thickness of topsoil where required.
   b. Maximum 8-inch thick lifts.
   c. Place and compact fill across full width of embankment.
   d. Compact to minimum 95 percent relative compaction as determined in accordance with ASTM D698 and based upon average of most recent four tests on like material. If any two of the four most recent tests falls below 95 percent, additional compactive effort will be required.
   e. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.
3.04 SITE TESTING

A. Gradation:

1. One sample from each 1,500 tons of finished product or more often as determined by Engineer, if variation in gradation is occurring, or if material appears to depart from Specifications.

2. If test results indicate material does not meet Specification requirements, terminate material placement until corrective measures are taken.

3. Remove material placed in Work that does not meet Specification requirements.

B. In-Place Density Tests:

1. In accordance with ASTM D6938. During placement of materials, test as follows:
   a. Granular Fill: At least one test per day during placement and one test every 10 cubic yards.
   b. Sand: Every 5 cubic yards.
   c. Base Course Rock: One test for every 50 cubic yards of in place material.

3.05 GRANULAR BASE, SUBBASE, AND SURFACING

A. Place and Compact as specified in Section 32 11 23, Aggregate Base Courses.

3.06 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried belowgrade lines shown or established by Engineer as follows:

1. Beneath Footings: Concrete Fill as specified in Section 31 23 23.15, Trench Backfill.
2. Beneath Grouted Core Rock: Concrete Fill as specified in Section 31 23 23.15, Trench Backfill.
3. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
5. Trenches:
   a. Trenches in Bedrock: Concrete Fill as specified in Section 31 23 23.15, Trench Backfill.
   b. Unauthorized Overexcavation: Either trench stabilization material or granular pipe base material, as specified in Section 31 23 23.15, Trench Backfill.
   c. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 23.15, Trench Backfill.

6. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
   a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Earthfill.
   b. Steep Slopes (Steeper than 3:1):
      1) Correct overexcavation by transitioning between overcut areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.
      2) Backfilling overexcavated areas is prohibited, unless in Engineer’s opinion, backfill will remain stable, and overexcavated material is replaced as compacted earthfill.

3.07 PLACING FILL OVER GEOSYNTHETICS

A. General:
   1. Place fill over geosynthetics with sufficient care so as not to damage them.
   2. Place fill only by back dumping and spreading only.
   3. Dump fill only on previously placed fill.
   4. While operating equipment, avoid sharp turns, sudden starts or stops that could damage geosynthetics.

B. Hauling: Operate hauling equipment on minimum of 3 feet of covering.

C. Spreading:
   1. Spreading equipment shall be track mounted low ground pressure, D-6 or lighter.
   2. Operate spreading equipment on minimum of 12 inches of fill over geosynthetics.
   3. Spread fill in same direction as unseamed overlaps to avoid separation of seams and joints.
4. Never push fill downslope. Spread fill over sideslopes by pushing up from slope bottom. If access to bottom of slope is unavailable, progressively place fill, beginning at toe of slope and working upslope, with backhoe or dragline operated from top of slope. Limit distance material falls onto the geosynthetics to maximum of 2 feet.

5. Flatten wrinkles of geosynthetics in direction of spreading. Correct wrinkles in geotextiles as specified in Section 31 32 19.16, Geotextile.


7. Avoid overstressing geosynthetics and seams.

D. Compaction: Compact fill only after uniformly spread to full thickness shown.

E. Geosynthetic Damage:

1. Mark punctures, tears, or other damage to geosynthetics, so repairs may be made.

2. Clear overlying fill as necessary to repair damage.

3. Repairs to geosynthetics shall be made by respective installers as specified in respective specification section for each geosynthetic.

3.08 ACCESS ROAD SURFACING

A. Place and compact as specified in Standard Specifications.

END OF SECTION
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

2. ASTM International (ASTM):
   f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   h. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
   j. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)).
   k. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   l. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   m. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
1.02 DEFINITIONS

A. Base Rock: Granular material upon which manhole bases and other structures are placed.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

C. Imported Material: Material obtained by Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.

F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.

G. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698. Corrections for oversize material may be applied to either as-compacted field dry density or maximum dry density, as determined by Engineer.

H. Relative Density: As defined by ASTM D4253 and ASTM D4254.

I. Selected Backfill Material: Material available onsite that Engineer determines to be suitable for a specific use.

J. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Satisfying both of the following requirements, as defined in ASTM D2487:

1. Coefficient of Curvature: Greater than or equal to 1 and less than or equal to 3.
2. Coefficient of Uniformity: Greater than or equal to 4 for materials classified as gravel, and greater than or equal to 6 for materials classified as sand.
1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer’s descriptive literature for marking tapes.
2. Samples:
   a. Trench stabilization material.
   b. Bedding and pipe zone material.
   c. Granular drain.
   d. Granular backfill.
   e. Earthfill.
   f. Geotextile.

B. Informational Submittals:

1. Catalog and manufacturer’s data sheets for compaction equipment.
2. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to Site.
3. Controlled Low Strength Material: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

PART 2 PRODUCTS

2.01 GEOTEXTILE

A. As specified in Section 31 32 19.16, Geotextile.

2.02 MARKING TAPE

A. Nondetectable:

1. Inert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
2. Thickness: Minimum 5 mils.
3. Width: 6 inches.
4. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
5. Manufacturers and Products:
   a. Reef Industries; Terra Tape.
   b. Mutual Industries; Non-detectable Tape.
   c. Presco; Non-detectable Tape.
B. Detectable:

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.
2. Foil Thickness: Minimum 0.35 mils.
3. Laminate Thickness: Minimum 5 mils.
5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
6. Joining Clips: Tin or nickel-coated furnished by tape manufacturer.
7. Manufacturers and Products:
   a. Reef Industries; Terra Tape, Sentry Line Detectable.
   b. Mutual Industries; Detectable Tape.
   c. Presco; Detectable Tape.

C. Color: In accordance with APWA Uniform Color Code.

<table>
<thead>
<tr>
<th>Color*</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Electric power lines, cables, conduit, and lightning cables</td>
</tr>
<tr>
<td>Orange</td>
<td>Communicating alarm or signal lines, cables, or conduit</td>
</tr>
<tr>
<td>Yellow</td>
<td>Gas, oil, steam, petroleum, or gaseous materials</td>
</tr>
<tr>
<td>Green</td>
<td>Sewers and drain lines</td>
</tr>
<tr>
<td>Blue</td>
<td>Potable water</td>
</tr>
<tr>
<td>Purple</td>
<td>Reclaimed water, irrigation, and slurry lines</td>
</tr>
</tbody>
</table>

*As specified in NEMA Z535.1, Safety Color Code.

2.03 TRENCH STABILIZATION MATERIAL

A. Trench stabilization materials must be compatible with trench subgrade. Obtain Engineer’s written approval of Trench Stabilization Material for each material used.

B. For trenches in bedrock, or riprap, or existing geogrid reinforced soil, concrete fill as specified in Section 03 30 00, Cast-In-Place Concrete.

C. For Trenches in Native Soils:

1. Granular Trench Stabilization Material:
   a. Clean gravel or crushed rock, reasonably well-graded from coarse to fine and containing less than 5 percent of weight passing the No. 200 sieve, as determined in accordance with ASTM D1140.
   b. Maximum Particle Size: 1-inch.
c. Dry sand, accepted by Engineer, may be provided for trenches above maximum groundwater level.

2.04 BEDDING MATERIAL AND PIPE ZONE MATERIAL

A. Unfrozen, friable, and containing no clay balls, roots, or other organic material.

B. Clean or gravelly sand with less than 5 percent passing No. 200 sieve, as determined in accordance with ASTM D1140, or gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified.

1. Duct Banks: 3/4-inch maximum particle size.
2. PVC Irrigation System Piping and Ductile Iron Pipe with Polyethylene Wrap: 3/8-inch maximum particle size.
4. Pipe 18-Inch Diameter and Greater: 1-1/2-inch maximum particle size for ductile iron pipe, concrete pipe, welded steel pipe, and pretensioned or prestressed concrete cylinder pipe.
5. Perforated Pipe: Granular drain material.
6. Conduit and Direct-Buried Cable:
   a. Sand, clean or clean to silty, less than 12 percent passing No. 200 sieve.
   c. Maximum Size Particle: Pass a No. 4 sieve.
   d. If more than 5 percent passes No. 200 sieve, the fraction that passes No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.

C. Concrete Fill as described in Section 03 30 00, Cast-In-Place Concrete, shall be used for bedding and pipe zone material where shown and in the following locations:

1. Grouted core rock.
2. Sculpted concrete.
3. Riprap and riprap bedding.
5. Slopes steeper than 4 horizontal to 1 vertical.
7. Other locations as directed by the Engineer.
2.05 GRANULAR DRAIN MATERIAL


<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing By Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 inches</td>
<td>100-90</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>50-30</td>
</tr>
<tr>
<td>No. 4</td>
<td>10-20</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-5</td>
</tr>
</tbody>
</table>

2.06 EARTH BACKFILL

A. Also referred to as Earthfill.

B. Sandy soil, sediment, other excavated material suitable for use as backfill.

C. Less than 20 percent fines (passing the No. 200 sieve) as determined by ASTM D1140.

D. Free from roots or organic matter, refuse, boulders, or other deleterious materials.

E. Free from boulders and cobbles that would be retained on a 3 inch screen.

2.07 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

A. Select and proportion ingredients to obtain compressive strength between 50 psi and 150 psi at 28 days in accordance with ASTM D4832.

B. Materials:

1. Cement: ASTM C150/C150M, Type I or Type II.
3. Fly Ash (Pozzolan): Class F fly ash in accordance with ASTM C618, except as modified herein:
   a. ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.
   b. Test in accordance with ASTM C1012/C1012M to verify sulfate resistance is acceptable.
4. Water: Clean, potable, containing less than 500 ppm of chlorides.

2.08 CONCRETE BACKFILL

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.
B. Mix: ASTM C94/C94M, Option A.
   1. Cement: ASTM C150/C150M, Type I or Type II.
   2. Coarse Aggregate Size: 3/4-inch.
   3. Design for Minimum Compressive Strength at 28 Days: 3,000 psi.

2.09 GRAVEL SURFACING ROCK
A. As specified in Section 32 11 23, Aggregate Base Courses.

2.10 SOURCE QUALITY CONTROL
A. Perform gradation analysis in accordance with ASTM C136 for:
   1. Earth backfill, including specified class.
   2. Trench stabilization material.
   3. Bedding and pipe zone material.

B. Certify Laboratory Performance of Mix Designs:
   1. Controlled low strength material.
   2. Concrete.

PART 3 EXECUTION

3.01 TRENCH PREPARATION
A. Water Control:
   1. Promptly remove and dispose of water entering trench as necessary to grade trench bottom and to compact backfill and install manholes, pipe, conduit, direct-buried cable, or duct bank. Do not place concrete, lay pipe, conduit, direct-buried cable, or duct bank in water.
   2. Remove water in a manner that minimizes soil erosion from trench sides and bottom and protects bedrock, if encountered, from disturbance.
   3. Provide continuous water control until trench backfill is complete.

B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

3.02 TRENCH BOTTOM
A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.
B. Soft Subgrade: If subgrade is encountered that may require removal to prevent pipe settlement, notify Engineer. Engineer will determine depth of overexcavation, if any required, and appropriate material for replacement.

C. Bedrock Subgrade: If subgrade is bedrock, clean bottom and sides of bedrock trench to remove all sand, debris, mud, loose rocks, or other materials. Excavate bedrock with maximum 4 foot vertical cut. Bench excavation such that overall excavation has average slope of 0.5 horizontal to 1 vertical. Soil over bedrock shall be sloped and include a bench at bedrock contact.

3.03 GEOTEXTILE INSTALLATION

A. Where shown and as specified in Section 31 32 19.16, Geotextile, except as follows:

1. Extend geotextile for full width of trench bottom and up the trench wall to the top of the pipe zone, or base material for manholes and miscellaneous structures.
2. Anchor geotextile trench walls prior to placing trench stabilization or bedding material.
3. Provide 24-inch minimum overlap at joints.

3.04 TRENCH STABILIZATION MATERIAL INSTALLATION

A. Rebuild trench bottom with trench stabilization material.

B. Place material over full width of trench in 6-inch lifts to required grade, providing allowance for bedding thickness.

C. Compact each lift so as to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts. Concrete fill, if used at Engineer’s direction, does not require compaction.

3.05 BEDDING

A. Furnish imported bedding material where, in the opinion of Engineer, excavated material is unsuitable for bedding or insufficient in quantity.

B. Confirm bedding material selection with Engineer prior to placement. Concrete Backfill is required for bedding in bedrock, grouted core rock. And Sculpted concrete.

C. Place over full width of prepared trench bottom in two equal lifts when required depth exceeds 8 inches.

D. Hand grade and compact each lift to provide a firm, unyielding surface.
E. Minimum Thickness:

1. As follows, except use concrete backfill in areas of bedrock, grouted core rock, or sculpted concrete:
   a. Pipe 15 Inches and Smaller: 4 inches.
   b. Pipe 18 Inches to 36 Inches: 6 inches.
   c. Pipe 42 Inches and Larger: 8 inches.
   d. Conduit: 3 inches.
   e. Direct-Buried Cable: 3 inches.
   f. Duct Banks: 3 inches.

F. Check grade and correct irregularities in bedding material. Loosen top 1 inch to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.

G. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

H. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.

3.06 BACKFILL PIPE ZONE

A. Upper limit of pipe zone shall not be less than following:

1. Pipe: 12 inches, unless shown otherwise.
2. Conduit: 3 inches, unless shown otherwise.
3. Direct-Buried Cable: 3 inches, unless shown otherwise.
4. Duct Bank: 3 inches, unless shown otherwise.

B. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement or buoyant uplift during backfill operations.

C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.

1. Pipe 10-Inch and Smaller Diameter: First lift less than or equal to 1/2 pipe diameter.
2. Pipe Over 10-Inch Diameter: Maximum 6-inch lifts.

D. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by “walking in” and slicing material under haunches with a shovel to ensure voids are completely filled before placing each succeeding lift.
E. Do not use power-driven impact compactors to compact pipe zone material. After full depth of pipe zone material has been placed as specified, compact material by a minimum of three passes with a vibratory plate compactor only over area between sides of pipe and trench walls. Take care to avoid damaging pipe and pipe coating.

3.07 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of buried piping, on top of last lift of pipe zone material unless otherwise shown on Drawings. Coordinate with piping installation drawings.

1. Detectable Marking Tape: Install with nonmetallic piping and waterlines.

3.08 BACKFILL ABOVE PIPE ZONE

A. General:

1. Process excavated material to meet specified gradation requirements.
2. Adjust moisture content as necessary to obtain specified compaction.
3. Do not allow backfill to free fall into trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over top of pipe.
4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
5. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
6. Backfill around structures with same class backfill as specified for adjacent trench, unless otherwise shown or specified.

B. Concrete Backfill:

1. Place above bedding.
2. Minimum Concrete Thickness: 6 inches on top and sides of pipe.
3. Do not allow dirt or foreign material to become mixed with concrete during placement.
4. Allow sufficient time for concrete to reach initial set before additional backfill material is placed in trench.
5. Prevent flotation of pipe.
6. Begin and end concrete backfill within 4 inches of a pipe joint on each end.
7. Do not encase pipe joints except within the limits of the concrete backfill.
C. Controlled Low Strength Material:
   1. Discharge from truck mounted drum type mixer into trench.
   2. Place in lifts as necessary to prevent uplift (flotation) of new and existing facilities.
   3. In traveled areas fill entire trench section to pavement finish grade for a temporary driving surface, and screed off excess and finish with a float.
   4. In other areas fill trench section as shown.

3.09 REPLACEMENT OF TOPSOIL
   A. Replace topsoil in top 6 inches of backfilled trench, unless otherwise shown.
   B. Maintain finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

3.10 MAINTENANCE OF TRENCH BACKFILL
   A. After each section of trench is backfilled, maintain surface of backfilled trench even with adjacent ground surface until final surface restoration is completed.
   B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep surface of backfilled trench even with adjacent ground surface, and grade and compact as necessary to keep surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.
   C. Topsoil: Add topsoil where applicable and as necessary to maintain surface of backfilled trench level with adjacent ground surface.
   D. Concrete Pavement: Replace settled slabs as specified in Section 32 12 16, Asphalt Paving.
   E. Asphaltic Pavement: Replace settled areas or fill with asphalt as specified in Section 32 12 16, Asphalt Paving.
   F. Other Areas: Add excavated material where applicable and keep surface of backfilled trench level with adjacent ground surface.

3.11 SETTLEMENT OF BACKFILL
   A. Settlement of trench backfill, or of fill, or facilities constructed over trench backfill will be considered a result of defective compaction of trench backfill.

END OF SECTION
PART 1  GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
   g. D4716, Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
   n. D6193, Standard Practice for Stitches and Seams.
1.02 DEFINITIONS

A. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

B. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile furnished.

C. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile furnished.

D. Nondestructive Sample: Sample representative of finished Work, prepared for testing without destruction of Work.

E. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

F. Seam Efficiency: Ratio of tensile strength across seam to strength of intact geotextile, when tested according to ASTM D4884.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer material specifications and product literature.
   b. Installation drawings showing geotextile sheet layout, location of seams, direction of overlap, and sewn seams.
   c. Description of proposed method of geotextile deployment, sewing equipment, sewing methods, and provisions for holding geotextile temporarily in place until permanently secured.

2. Samples:
   a. Geotextile: One-piece, minimum 18 inches long, taken across full width of roll of each type and weight of geotextile furnished for Project. Label each with brand name and furnish documentation of lot and roll number from which each Sample was obtained.
   b. Field Sewn Seam: 5-foot length of seam, 12 inches wide with seam along center, for each type and weight of geotextile.
   c. Securing Pin and Washer: One each.

B. Informational Submittals:

1. Certifications from each geotextile manufacturer that furnished products have specified property values. Certified property values shall be either minimum or maximum average roll values, as appropriate, for geotextiles furnished.

2. Field seam efficiency test results.
1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver each roll with sufficient information attached to identify it for inventory and quality control.

B. Handle products in manner that maintains undamaged condition.

C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

1.05 SCHEDULING AND SEQUENCING

A. Where geotextile is to be laid directly upon ground surface, prepare subgrade as specified in Section 31 23 13, Subgrade Preparation, first.

B. Notify Engineer whenever geotextiles are to be placed. Do not place geotextile without Engineer’s approval of underlying materials.

PART 2 PRODUCTS

2.01 NONWOVEN GEOTEXTILE

A. Pervious sheet of polyester, polypropylene, or polyethylene fabricated into stable network of fibers that retain their relative position with respect to each other. Nonwoven geotextile shall be composed of continuous or discontinuous (staple) fibers held together through needle-punching, spun-bonding, thermal-bonding, or resin-bonding.

B. Geotextile Edges: Selvaged or otherwise finished to prevent outer material from pulling away from geotextile.

C. Unseamed Sheet Width: Minimum 8 feet.

D. Nominal Weight per Square Yard: 12 ounces per ASTM D5261.
E. Physical Properties: Conform to requirements in Table No. 1.

<table>
<thead>
<tr>
<th>Physical Property Requirements for Nonwoven Geotextile</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Property</strong></td>
</tr>
<tr>
<td>Water Permittivity</td>
</tr>
<tr>
<td>Apparent Opening Size (AOS)</td>
</tr>
<tr>
<td>Grab Tensile Strength, Machine Direction</td>
</tr>
<tr>
<td>Grab Elongation, Machine Direction</td>
</tr>
<tr>
<td>Trapezoid Tear Strength</td>
</tr>
<tr>
<td>Ultraviolet Radiation Resistance</td>
</tr>
</tbody>
</table>

2.02 SEWING THREAD

A. Polypropylene, polyester, or Kevlar thread.

B. Durability: Equal to or greater than durability of geotextile sewn.

2.03 SECURING PINS

A. Steel Rods or Bars:

1. 3/16-inch diameter.
2. Pointed at one end.
3. With head on other end sufficiently large to retain washer.

B. Steel Washers for Securing Pins:

1. Outside Diameter: Not less than 1.5 inches.
2. Inside Diameter: 1/4-inch.
PART 3 EXECUTION

3.01 LAYING GEOTEXTILE

A. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

3.02 SHEET ORIENTATION ON SLOPES

A. Orient geotextile with long dimension of each sheet parallel to direction of slope.

B. Geotextile may be oriented with long dimension of sheet transverse to direction of slope only if sheet width, without unsewn seams, is sufficient to cover entire slope and anchor trench and to extend at least 18 inches beyond toe of slope.

3.03 JOINTS

A. Unseamed Joints:

1. Overlapped.
2. Overlap, unless otherwise shown:
   b. Riprap: Minimum 18 inches.
   c. Drain Trenches: Minimum 18 inches, except overlap shall equal trench width if trench width is less than 18 inches.
   d. Other Applications: Minimum 12 inches.

B. Sewn Seams: Made wherever stress transfer from one geotextile sheet to another is necessary. Sewn seams, as approved by Engineer, also may be used instead of overlap at joints for applications that do not require stress transfer.

1. Seam Efficiency:
   a. Minimum 70 percent.
   b. Verified by preparing and testing minimum of one set of nondestructive Samples per acre of each type and weight of geotextile installed.
   c. Tested according to ASTM D4884.
2. Types:
   a. Preferred: “J” type seams.
   b. Acceptable: Flat or butterfly seams.

3. Stitch Count: Minimum three to maximum seven stitches per inch.

4. Stitch Type: Double-thread chainstitch according to ASTM D6193.

5. Sewing Machines: Capable of penetrating four layers of geotextile.

6. Stitch Location: 2 inches from geotextile sheet edges, or more, if necessary to develop required seam strength.

3.04 SECURING GEOTEXTILE

A. Secure geotextile during installation as necessary with sandbags or other means approved by Engineer.

B. Secure Geotextile with Securing Pins or Staples:

   1. Insert securing pins with washers through geotextile.
   2. Securing Pin Alignment:
      a. Midway between edges of overlaps.
      b. 6 inches from free edges.
   3. Spacing of Securing Pins:

<table>
<thead>
<tr>
<th>Slope</th>
<th>Maximum Pin Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steeper than 3:1</td>
<td>2 feet</td>
</tr>
<tr>
<td>3:1 to 4:1</td>
<td>3 feet</td>
</tr>
<tr>
<td>Flatter than 4:1</td>
<td>5 feet</td>
</tr>
</tbody>
</table>

4. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.

5. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.

6. Where staples are used instead of securing pins, install in accordance with alignment and spacing above. Push in to secure geotextile firmly to subgrade.

3.05 PLACING PRODUCTS OVER GEOTEXTILE

A. Before placing material over geotextile, notify Engineer. Do not cover installed geotextile until after Engineer provides authorization to proceed.

B. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose
damaged geotextile. Repair damage as specified in Article Repairing Geotextile.

3.06 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way to completely envelope granular drain material to be placed in trench and with specified overlap at joints. Overlap geotextile in direction of flow. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

B. After granular drain material is placed to required grade, fold geotextile over top of granular drain material, unless otherwise shown. Maintain overlap until overlying fill or backfill is placed.

3.07 RIPRAP APPLICATIONS

A. Overlap geotextile at each joint with upstream sheet of geotextile overlapping downstream sheet.

B. Sew joints where wave run-up may occur.

C. Limit height of riprap fall onto geotextile to prevent damage.

   1. Drop Height: 0 foot for greater than 200-pound rock. 2 feet for less than 200-pound rock.

3.08 GEOTEXTILE-REINFORCED EARTH WALL APPLICATIONS

A. Sew exposed joints; extend sewn seams minimum 3 feet behind face of wall.

B. Protect exposed geotextile from damage, ultraviolet light exposure, and deterioration until permanent facing is applied.

3.09 SILT FENCE APPLICATIONS

A. Install geotextile in one piece, or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench.

B. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.

C. Securely fasten geotextile to wire mesh backing and each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.

D. Promptly repair or replace silt fence that becomes damaged.
3.10 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile.

B. Repair Procedure:
   1. Place patch of undamaged geotextile over damaged area and at least 18 inches in all directions beyond damaged area.
   2. Remove interfering material as necessary to expose damaged geotextile for repair.
   3. Sew patches or secure them with heat fusion tacking or with pins and washers, as specified above in Article Securing Geotextile, or by other means approved by Engineer.

3.11 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in Engineer’s opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

END OF SECTION
PART 1 GENERAL

1.01 DESCRIPTION

A. The work of this Section consists of the Start-up and Tuning, including interim and final modifications of in-river recreational features and grading. Iterative trials and testing, modifications, and adjustments to WaveShapers, blocks, sculpted rock, and modifications and additions to boulders surfacing, jetties, and other features in and around the drops and pools are anticipated after initial start-up and observation. The intent of the Start-up and Tuning effort is to optimize performance and improve operational ease and safety.

1.02 JOB CONDITIONS

A. Protection of Structures, Banks, Riverbed and Vegetation: All structures, final grading, existing banks, riverbed, and existing natural vegetation both inside and outside of the project boundaries shall be protected from injury during modifications and operational tuning of the project. Any damage to such facilities or resources shall be repaired by the Contractor to a condition equal to or better than original at no additional expense to the Owner. Any required repairs shall be made to the satisfaction of the Engineer.

B. Permits: The Contractor shall be responsible for adhering to all permits associated with or obtained for the project during any work carried out under the Modifications phase of the project.

C. Water Control: The Contractor shall be responsible for all elements of water control required to carry out the work covered by this Section of the Specifications.

D. Coordination: The Contractor shall coordinate with the Owner during the execution of the Tuning. Following substantial completion of the project the Contractor shall provide notice to the Owner and Engineer.

1.03 RELATED WORK

A. Section 03 30 00, Cast-in-Place Concrete.

B. Section 03 45 39, Sculpted Concrete.

C. Section 05 70 00, Miscellaneous Metal.

D. Section 31 10 00, Site Clearing.
ZINK DAM IMPROVEMENTS

E. Section 31 23 13, Subgrade Preparation.
F. Section 31 23 16, Excavation.
G. Section 31 23 19.01, Dewatering.
H. Section 31 23 23, Fill and Backfill.
I. Section 31 23 23.15, Trench Backfill.
J. Section 31 38 00, Rock.
K. Section 31 41 00, Shoring.

PART 2 PRODUCTS

2.01 RELATED WORK

A. As required for the various related Work, see Paragraph Related Work. This is applicable to final/permanent modifications determined during and after completion of the iterative testing, and as required to support the individual trials and testing.

2.02 ITERATIVE TRIALS

A. As required to support iterative testing and trials, including temporary wood structures (plywood, framing wood, concrete anchors, etc.) anchored to concrete and rock and sandbags to temporarily direct flows. Contractor should assume at least $10,000 worth of direct materials costs (unburdened, locally available but not delivered) for these miscellaneous temporary structures used in the iterative testing. Contractor will keep receipts and provide itemized list on an on-going basis for all such materials.

PART 3 EXECUTION

3.01 GENERAL

A. Iterative trials, temporary and permanent structure, modifications to previous work, and adjustments to WaveShapers and appurtenances, pool banks, jetties, etc. Work shall support:

1. Interim Trials and Testing: Temporary structures to guide flow during iterative trials (plywood, sandbags, etc.), and some final installation of Sculpted Rock, and Grouted Boulders. Grout, modifications of jetties, and other features in and around the drops and pools using temporary obstructions with final addition of boulders and/or Sculpted Rock.
2. Final Modifications: After trials are completed, some of the final work to finish and replace temporary structures is anticipated.

3.02 START-UP AND TUNING

A. The project shall be re-watered and initial operation of improvements completed. Specific requirements include that the river will be observed at normal flow rates during Start-up. Therefore, work in Start-up will have to be scheduled once flows in the river are within the range of 50 cfs to 600 cfs. Adequate operating time for the Engineer to observe, survey and complete documentation shall be allowed for all trials (up to 2 hours to 8 hours for each day of tuning). During these operational periods, and to implement interim and final modifications, the Contractor shall supply a representative to communicate with the describe aspects of the project and assist the Engineer with observation and documentation of the Start-up.

3.03 SCHEDULE

A. The Contractor shall coordinate, schedule, and supply all labor and materials, miscellaneous materials, and equipment, to support the Start-up and Tuning effort and construct all temporary/interim modifications and structures, and construct all Final Modifications.

3.04 TUNING AND MODIFICATIONS

A. Wave Shaper and Appurtenance: Including opening and closing of any vents, installation and movement of all blocks, installing and adjusting apparatus that is designed to adjusted or modified, adjustment to sides (shoulders) of WaveShaper structures; installation and movement of Pool Blocks.

B. Blocks shall be attached to the WaveShaper foundation and in the Pool prior to Start-up as directed by the Engineer, or as shown on Drawings. During Start-up, the Engineer will evaluate needed modifications to the block configurations or block shapes/sizes or foundation to achieve the desired hydraulic. The Contractor shall attach new blocks, rearrange original blocks, or a combination of the two as directed by the Engineer. It should be anticipated that two full sets of blocks will be required to adequately adjust and tune the WaveShaper.

C. Tuning Areas: Areas adjacent to each side of the WaveShaper foundations have been included in the design to allow placement of Sculpted Rock and loose or grouted boulders for tuning. An initial configuration of loose boulders will be provided by the Engineer and shall be installed by the Contractor prior to Start-up. The Engineer will evaluate the tuning areas during Start-up and provide recommended modifications. Boulders shall be reworked by the
Contractor as directed by the Engineer. It should be expected that two loose boulder configurations in the tuning areas will be required.

D. Adjustments to Grouted Boulders, and Loose Boulders, Sculpted Rock, and Riverbed: Shape and sizes of individual surface boulders and excavated bedrock vary significantly and some adjustment to, or replacement of, individual boulders, and bedrock areas may be required to achieve performance goals for the overall Project. The Contractor shall exercise proper care in the replacement and/or adjustment of individual boulders so that all other portions of the Project remain undamaged.

E. Time Period for Modifications: The Contractor shall be responsible for providing all materials, equipment and personnel required to facilitate observation of performance and carry out Modifications as directed by the Engineer for a period up to 2 months following completion of project construction. At a minimum, it is anticipated that a 1-month period will be required for observation of performance with more moderate interim structures and temporary modifications and Engineer recommended modifications, and second 1-month period for more extensive modifications and adjustments.

F. Payment Methods for Tuning Modifications: Following the Start-up, the Engineer will prepare memorandums and sketches detailing requested Modifications. Tuning and modifications of Tuning Areas and WaveShaper (including furnishing blocks) shall be included in the Contractors Lump Sum Bid Price. Other Items requiring Modifications for tuning will be paid for by negotiating change orders based on existing unit prices in the Schedule of Values provided by the Contractor. If the required adjustment is a result of workmanship that does not meet the tolerances for grades or the dimensions provided on the drawings, the costs of adjustment will be borne by the Contractor.

END OF SECTION
SECTION 31 37 00
RIPRAP

PART 1   GENERAL

1.01  REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   e. D5519, Standard Test Methods for Particle Size Analysis of Natural and Man-Made Riprap Materials.

1.02  DEFINITIONS

A. Refer to applicable definitions in Section 31 23 23, Fill and Backfill.

B. Standard Specifications, as used in this section, refer to 2009 Edition of Oklahoma State Department of Transportation Specifications for Roadway Construction.

1.03  SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Description and location of proposed sources of riprap bedding and riprap.
   b. Description and location of three projects where proposed riprap has been successfully used for minimum 5 years’ duration under similar service conditions.

2. Samples:
   a. General:
      1) Deliver to Site at location designated by Engineer.
      2) Incorporate Samples into Work after material placement is nearly complete.
b. Riprap:
   1) Provide minimum 20 tons of LR07.
   2) Each Sample shall meet gradation requirements specified for corresponding riprap type, include at least one piece of maximum size, and be representative of material to be furnished for incorporation into Work. Weigh individual pieces of riprap with scales that are certified accurate to within plus or minus 1 percent of actual weight.

c. Riprap Bedding: Provide minimum 1,100 pounds.

B. Informational Submittals:

1. Quarry Certificate of Conformance and supporting documentation showing proposed riprap bedding or riprap meet Standard Specification gradation and materials requirements for the Class or Type specified.

2. Certified Test Results:
   a. Riprap Bedding:
      1) Gradation by ASTM D5519 Method B.
      2) Bulk specific gravity and absorption by ASTM D6473.
      3) Abrasion resistance by U.S. Army Corps of Engineers Method CRD-C 144.
   
   b. Riprap:
      1) Gradation by ASTM D5519 Method B including photos of material.
      2) Bulk specific gravity and absorption by ASTM D6473.
      3) Abrasion resistance by U.S. Army Corps of Engineers Method CRD-C144.

3. Trip tickets showing source, type, and weight of each load of material delivered to Site.

1.04 QUALITY ASSURANCE

A. Riprap Source: Quarry that has produced riprap and has performed satisfactorily on other projects for at least 5 years.

B. Site Visit: Make arrangements for Engineer to visit quarry site to observe materials proposed for riprap and riprap bedding.

1.05 SCHEDULING AND SEQUENCING

A. Complete subgrade preparation as specified in Section 31 23 13, Subgrade Preparation, and geotextile installation, where shown, as specified in Section 31 32 19.16, Geotextile, prior to placing riprap bedding or riprap.
PART 2  PRODUCTS

2.01  AGGREGATE RIPRAP BEDDING

A. Conforming to upper course filter blanket material and lower course filter blanket material as defined in Section 713.02 of the Standard Specifications.

B. Where riprap is placed against native sandy, silty, or clayey soils, place upper course filter blanket material upon minimum 12 inches of compacted lower course filter blanket material.

2.02  GEOTEXTILE RIPRAP BEDDING

A. Bedding geotextile as specified in Section 31 32 19.16, Geotextile.

2.03  RIPRAP

A. Hard and durable quarry stone free from fractures, bedding planes, pronounced weathering, and earth or other adherent coatings.

B. Minimum Dimension of Individual Pieces: Not less than 1/3 maximum dimension.

C. Abrasion Resistance: Maximum 35 percent wear as determined in accordance with ASTM C535.

D. Bulk Specific Gravity: Minimum 2.5 as measured in accordance with ASTM D6473.

E. Gradation: Smaller pieces shall generally fill voids between larger pieces without either excess or deficiency of one or more sizes of stone.

<table>
<thead>
<tr>
<th>Class</th>
<th>Thickness (Inches)</th>
<th>Weight (Pounds)</th>
<th>% Greater Than</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>150</td>
<td>0 to 5</td>
</tr>
<tr>
<td>I</td>
<td>12</td>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>250</td>
<td>0 to 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>150</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>II</td>
<td>18</td>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>Class</td>
<td>Thickness (Inches)</td>
<td>Weight (Pounds)</td>
<td>% Greater Than</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>III</td>
<td>24</td>
<td>800</td>
<td>0 to 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>IV</td>
<td>30</td>
<td>1,600</td>
<td>0 to 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>800</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>V</td>
<td>36</td>
<td>2,700</td>
<td>0 to 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,600</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>800</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>90</td>
</tr>
</tbody>
</table>

F. LR07 Riprap Gradation shall be between the upper bound and lower bound gradation limits as measured in accordance with by ASTM D5519 Method B:

<table>
<thead>
<tr>
<th>Upper Bound Particle Size (pounds)</th>
<th>Percent Finer (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,000</td>
<td>100</td>
</tr>
<tr>
<td>8,000</td>
<td>85</td>
</tr>
<tr>
<td>4,000</td>
<td>50</td>
</tr>
<tr>
<td>900</td>
<td>10</td>
</tr>
<tr>
<td>500</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lower Bound Particle Size (pounds)</th>
<th>Percent Finer (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,000</td>
<td>100</td>
</tr>
<tr>
<td>2,000</td>
<td>80</td>
</tr>
<tr>
<td>800</td>
<td>50</td>
</tr>
<tr>
<td>600</td>
<td>40</td>
</tr>
<tr>
<td>200</td>
<td>10</td>
</tr>
<tr>
<td>80</td>
<td>0</td>
</tr>
</tbody>
</table>
2.04 CONCRETE GROUT

A. Portland cement concrete as specified in Section 03 30 00, Cast-in-Place Concrete, having a 28-day compressive strength of 3,000 psi.

2.05 CONCRETE GROUT

A. Mix: ASTM C94/C94M, Option A.
   1. Cement: ASTM C150, Type I/II with maximum alkyl content of 0.606 percent.
   2. Coarse Aggregate Size: 1 inch.
   3. Design for Minimum Compressive Strength at 28 Days: 3,000 psi.

PART 3 EXECUTION

3.01 PLACING RIPRAP BEDDING

A. Place riprap bedding over prepared subgrade and geotextile to lines and grades shown.

B. No mechanical compaction of riprap bedding is required; however, work riprap bedding as necessary to distribute it and to eliminate detrimental voids. Avoid overworking or long pushes that result in segregation of particle sizes.

C. Grade surface of riprap bedding free from irregularities and to tolerances of 0.3 feet from established grade.

D. Place and grade riprap bedding in a manner that avoids subgrade disturbance and displacement or damage to geotextile. Do not push riprap bedding down slope. If wrinkles form in geotextile as riprap bedding is placed, correct them as specified in Section 31 32 19.16, Geotextile.

E. Place riprap bedding on geotextile without puncturing or damaging geotextile. If accidentally damaged, repair geotextile prior to proceeding.

3.02 PLACING RIPRAP ON RIPRAP BEDDING

A. Place riprap over prepared subgrade or riprap bedding to uniform thickness shown. If riprap bedding is underlain with geotextile, place riprap from bottom to top of slope.

B. Intermix different sizes of pieces to eliminate segregation and to fill voids between larger pieces with smaller pieces and work surface free from irregularities.
C. Use placement and intermixing methods that avoid disturbing prepared subgrade, riprap bedding, and underlying geotextile or damaging existing facilities, completed Work, or adjacent property.

3.03 PLACING GROUTED CORE ROCK

A. Remove dirt and foreign substances from surfaces of riprap and then moisten.

B. Deposit grout by means of chutes, tubes, or buckets, or place by means of pneumatic equipment or other mechanical methods. Place grout in a continuous operation for any day’s run at any one location.

C. Limit flow distance of grout along slope to less than 10 feet.

D. Spade and rod grout into place with suitable spades, trowels, or other approved means immediately after depositing grout. Depths of grout shall be approximately 1/2 the thickness of the riprap.

E. Following placement of grout, thoroughly brush rocks so top surfaces are exposed. Outer rocks shall project 1/3 to 1/4 their diameter above grout surface. Brushing shall follow closely behind rodding such that grout shall not be in place more than 1 hour before brushing.

F. Once brushing of area is complete, no worker or load will be permitted on surface for period of at least 24 hours, or longer if so required by Engineer.

G. Cure grout as provided in Section 03 30 00, Cast-in-Place Concrete.

END OF SECTION
PART 1 GENERAL

1.01 DESCRIPTION

A. The work of this Section consists of installation of water control measures, subgrade preparation, riprap, boulders, boulders to be grouted, grout, weep/underdrains (if included), sculpted rock, and miscellaneous appurtenant items as indicated herein and on Drawings.

B. The terms “boulder grout” or “grout,” when referenced related to grouting rock, boulders, core rock, etc., as used in these specifications, refers to a type of concrete to be used as a filler and cementing agent between boulders. The grout, and all related boulder grout work, shall meet the requirements of this Section and Section 03 30 00, Cast-in-Place Concrete, including, but not limited to: mix design, quality assurance and control, submittals, materials, job conditions, placement, curing and testing. The term “rock” includes all boulders, rip rap, core rock, cobble, and other types defined in Part 2 of this specification. The term “boulders” includes surface boulders, rounded surface boulders, and feature boulders as determined in Part 2 of this specification.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03 30 00, Cast-in-Place Concrete.
B. Section 03 45 39, Sculpted Concrete.
C. Section 31 10 00, Site Clearing.
D. Section 31 23 13, Subgrade Preparation.
E. Section 31 23 16, Excavation.
F. Section 31 23 19.01, Dewatering.
G. Section 31 23 23, Fill and Backfill.
H. Section 31 23 23.15, Trench Backfill.
I. Section 31 37 00, Riprap.
J. Section 31 41 00, Shoring.
K. Section 33 46 00, Subsurface Drainage.
1.03 SUBMITTALS AND TESTING

A. General: Submittals shall be prepared and submitted in accordance with Section 01 33 00, Submittal Procedures.

B. In advance of delivery of imported rock to the work site an inspection of the quarry or source of any imported rock shall be arranged by the Contractor and shall include the Contractor, Engineer, and Quarry Representative.

C. Rock Work Plan:

1. The Contractor shall prepare a Rock Work Plan for the project. The plan shall provide the Contractor’s methods and procedures for managing the sourcing, supply, stockpiling, delivery, and installation of rock work for the project including the following:
   a. Rock shall be imported from a quarry or other source. Identify material sources and expected quantities for each type of rock. Estimated quantities will be made at the earliest time practicable and the Rock Work Plan will be updated or amended to reflect quantities.
   b. For each type of imported rock, include certificates stating the source of the rock and that the rock will meet the requirements of this Section. Include test results for specific gravity, abrasion, gradation and freeze thaw on samples of rock to be supplied on this project.
   c. For rock that is from a source other than a quarry, methods for identifying suitable rock that meets the requirements defined for each type specified shall be identified and described. The Engineer will provide guidance on identifying rock that is of sufficient quality. Sorting methods that are to be performed on such imported rock (other than from a quarry) shall be identified in the Rock Workplan and shall be shown to produce reliable results.
   d. The Contractor and quarry or rock supplier shall identify procedures that will be used to stockpile, mix and grade the types of riprap and boulders specified.
   e. Sketches or exhibits indicating material stockpile and staging areas.
   f. Describe methodologies and techniques for installation of each rock type. Include the coordination of faux and sculpted rock installations with rock work where applicable.

D. Submit design mix for boulder grout per requirements of Section 03 30 00, Cast-in-Place Concrete.
E. Visual Checking: Boulders shall be visually checked by the Contractor at the quarry or source of imported rock, or at the work site as required for size, elongation, cracks, deterioration and other defects visible on the entire surface area of the stone. If cracks are observed, the Contractor shall notify the Engineer to make a determination as to acceptability of rock. Boulders with cracks or defects that are detrimental to a long-lasting product shall not be shipped to the work site.

F. Sample Installation of Grouted and Loose Boulders: The Contractor will be required to construct a sample installation of grouted and/or loose boulders a minimum of 20 feet by 20 feet for each type and detail (as shown in the Specifications and/or Drawings) of rock used at locations to be designated by the Engineer. The sample installation shall incorporate all aspects of grouted and loose boulder construction and shall be approved by the Engineer before any permanent placement of grouted or loose boulders on the job. The sample areas will serve as a guide for all subsequent boulder installations and remain undisturbed for the entirety of the project. The Engineer shall be given a minimum of 10 working days’ notice by the Contractor of their intent to construct this sample installation. The sample boulder installation may constitute a portion of the final project at a location approved by the Engineer and shall be constructed only in the presence of the Engineer or their Representative.

PART 2 PRODUCTS

2.01 ROCK

A. General: Rock shall be imported. Imported rock shall be derived from offsite sources, such as quarries, pits excavations, or surface sources. Imported rock must meet all the requirements of this Section. All rock must be screened and/or sorted and stockpiled into the various rock types to be used on the project. Graded materials shall be stockpiled in a manner to avoid segregation.

1. All rock and boulders are to be sound and durable against disintegration under conditions to be met in handling and placing. Rock and boulders shall be hard and tenacious and otherwise of a suitable quality to ensure permanency in the specified kind of work. Rock shall be free of calcite intrusions.

2. The color of imported boulders and riprap (other than core rock) shall be gray with gray/blue hues or other acceptable colors approved by the Engineer.

3. For riprap and core rock, each rock/boulder shall have its greatest dimensions not greater than 3 times its least dimension.
4. All rock and boulders shall conform to the following test requirements of the ASTM International (ASTM) and American Association of State Highway and Transportation Officials (AASHTO) Standards:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Testing Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent Specific Gravity</td>
<td>2.60 minimum ASTM C127</td>
</tr>
<tr>
<td>Abrasion Loss</td>
<td>40% maximum ASTM C-535</td>
</tr>
<tr>
<td>Freeze Thaw Loss</td>
<td>10% maximum after 12 cycles AASHTO 103 Procedure A</td>
</tr>
</tbody>
</table>

5. All rock and boulders to be used on the project must be approved by the Engineer. Once approved, the rock shall be kept consistent through the project. No change may be made to the rock source unless specifically approved by the Engineer.

B. Types: The following types of rock shall be imported for this project.

1. Surface Boulders: To be used for grouted boulder or loose boulder installations in areas where smoothness or aesthetics of finished rock work is desired. The minimum size of surface boulders to be used on this project is shown on Drawings or details but shall be at least 24 inches in all dimensions.

2. Feature Boulders: To be used in grouted boulder and loose boulder installations. Feature boulders shall be 4 feet to 10 feet in at least one dimension and no less than 36 inches in any dimension as shown on Drawings. Feature boulders size and location as shown on Drawings. Where rounded feature boulders are specified, they shall also meet the requirements specified above.

3. Rounded Surface and Feature Boulders: Where rounded surface or feature boulders are specified, they shall meet the requirements of surface boulders and the following conditions related to roundness and smoothness. Rounded be defined as having rounded surfaces with no sharp edges on at least three sides or 75 percent of continuous surface area. All rounded surface and feature boulders shall be rounded naturally by prolonged exposure to weather, glaciation, or moving water. Rounded surface and feature boulders shall be natural appearing material and shall be subject to acceptance by the Engineer. Any remaining sharp edges on exposed surfaces of rounded surface boulders and feature boulders shall be mechanically rounded to 3 inches or greater radius unless otherwise directed by the Engineer.
4. Core Rock (Nonexposed or Buried): Rock obtained from sources listed above to be used in grouted boulder installations that are buried or beneath a layer of surface boulders. Core rock shall be angular rock or broken onsite concrete meeting size requirements. Sharp edges are not a concern for buried/nonexposed core rock. Permissible locations for core rock are shown on Drawings. The minimum size of core rock to be used on this project is 18 inches in any and all dimensions.

5. Core Rock (Exposed): Exposed core rock is to be installed only in the areas below the water surface elevations as delineated on Drawings. Exposed core rock will be imported material only and shall conform to the testing requirements as specified in this article, Paragraph A above. The minimum size of core rock to be used on this project is 18 inches in any and all dimensions.

6. River Cobble: Rock obtained from offsite sources shall be cleaned and stockpiled onsite. The river cobble shall have rounded edges and be cleaned to be free of organics, trash, foreign matter and sharp rock. The size of river cobble to be used in this project 4 inches to 12 inches in the largest dimension.

7. Riprap:  
   a. Imported rock meeting the following gradation:

<table>
<thead>
<tr>
<th>Riprap Designation</th>
<th>% Smaller than Given Size by Weight</th>
<th>Intermediate Rock Dimensions (inches)</th>
<th>$d_{50}$ (inches)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type VL</td>
<td>70 – 100</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>35 – 50</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2-10</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Type L</td>
<td>70 – 100</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>35 – 50</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>2 – 10</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Type M</td>
<td>70 – 100</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>35 – 50</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>2 – 10</td>
<td>4</td>
<td>12</td>
</tr>
</tbody>
</table>
### Classification of Gradation of Ordinary Riprap (Imported)

<table>
<thead>
<tr>
<th>Riprap Designation</th>
<th>% Smaller than Given Size by Weight</th>
<th>Intermediate Rock Dimensions (inches)</th>
<th>$d_{50}$ (inches)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type H</td>
<td>70 – 100</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>24</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>35 – 50</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>2 – 10</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Type VH</td>
<td>70 – 100</td>
<td>42</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>50 – 70</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>35 – 50</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>2 – 10</td>
<td>9</td>
<td>24</td>
</tr>
</tbody>
</table>

* $d_{50}$ = Mean Particle Size

1) Unless otherwise noted on Drawings, riprap shall be placed in the following minimum thickness (not including bedding thickness as applicable):

<table>
<thead>
<tr>
<th>Riprap Designation</th>
<th>Riprap Layer Thickness (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type VL</td>
<td>12</td>
</tr>
<tr>
<td>Type L</td>
<td>16</td>
</tr>
<tr>
<td>Type M</td>
<td>21</td>
</tr>
<tr>
<td>Type H</td>
<td>30</td>
</tr>
<tr>
<td>Type VH</td>
<td>42</td>
</tr>
</tbody>
</table>
8. Granular Bedding Material: Granular bedding designation and total thickness of bedding shall be as shown on Drawings. Granular bedding shall meet the same requirements for specific gravity, absorption, abrasion, sodium sulfate soundness, and freeze, that durability as required for riprap and specified above.

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Type I (CDOT)</th>
<th>Type II (CDOT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-inch</td>
<td>-</td>
<td>90 – 100</td>
</tr>
<tr>
<td>1-1/2 inch</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>-</td>
<td>20 – 90</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>No. 4</td>
<td>95 – 100</td>
<td>0 – 20</td>
</tr>
<tr>
<td>No. 16</td>
<td>45 – 80</td>
<td>-</td>
</tr>
<tr>
<td>No. 50</td>
<td>10 – 30</td>
<td>-</td>
</tr>
<tr>
<td>No. 100</td>
<td>2 – 10</td>
<td>-</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 – 2</td>
<td>0 – 3</td>
</tr>
</tbody>
</table>

9. Crusher Fines: Crusher fines shall be irregular angular particles that interlock and bind into a firm matrix. Crusher fines shall be granite or limestone and shall meet the following gradation.

<table>
<thead>
<tr>
<th>U.S. Standard Sieve Size</th>
<th>Percent Weight by Passing Square-Mesh Sieves</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch</td>
<td>100</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>65</td>
</tr>
<tr>
<td>3/16 inch</td>
<td>50</td>
</tr>
<tr>
<td>1/8 inch</td>
<td>35</td>
</tr>
<tr>
<td>1/16 inch</td>
<td>25</td>
</tr>
</tbody>
</table>
C. Quality Control: The Contractor shall manage the delivery and stockpiling of rock at the site to assure that adequate supply of rock meeting the specification is available for installation when required. Stockpile locations shall be arranged to avoid interference with other project operations. Rock which does not meet specifications or is not installed shall be removed from the site.

2.02 BOULDER GROUT (GROUT)

A. Concrete used for grouted rocks and boulders, “boulder grout” or “grout,” shall be an approved batch and meet all requirements of Section 03 30 00, Cast-in-Place Concrete, as modified below.

B. Strength and General Requirements:

1. Design and proportion boulder grout to meet the following minimum compressive strengths and other criteria:

<table>
<thead>
<tr>
<th>Location</th>
<th>Aggregate Size inch– (ASTM C33 size)</th>
<th>Design Strength 28-day (psi)</th>
<th>Required Strength 7-day (psi)</th>
<th>Slump + 1-inch</th>
<th>Minimum Cement Content* (lbs/yd)</th>
<th>Flyash Content</th>
<th>Maximum Water Cement Ratio*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder Grout **</td>
<td>3/8 – (No.8)</td>
<td>4,500</td>
<td>3,000</td>
<td>2-10</td>
<td>611</td>
<td>20% max.</td>
<td>0.38</td>
</tr>
</tbody>
</table>

* The maximum water-cementitious materials ratio by weight, which shall be based on all water in the mix, including correction for moisture in aggregates, and shall be based on the total cementitious materials including cement and fly ash, if any.

** Add synthetic fiber reinforcement. See Admixtures.

2. Entrained Air for Boulder Grout: Entrained air, 6 plus or minus 1-1/2 percent for ASTM C33 Size 67 or Size 57 coarse aggregate. Refer to ACI 301 for air entrainment required for other coarse aggregate sizes.

3. The slump of the boulder grout will be adjusted depending on the number of rock or boulder layers grouted in a single pour. All boulder grout shall meet the specified requirements for slump, durability, strength, water-cement ratio and other properties. Boulder grout slump shall vary per the following table:

<table>
<thead>
<tr>
<th>Boulder Grout Location</th>
<th>Slump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Boulder Layer</td>
<td>2” to 6”</td>
</tr>
<tr>
<td>Multiple Boulder Layer</td>
<td>6” to 10”</td>
</tr>
</tbody>
</table>
4. When boulder grout arrives at the project with slump below 1 inch, first the boulder grout shall be remixed for at least 1 minute at mixing speed; if the slump is still too low, water may be added only if the maximum permissible water-cement ratio is not exceeded. The water-cement ratio must be verified by truck batch tickets and corrections for moisture in the aggregates. The water must be incorporated by additional mixing equal to at least half of the total mixing required. Any water addition must be reviewed and approved by the Engineer.

5. When grouting multiple boulder layers, boulder grout shall arrive at the job site at a slump of less than 2 inches, be verified, then the high-range water-reducing admixture (super-plasticizer) added to increase the slump to the approved level for placement. Water shall not be added for this purpose. Contractor shall review recommendations of the admixture supplier and ready-mix producer with Engineer. Batch plant additions of part or the entire high-range water-reducing admixture may be considered if found acceptable by the Engineer and if shown to produce equal or better results.

6. Slump shall be adjusted by the Contractor within the ranges given above to assure complete penetration of the boulder grout through each rock layer and into the layer below.

7. Do not retemper mix by adding water once slump is attained in each truck load.

C. Boulder Grout Admixtures:

1. Fibrous Concrete Reinforcement: Per Section 03 30 00, Cast-in-Place Concrete.

2. Color Additives for Boulder Grout: When indicated on Drawings or Specifications, boulder grout shall have integral color pigments added to the mix and be as manufactured by Davis Colors, “or-equal,” at the rates indicated as acceptable following sample panel installation.
   a. Colored additives shall contain pure, concentrated mineral pigments specially processed for mixing into concrete and complying with ASTM C979.
   b. Color additives containing carbon black are not acceptable. Black and Gray coloring shall be obtained using black iron oxide pigments.
   c. The Contractor shall determine exact color or combination of colors to be added to mimic the natural rock of the project and construct sample panel for approval by the Engineer. Color samples shall be submitted to the Engineer prior to sample panel construction.
   d. Dosage rates shall typically be between 3 percent and 5 percent and shall not exceed 10 percent of weight of cementitious materials mix. Contractor shall determine the exact dosage.
required to produce boulder grout to mimic the natural rock of the project as per manufacturer recommendations and Engineer approval.

e. Meter and dispense colors using computer-controlled automated color weighing and dispensing systems provided by the manufacturer of the color additive. As an alternative, manual dispensing may be used and accomplished by addition of premeasured disintegrating bags. Particular attention must be given to thorough mixing of concrete after addition of the color additives.

D. Surface Treatment and Finishes:

1. Boulder grout shall be finished using dry shake color hardeners, stain, and sealant where shown on Drawings or as specified below.

2. Dry Shake Color Hardeners: Color hardeners, where indicated on Drawings or in the Specifications, shall be as manufactured by Brickform, “or-equal,” at the manufacturer recommended application rates or as approved following sample panel(s) installation.
   a. The Contractor shall determine exact color or combination of colors to be applied to mimic the natural rock of the project and construct sample panel for approval by the Engineer. Color samples shall be submitted to the Engineer prior to sample panel construction.
   b. Boulder Grout Color: Dry shake color hardener shall be applied to the 75 percent of the boulder grout surface area above “Low Water Level” and as shown on Drawings. Coloring shall be applied randomly to create variegation of colors, hues, and shades similar to natural rock. Apply per manufacturer’s recommendations and approved sample panel installation.

3. Stain and Sealant: Concrete stain, where required by Drawings or Specifications, shall be as recommended by the Contractor to meet the following requirements.
   a. Create base colors, and color variations that are deemed acceptable following test panel production.
   b. Accurately simulate hues, streaking and coloration matching onsite bedrock boulders.
   c. Must maintain color (little to no fading) in submerged conditions or direct sunlight.
   d. Following staining, the finish shall be sealed with sealant recommended by the Contractor and stain manufacturer, and shall meet the following requirements:
      1) No discoloration with exposure to sunlight.
      2) Increase durability by limiting water penetration.
      3) Preserve color of original stain.
e. Stain and sealants shall be applied per manufacturer recommendation.

E. Coloring and Finishes Summary:

1. See the information in the following table for a summary of the coloring and finishes requirements for this project:

<table>
<thead>
<tr>
<th>Finish</th>
<th>Integral Concrete Color</th>
<th>Dry-Shake Surface Color Hardeners</th>
<th>Surface Stain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder Grout</td>
<td>None</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

2.03 SOIL MIXTURE FOR VOIDS

A. Onsite material for placement where shown on Drawings or specified, such as in riprap, loose boulder mats, and loose/terraced boulders, voids shall be free from trash and organic debris and shall be approved by the Engineer before use.

B. Organic Compost (Soil Amendment): Where soil mixture is placed a minimum of 18 inches from the surface and 18 inches above the invert of the river or channel, or as shown on Drawings, an organic compost soil amendment shall be used. Use a well decomposed, stable, weed free organic matter source, derived from agricultural food, or industrial residuals’ biosolids (treated sewage sludge); yard trimmings, or source-separated or mixed solid waste as a component for seed establishment. The product shall contain no substances toxic to plants and shall be reasonably free (less than 1 percent by dry weight) of man-made foreign matter. Compost shall possess no objectionable odors and shall not resemble the raw material from which it was derived.

C. Compost shall have the following characteristics:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH Range</td>
<td>5.5 – 8.0</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>35% - 55%</td>
</tr>
<tr>
<td>Particle Size</td>
<td>Pass through 1-inch screen or smaller</td>
</tr>
<tr>
<td>Stability</td>
<td>Stable to highly stable, providing nutrients for plant growth</td>
</tr>
<tr>
<td>Maturity/Growth Screening</td>
<td>Demonstrate ability to enhance plant growth</td>
</tr>
<tr>
<td>Soluble Salt Concentrations</td>
<td>2.5 dS (mmhos/cm) or less preferred</td>
</tr>
</tbody>
</table>
Parameter Requirement

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter Content</td>
<td>30% - 70%</td>
</tr>
<tr>
<td>Suggested Source</td>
<td>A-1 Organic, Eaton, Colorado (970) 454-3492, “or-equal.” Submit Sample for approval.</td>
</tr>
</tbody>
</table>

D. Organic Compost Soil Amendment shall be well mixed with onsite soil at an applied rate of 1 cubic yard per 5 cubic yards.

E. Unless specified elsewhere, seed for buried riprap shall be with a mix of native grasses as proposed by a local, well qualified supplier. Rates and application will be as recommended by the supplier.

2.04 FILTER FABRIC

A. Use Mirafi 140 N filter fabric where shown on Drawings.

2.05 CURING COMPOUND

A. Membrane-curing compound shall be in accordance with ASTM C309. Membrane curing compound shall be sprayable, 18 percent minimum solids content, MasterKure 123, “or-equal” acceptable to Engineer. Membrane curing compound used on colored concrete shall be BASF Kure 1315, “or-equal” acceptable to Engineer. Curing compound must not cause discoloration of the boulder grout and boulders. When used on colored or stained boulder grout, curing compound shall be approved by color additive/stain manufacturer and compatible with the color additives, stains, and any surface treatments/finishes used.

2.06 UNDERDRAIN

A. See Section 33 46 00, Subsurface Drainage.

2.07 EROSION CONTROL BLANKET

A. Erosion control blanket shall be C125BN 100 percent.

2.08 SCULPTED ROCK (STAMPED/TEXTURED AND COLORED CONCRETE)

A. Sculpted rock per requirements of Section 03 45 39, Sculpted Concrete.

2.09 FAUX ROCK

A. Faux rock per requirements of Section 03 37 14, Faux Rock.
2.10 PLANTERS

A. Planters shall be per details shown on Drawings. Planters shall be HDPE pipe, reinforced concrete pipe, or precast concrete manhole sections. HDPE pipe shall be N-12 ST IB as manufactured by Advanced Drainage Systems, Inc., “or-equal,” have smooth interior walls and annular exterior corrugations and meet the requirements of ASTM F2648. Reinforced concrete pipe shall be Class II per ASTM C76 with joints meeting requirements of ASTM C443. Precast concrete manholes shall meet the requirements of ASTM. The bottom of the planter shall be covered to eliminate seepage of boulder grout upward into the planter during boulder grout placement. Erosion control mat shall be Enkamat 7020, “or-equal,” at locations shown on Drawings. Metal fasteners, bolts, and washers shall be fabricated from stainless steel, Type 316, (B8M, B8MA) in accordance with ASTM A193.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. Water Control: Prior to commencing work on rock placement, install water control measures as required to perform work in dry conditions. Water control measures shall include, but are not limited to, diversions, sumps with pumps or other means necessary to maintain the level of groundwater below subgrade elevation and to divert surface water away from the work area. The Contractor is responsible for investigating and understanding all site conditions that may affect the work, including surface water, level of groundwater and time of year the work is to be done. By submitting a bid, the Contractor acknowledges that such investigations have been made and consideration of such conditions are a part of the Contractor’s bid.

B. Subgrade Preparation for Riprap, and Boulders: Excavate for placement of rock as indicated, providing a firm smooth uniform surface at the proper grade. The subgrade shall undisturbed native material unless shown in fill areas or as otherwise shown on Drawings. Excavation and subgrade shall meet requirements of Section 31 23 13, Subgrade Preparation, and Section 31 23 16, Excavation. In fill areas under nongrouted armoring or structures, the subgrade to be compacted to 95 percent maximum density (ASTM D698) or to 70 percent of its maximum relative density (ASTM D2049). In fill areas under or otherwise supporting grouted rock, sculpted concrete, faux rock, or structures, the subgrade shall meet the stricter requirements of Subgrade under Structures as specified in Section 31 23 13, Subgrade Preparation. In fill areas after removal of topsoil and any soft yielding material, place approved onsite material and compact as specified herein to the designated subgrade elevation. Subgrade elevation and compaction shall be verified by the Engineer prior to placement of riprap or
boulders. Refer to Section 31 23 13, Subgrade Preparation, for removal and replacement of unsuitable material.

3.02 RIPRAP PLACEMENT

A. Install water control measures. Prepare subgrade and machine place stones into position following details on Drawings. Arrange as necessary by machine or by hand to interlock. The finished area shall be well graded and free from objectionable pockets of small stones and clusters of larger stones. Dumping and/or backhoe placement alone is not sufficient to ensure proper interlocked placement. The basic procedure shall result in larger materials flush to the top surface with faces and shapes arranged to minimize voids, and smaller material below and between larger material. Surface grades will be a plane or as indicated, but projections above or depressions under the finished design grade more than 10 percent of the rock layer thickness will not be allowed. Smaller rock shall be securely locked between the larger stone. It is essential that the material between the larger stones not be loose, or easily displaced by flow or by vandalism. The stone will be consolidated by the bucket of the backhoe or other means that will cause interlocking of the material. The outside edges of the material are to be uniform and free from bulges, humps, or cavities. All rock is to be placed in a dewatered condition beginning at the toe of the slope or other lowest point. Placing in layers will not be permitted.

B. Where Buried or Soil Filled: Following placement and acceptance of riprap, fill voids completely with approved onsite soils in accordance with the requirements herein. Final grade shall be covered with erosion control blanket and secured with biodegradable stakes at locations shown on Drawings.

3.03 PLATED OR HAND-PLACED RIPRAP

A. Plated or hand-placed riprap is riprap meeting other material and installation requirements of that specified elsewhere with the following additional material and installation requirements with stone that is either:

1. Hand Placed: Laid carefully by hand or by derrick following a definite pattern, with the voids between the larger stones filled with smaller stones and the surface kept relatively even. The need for interlocking stone in a hand-placed revetment requires that the stone be relatively uniform in size and shape (square or rectangular); or
2. Plated: Placed on the bank with a skip and then tamped into place using a steel plate, thus forming a regular, well organized surface. During the plating operation, the larger stones are fractured, producing smaller rock sizes to fill voids in the riprap blanket.
   a. In either installation method the following is required:
      1) The even interlocking surface produces a neat appearance and reduces flow turbulence at the water revetment interface.
      2) Provide an even, tight finished surface true to the dimensions shown on Drawings.
      3) Irregular surface protrusions shall be less than the greater of:
         a) 1/4 of the d_{50} of the specified riprap stone size, or
         b) 2 inches, or
         c) As otherwise directed by the Engineer.

B. Installation Requirements for Hand-Placed Riprap:
   1. Place and bed the stones, one against the other, and key together. Fill irregularities between stones with suitable size stones rammed tightly into place.
   2. Provide an even, tight finished surface true to the dimensions shown in the plans.
   3. Embed riprap below the ground surface.

C. Installation Requirements for Plated Riprap:
   1. Place loose riprap according to this Section and as indicated on Drawings.
   2. Compact properly placed loose riprap by repeatedly striking the riprap surface with a steel (armor) plate, approximately 5 feet by 5 feet and weighing 6,000 pounds, dropped from a height of 3 feet to 5 feet.
3. Compaction is complete when plating action has resulted in a reasonably uniform surface, true to the dimensions shown on Drawings, and free from any irregular surface protrusions over 3 inches high.

![Figure 1 - Examples of Plated Riprap](image1)

3.04 LOOSE BOULDER MAT PLACEMENT

A. Definition: Loose boulders that create a reinforcing/armoring mat in contract with the subgrade.

B. Prepare subgrade. Bedding shall be that as defined for VH Riprap unless otherwise indicated on the details of Drawings (i.e., may not be indicated on Drawing views).
C. Boulders shall be individually placed in a manner to avoid displacing underlying materials. Each boulder shall be placed to the final position by the use of a multi-prong grapple device or suitable equipment for handling individual boulders. If necessary, the boulder shall be picked up and repositioned with minimal disturbance to the subgrade.

D. Boulders shall be set in contact with each other so that the interstices between adjacent boulders shall be as small as the character of the rock will permit.

E. Placement shall begin at the bottom of slope.

F. Moving boulders by drifting or manipulation down the slope will not be permitted. Boulders shall not be dropped from a height of greater than 1 foot.

G. Voids between boulders shall be filled with smaller rock by hand and machine as directed by the Engineer.

H. Arrange each boulder as directed by Engineer. In general, loose boulders in contact with the subgrade will be arranged with a flat surface upward and horizontal. It should be anticipated that rehandling of individual stones after initial placement will be required to achieve required slopes, grades, elevations, aesthetics, and position. A tolerance of plus or minus 0.17 feet from the indicated grade, slope, and elevations shown on Drawings will be allowed in the finished surface unless indicated otherwise on Drawings. Control structures crests and inverts shall have a tolerance of 0.1 feet from elevations shown on Drawings. Prior to placing boulders with dimensions that exceed the minimum specified, excavate the subgrade as required to achieve top surface elevations within the specified tolerance.

I. Place soil or cobble (as indicated on Drawings) between all individual boulders of the loose boulder mat to a height of 3/4 of the diameter of the boulders unless otherwise shown on Drawings.

3.05 ALL BOULDERS AND ROCK TO BE GROUTED

A. See requirements in Section 2 above.

B. Grouted rock (core rock, feature boulders, and surface boulders) installation shall be subject to approval by the Engineer at two stages:

1. Following subgrade preparation and before placement of any rock; and,
2. Before grouting the placed rock.
C. The Engineer shall be notified a minimum of 48 hours before the schedule placement of any rock for grouted rock installation to allow inspection of prepared subgrade. The prepared subgrade shall be subject to approval by the Engineer and no rock shall be placed without such approval.

D. The Engineer shall be notified a minimum of 48 hours before the scheduled placement of any boulder grout for grouted rock installations. The arrangement, elevation and cleanliness of rock to be grouted shall be subject to approval by the Engineer and no boulder grout shall be placed prior to such approval.

E. Prepare subgrade. Placement methods will avoid displacing the compacted subgrade. Install fabric where shown on Drawings.

F. Boulders shall be set in contact with each other so that the interstices between adjacent boulders shall be as small as the character of the rock will permit.

G. Tolerances for boulder placement shall be as indicated on Drawings or specified herein. In some cases, it may be necessary to remove a boulder, adjust the subgrade elevation and reset the boulder to achieve the required surface tolerance.

3.06 FEATURE BOULDERS AND SURFACE BOULDERS TO BE GROUTED (ADDITIONAL REQUIREMENTS)

A. Prepare subgrade (see Article Subgrade Preparation).

B. Boulders shall be individually placed in a manner to avoid displacing underlying materials. Each boulder shall be placed to the final position by the use of a multi-prong grapple device or suitable equipment for handling individual boulders. If necessary, the boulder shall be picked up and repositioned with minimal disturbance to the subgrade.

C. Placement shall begin at the bottom of slope.

D. Moving boulders by drifting or manipulation down the slope will not be permitted. Boulders shall not be dropped from a height of greater than 1 foot.

E. Arrange each boulder as directed by Engineer. In general boulders will be arranged with a flat surface upward and horizontal. It should be anticipated that rehandling of individual stones after initial placement will be required to achieve required slopes, grades, elevations, and position. A tolerance of plus or minus 0.17 feet from the indicated grade, slope, and elevations shown on Drawings will be allowed in the finished surface unless indicated otherwise on the Drawings. Control structure crests or inverts shall have a tolerance of 0.1 feet from elevations shown on Drawings. Prior to placing boulders with
dimensions that exceed the minimum specified, excavate the subgrade as required to achieve top surface.

3.07 FEATURE BOULDER INSTALLATION (ADDITIONAL REQUIREMENTS)

A. Feature boulders shall be set in locations shown on Drawings and as directed by the Engineer or Inspector in the field.

B. Stake locations of boulders for review prior to setting boulders.

C. Engineer or Inspector will hand select each feature boulders at source.

D. Contractor shall rotate boulder as directed by the Engineer and measure limit of height, width and length. It should be anticipated that rehandling and moving of individual boulders after initial placement will be required to achieve the required slopes, grades, and positions.

E. The finished elevation of feature boulders shall be within 0.3 feet of the elevations shown on Drawings, unless otherwise authorized by the Engineer or Inspector in the field.

3.08 BOULDER GROUT PLACEMENT

A. Boulder grout placement shall meet all applicable requirements of Section 03 30 00, Cast-in-Place Concrete, and in Section 2 above. See required notification requirements above.

B. Unless otherwise shown on Drawings, slump shall be adjusted onsite as specified in Section 2 above for single layer and multiple layer grouting. The use of stiffer mixes or other measures may be approved for individual or partial truck loads by the Engineer for steeper slope applications.

C. Maintain water control measures before, during and after boulder grout placement until sufficient cure is obtained. Care shall be taken to remove all fines and smaller rock. Wash the rock free of fines or soil which would affect the bond. Any loose material between rocks shall be removed to ensure complete grout penetration down to compacted subgrade and in all voids between rocks.

D. All boulders shall be wetted prior to boulder grout placement for proper bonding. Excess water or ponding on the subgrade shall be removed prior to boulder grout placement.
E. The boulder grout shall be injected into the voids by pumping under low pressure, through a 3-inch maximum diameter hose to ensure complete penetration of the boulder grout to the subgrade. The voids at the surface, as detailed on Drawings, will not be grouted unless designated. Operator shall be able to stop the flow and will place boulder grout in the voids and not on the surface of the rock. Clean and wash any spillage before the boulder grout sets. The visual surfaces of the rock will be free of boulder grout to provide a clean natural appearance. A “pencil” vibrator will be used to make sure all voids are filled between and under rock. The intent is to fill all voids with boulder grout from the subgrade level through the rock layer. In all cases, boulder grout must penetrate to subgrade. The pencil vibrator may be used to smooth the appearance of the surface, but the Contractor shall use a wood or steel float and/or trowel to smooth and grade the boulder grout surface to drain. Final surface shall be broomed or textured for a slip-resistant finish.

F. Boulder grout shall be cured as outlined in Section 03 30 00, Cast-in-Place Concrete. If curing compound is allowed, it shall not be sprayed into or washed off in the river. The curing compound shall dry for 24 hours minimum before allowing water to flow over it. In cold weather conditions, the entire grouted rock mass shall be protected from freezing as outlined in Section 03 30 00, Cast-in-Place Concrete.

G. Provisions for Grouting Multiple Boulder Layers: Multiple layers of boulders having boulder grout depths up to 6 feet thick shall be grouted in a single operation in order to form a single monolithic structure.

1. Where the boulder grout depth is greater than 6 feet thick, grouting shall be completed in multiple lifts less than 6 feet unless otherwise approved by the Engineer. The initial layer(s) of rock to be grouted shall be placed and then grouted with the boulder grout held a minimum of 6 inches and not more than 50 percent of the rock diameter below the top of the rock. Boulder grout placed for the subsequent layer will then penetrate down and around the tops of the first layer maximizing the strength of the joint. Successive layers of rock shall not be placed on top of grouted boulders until the boulder grout has cured at least 7 days or until the boulder grout reaches 80 percent of the design strength required by these Specifications.

H. Boulder Grout Coloring, Surface Treatments, and Staining:

1. Integral Color:
   a. Integral colored boulder grout shall meet the following finishing requirements:
      1) Do not dampen finishing tools.
      2) Do not over-trowel or start troweling late.
3) Finishing per the approved sample panel.

2. Dry Shake Color Hardeners: Apply per manufacturer recommendations and approved sample panel installation.

3. Surface Stains:
   a. Staining of Boulder Grout shall meet the following requirements:
      1) Application of stains shall be per manufacturer recommendations and the approved sample panel.
      2) Stain shall be applied once the Boulder Grout has cured 28 days.
      3) A sealant shall be applied per manufacturer’s recommendations that is compatible with the stain used.

3.09 SOIL PLACEMENT IN AND OVER ROCK

A. Where rock is designated to be buried or voids partially filled, place onsite excavated material that is free from trash and organic matter in voids by washing and rodding. When voids are filled and the surface accepted by the Engineer. Fine grade per Section 02200, Earthwork.

3.10 SCULPTED ROCK

A. Methods of construction shall be per Section 03 45 39, Sculpted Concrete.

3.11 FAUX ROCK

A. Methods of construction shall be per Section 03 37 14, Faux Rock.

3.12 PLANTERS

A. Planters shall be installed at locations shown on Drawings unless modified by the Engineer. Planters shall be installed to not damage or deform the walls of the structures. After grouting adjacent areas, soil shall be placed in the planter, the shrub or tree shall be planted as defined in other sections of these specifications, and the covering geotextile and cobble shall be installed to effectively protect the soil and tree against river currents.

END OF SECTION
PART 1  GENERAL

1.01  SUBMITTALS

A.  Informational Submittals:
   1. Excavation support plan.
   3. Trench excavation plan.
   4. Movement measurement and data and reduced results indicating movement trends.

1.02  QUALITY ASSURANCE

A.  Provide surveys to monitor movements of critical facilities.

PART 2  PRODUCTS (NOT USED)

PART 3  EXECUTION

3.01  GENERAL

A.  Design, provide, and maintain shoring, sheeting, and bracing as necessary to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed the Work.

3.02  EXCAVATION SUPPORT PLAN

A.  Prepare excavation support plan addressing following topics:
   1. Details of shoring, bracing, sloping, or other provisions for worker protection from hazards of caving ground.
   2. Design assumptions and calculations.
   3. Methods and sequencing of installing excavation support.
   4. Proposed locations of stockpiled excavated material.
   5. Minimum lateral distance from the crest of slopes for vehicles and stockpiled excavated materials.
   6. Anticipated difficulties and proposed resolutions.
3.03 MOVEMENT MONITORING PLAN

A. Prepare movement monitoring plan addressing following topics:
   1. Survey control.
   2. Location of monitoring points.
   3. Plots of data trends.
   4. Interval between surveys.

3.04 REMOVAL OF EXCAVATION SUPPORT

A. Remove excavation support in a manner that will maintain support as excavation is backfilled.

B. Do not begin to remove excavation support until support can be removed without damage to existing facilities, completed Work, or adjacent property.

C. Remove excavation support in a manner that does not leave voids in the backfill.

3.05 TRENCHES

A. For trench excavation exceeding 5 feet in depth, provide adequate safety system meeting requirements of applicable state and local construction safety orders, and federal requirements.

END OF SECTION
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   d. A416, Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
   e. A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   f. A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   g. A882, Standard Specification for Epoxy-Coated Seven-Wire Prestressing Steel Strand.
   m. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   o. C942, Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
ZINK DAM IMPROVEMENTS


1.02 ALTERNATE SYSTEMS

A. Other types of post-tensioning systems complying with Drawings and Specifications will be considered as an alternate to basic system shown and specified.

B. Provide details of construction methods, materials, and design calculations.

C. Alternate system(s) will be subject to Engineer’s review and approval.

1.03 DEFINITIONS

A. Alignment Load: Nominal load maintained in anchor to keep testing equipment positioned.

B. Anchor: System used to transfer tensile loads to concrete or rock. Includes prestressing steel, anchorages, grout, coatings, sheathings, provisions for sounding the top of the primary grout, provisions for installing grout and venting air, and couplers if used.

C. Anchor Load: Load to which the anchor is stressed.

D. Centralizers: Spacers used to position tendon in center of anchor hole and to space the individual tendons in a particular pattern to ensure uniform grout cover for tendon.

E. Consolidation Grout: Portland cement grout that is injected into the hole prior to inserting tendon to seal or stabilize hole.
F. Creep Movement: Total movement that occurs during creep test of anchor.

G. Creep Test: Test to determine movement of tendon at constant load during certain time period.

H. Design Load: Anticipated final maximum effective load in anchor after allowance for time-dependent losses.

I. Double Corrosion Protection: Protection of tendons wherein the first layer of protection is provided by primary grout or secondary grout, and the second layer is as specified in this section.

J. Elastic Movement: Recoverable movement of anchor measured during performance test.

K. Leveling Grout: Nonshrink grout used for bedding and leveling tendon anchorage bearing plate.

L. Lift-Off Test: Checking force in prestressed anchor at any specified time with use of hydraulic jack.

M. Performance Test: Incremental test loading and unloading of tendon anchorage recording of movement of tendon at each increment.

N. Primary Grout (or Anchor Grout): Grout that is injected into anchor hole to provide anchorage of tendon prior to stressing.

O. Primary Grout Zone: That section of the anchor that is grouted before stressing.

P. Proof Load: Temporary prestressing load in anchor at force level greater than its design load for testing purposes.

Q. Proof Test: Incremental test loading of tendon anchorage, recording of tendon movement at each load increment.

R. Redrilling: Removal of consolidation grout from a tendon hole.

S. Residual Movement: Nonelastic (nonrecoverable) movement of anchor measured during performance test.

T. Secondary Grout: Grout that is injected into anchor hole after stressing to cover length of prestressed anchor above the primary grout, providing corrosion protection for high strength steel.

U. Secondary Grout Zone: That section of the anchor that is stressed before grouting.
V. Set Time: Time between start of mixing grout and liquid phase changing into plastic state.

W. Sheathing: Enclosure around the prestressing steel to avoid bonding between the surrounding grout or to provide corrosion protection.

X. Sounding: A method used by the Contractor to lower a rigid wire, bar, or pipe through a hole in the stressing head to physically touch the top of the primary grout and determine the actual elevation for comparison with the maximum elevation permitted.

Y. Tendon: Complete anchor assembly (excluding grout) consisting of stressing anchorage and high strength prestressing steel, with sheathing and coating when required.

Z. Tendon Manufacturer: Company supplying the high strength steel or bars.

AA. Test Load: Temporary prestressing load in anchor at force level equal to 1.33 times design load.

BB. Topping Grout: Nonshrink grout used to fill in stressing anchorage blockout after secondary grouting is completed and excess tendon lengths are cut off.

CC. Transfer (Lockoff) Load: Post-tensioning force (Kips) per anchor transferred to the anchor plate when the lockoff devices are set and jack load is released.

DD. Water Test: Testing of a drilled hole using water to determine watertightness of the hole.

1.04 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s Product Data:
   a. Prestressed Anchors: Material specification, load capacities, and installation procedures.
   c. Sheathing: Corrugated or extruded, if specified.
   d. Leveling and topping nonshrink grout.
   e. Admixtures.

2. Post-Tension System:
   a. Tendon Design, Details, and Calculations: Include size, number, and type of tensioning elements, anchorages, bearing plates, pipe sleeves, other related hardware, fabrication and erection details.
   b. Proposed method to provide the extruded polypropylene sheath a watertight seal with the base of the anchor head.
c. Structural and Stressing Calculations: Include allowances for increase in stressing length resulting from development of tendon anchorage at the top of the primary grout and time-dependent loss of load values.

d. Top Anchorage and Bearing Plates: Design and details. Show incorporation of specified functions.

e. Grout and Vent Tube: Arrangement details.

f. Tendon Anchorages: Detailed stressing procedures and data required for performance testing and proof testing.

3. Special Reinforcing Steel: Confirmation that details at tendon anchorages shown are adequate, or suggested specialized reinforcing.

B. Informational Submittals:

1. Schedule showing sequence of grouting operation.
2. Qualifications:
   a. Installer’s experience records.
   b. System designer.
   c. Testing laboratory.
3. Post-Tension System:
   a. Installation instructions.
   b. Certification of conformance.
   c. Onsite storage instructions.
   a. Steel Manufacturer’s Mill Certification:
      1) Physical and chemical properties including stress-strain curves, steel area, guaranteed ultimate tensile strength, yield strength, elongation at yield, and estimated values for relaxation characteristics of steel.
      2) Include one report per run and identify system, showing disposition of materials onsite.
5. Steel Reinforcement: Manufacturer’s test data.
6. Grouts: Mix design, trial batch test results, and field test reports.
7. Grout Admixtures: Manufacturer’s mixing and installation instructions.
8. Certification that grouts and admixtures do not contain chlorides, aluminum powder, or other corrosive elements for the prestressing.
9. Installation Details: Grout pipe and primary grout arrangement, sounding procedures, and grout pumping.
13. Anchor hole record data.
14. Grouting record data.
15. Submit record document tensioning, testing, and lift-off data applicable to tendon, including plot of performance tests showing total anchor
movement as a function of load and a plot of residual movement as a function of load.


1.05 QUALIFICATIONS

A. Installer: Minimum of 5 years’ acceptable experience involving type of post-tensioning system. Available onsite, full-time, during entire drilling, grouting, and prestressing operations.

B. System Design and Shop Drawing Preparation: Performed by a professional civil or structural engineer currently registered in the state of Oklahoma who will stamp and sign Shop Drawings.

C. Testing Laboratory: Independent, certified to perform grout cube strength testing in accordance with ASTM C942.

1.06 GROUT PREINSTALLATION MEETING

A. Attended by Contractor’s quality control representative, manufacturer’s representative, Subcontractor(s), and employees performing the grouting operation.

B. Purpose: Manufacturer’s representative will demonstrate recommended techniques for mixing and pumping grout by mixing and pumping grout into at least two tendon holes.

1.07 RECORD DOCUMENTS

A. Anchor Hole Record Data:

1. Record the following:
   a. Elevation of concrete-rock interface during anchor hole drilling.
   b. Hole deviation from design orientation, direction of deviation, and the amount.
   c. Anchor hole water testing, consolidation grouting, and redrilling.
   d. Tendon installation.
   e. Grout strength testing, fluidity tests, set time tests, as specified for each type of grout.
   f. Primary tendon grouting, tensioning, and tendon testing with plots of anchor movement as a function of load.
   g. Sounding measurements and elevation of top of primary grout.
   h. Secondary tendon grouting.
   i. Lift-off data.
   j. Date of certification of installation by manufacturer’s representative.
B. Grouting Operation Data: Record for each tendon installed.
   1. Type of mixer.
   2. Amount of water added per bag.
   3. Grout pressure.
   4. Strength test cube sample designations.
   5. Test results showing specific gravity, flow cone test, mud balance, and bleed test data.
   6. Volume of primary grout placed.
   7. Elevation at top of primary grout measured.
   8. Time and date.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Protect uncoated or otherwise unprotected tendon components with vapor-phase corrosion inhibitors and wrap or cover at factory to prevent damage and to prevent dirt, water, and rust from affecting components during shipping storage and up until time of installation.

B. Materials showing rust sufficient to cause excessive surface roughness, pitting visible to naked eye, or unevenness will be considered defective and will be rejected.

1.09 SEQUENCING AND SCHEDULING

<table>
<thead>
<tr>
<th>Activity</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product shipments</td>
<td>Submittals approval or acceptance by Engineer</td>
</tr>
<tr>
<td>1) Approval of the grout mix design; and 2) approval of the minimum primary grout cure time</td>
<td>Engineer’s acceptance of certified trial batch test results</td>
</tr>
<tr>
<td>Grouting operation</td>
<td>(1) Accepted related Submittals, and (2) grouting preinstallation meeting</td>
</tr>
<tr>
<td>Tendon tensioning</td>
<td>1) Approval of the grout mix design; 2) approval of the minimum primary grout cure time; 3) Primary grout and anchor plate leveling grout have cured for minimum specified time; 4) grout strength has been verified by certified testing laboratory; and 5) hydraulic jack and gauge calibration certification</td>
</tr>
<tr>
<td>Secondary grouting</td>
<td>1) Tendon alignment stressing for individual strand; 2) Tendon performance test; 3) Tendon proof test; and 4) Tendon certification of proper installation</td>
</tr>
</tbody>
</table>
### Activity Prerequisites

<table>
<thead>
<tr>
<th>Activity</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topping grout placement</td>
<td>Complete within 1 week of cutting tendon protrusions</td>
</tr>
<tr>
<td>Starting drilling, grouting, and tensioning operations</td>
<td>2 week written notification to Engineer</td>
</tr>
</tbody>
</table>

# PART 2 PRODUCTS

## 2.01 SYSTEM DESIGN

A. Design: Meet requirements of 2014 Edition of “Recommendations for Prestressed Rock and Soil Anchors” in Post-Tensioning Manual published by Post-Tensioning Institute (PTI), except requirements of these Specifications and Drawings will take precedence over PTI publication.

B. Design anchorage and blockout requirements.

C. Size tendon holes when required size exceeds minimum shown or specified.

D. Detail tendon anchor lengths subject to requirements shown.

E. Provide centralizers to center tendons in holes.

F. Special Reinforcing Steel: Design at tendon anchorages as necessary. Verify size and arrangement of local zone and general zone reinforcing within concrete member to resist spalling and splitting tensile stresses in concrete due to tensioning forces.

G. Performance Specification:

1. Maximum Tendon Stress: 80 percent of Guaranteed Ultimate Tensile Strength (GUTS).
2. Tendon Transfer (Lockoff) Load: Not to exceed 70 percent of GUTS.
3. Minimum requirements for each tendon at design load level, and with maximum allowable tendon hole bond stress allowable at any load level, as shown.
4. Design Load: Not to exceed 60 percent of GUTS after losses.

## 2.02 REINFORCING STEEL

A. Steel Reinforcement:

1. Conform to ASTM A615, Grade 60.
2. Bar Splices: Capable of developing 125 percent of bar yield strength.
2.03 PRESTRESSED ANCHOR TENDONS

A. Provide complete assembly including prestressing steel, grouted fixed anchorage, and stressing anchorage.

B. Steel Thread Bars:
   1. Deformations of Thread Bars:
      a. Form screw thread suitable for mechanically coupling lengths of thread bar and for positive attachment of anchor assemblies.
      b. Meet ASTM A722 requirements and be uniform such that any length of bar may be cut at any point and internal threads of a coupling designated for that size of bar can be freely screwed on bar.
   2. Tensile and Physical Properties:
      a. Nominal Diameter: As shown.
      b. Ultimate Tensile Stress: Minimum 150,000 psi.
      c. Yield Stress at 0.2 Percent Offset: Minimum 120,400 psi.
      d. Elongation in 10-Bar Diameter: Minimum 7 percent.
      e. Carbon Content: Maximum 0.55 percent.
      f. Sacrificial metal coatings shall not be applied to the prestressing steel, but may be used for bearing plates and/or trumpets.
   3. Thread bars with quenched or tempered steels are not permitted.
   4. Provide products from manufacturers with minimum 5 years’ experience, under their current name, in manufacturing of post-tensioning material.
   5. Bars and their deformations shall be hot-rolled.
   6. Manufacture to meet requirements of ASTM A722, including supplementary requirements of ASTM A722. When testing in accordance with ASTM A722, provide minimum of four Samples from material from each heat and test two samples in tension and two Samples in bend test.
   7. Components: Provide couplers, nuts, bearing plates, and other system components as required for complete installation.
   8. Manufacturers and Products:
      a. Use materials from single manufacturer.
      b. Dywidag Systems International, USA, Inc., Lincoln Park, NJ; Dywidag Prestressed Thread Bar Tendon System, or Williams Form Hardware and Rockbolt Ltd. Belmont, MI; Grout Bonded (Multiple Corrosion Protected) Rock and Soil Anchor Systems.

C. Top Anchorage and Bearing Plates:
   1. Design and fabricate of steel to dimensions sufficient to prevent permanent physical distortion when tested with tendon of size required.
2. Bearing Plate:


4. Couplers for Bars:
   a. Screw-on type as furnished by bar manufacturer.
   b. Capable of developing specified guaranteed minimum tensile strength of bars without evidence of failure.

5. Design anchorages to develop at least 95 percent of actual ultimate strength of tendon, tested in an unbonded state, without exceeding anticipated set.

6. Design anchorage to allow verification of prestress force in tendon prior to removal of stressing equipment.

D. Splices in Bar Tendons: As approved by Engineer in accordance with Article Submittals.

E. Centralizers: As required to ensure that specified clearance between tendon and grout hole is maintained.

F. Post-Tensioning Units: Do not weld; perform any necessary welding in vicinity of tendons or tendon materials with extreme caution to avoid touching tendon with electrode and to avoid electrical circuits that may cause resistance heating of tendon.

G. Grout and Vent Tubes:
   1. Designed by tendon manufacturer for coordination with holes required in baseplate and proper grouting procedures.
   2. Coordinate with methods for sounding top elevation of primary grout.
   3. Make provision to remove and dispose of water from bottom of hole if present.
   4. Verify drill hole size to receive anchor and, if this hole size is required to be of larger diameter than that shown to allow placement of tubes, grout, and sounding devices, show larger diameter on Shop Drawings.
   5. Provide a minimum of 1/2-inch diameter tube at centerline of tendon to be used to sound top of primary grout using a positive rigid or semi-rigid measuring rod to extend down to top of grout.
6. Sounding Device: Positive rigid measuring rod or wire.

2.04 PORTLAND CEMENT
   A. ASTM C150, Type II.
   B. Fresh, without lumps or other indication of hydration or “pack set.”

2.05 WATER
   A. Clean and meeting Federal and State Drinking Water Standards with regard to oil, acid, alkali, organic matter, and injurious quantities of chlorides, fluorides, sulphites, and nitrates.

2.06 SAND
   A. Fine aggregate for concrete as specified by ASTM C33.
   B. Not more than 4 percent passing U.S. Standard No. 200 sieve when tested in accordance with ASTM C117.

2.07 GRANULAR FILLER
   A. Size: As designated by Engineer in field.
   B. Gradation: Meeting requirements of ASTM C33.

2.08 LEVELING AND TOPPING GROUT MIX
   A. Nonmetallic, nongas liberating, fluid, prepackaged nonshrink grout with natural aggregate.
   B. Meet requirements of Corps of Engineers’ Specification for Non-Shrink Grout, CRD-C621, and ASTM C1107, Grade B.
   C. Fluid Grout: Fluid consistency (20 to 30 seconds), as determined by flow cone test, CRD-C611 or ASTM C939.
   D. Strength: Minimum cube strength of 2,500 psi at 1 day and 7,000 psi at 28 days as determined by CRD-C621 or ASTM C942.
   E. Manufacturers and Products:
      1. Master Builders, Cleveland, OH; Master Flow 928.
      2. Euclid Chemical Co., Cleveland, OH; Hi-Flow Grout.
2.09 WATER REDUCING PLASTICIZER ADMIXTURES

A. Manufacturers and Products:

2.10 CURING COMPOUND

A. ASTM C309.

B. Moisture Loss: Not to exceed 0.030 gram per square centimeter per 72 hours.

C. Manufacturers and Products:
   1. Masters Builders, Cleveland, OH; Masterkure.
   2. Euclid Chemical Co., Cleveland, OH; Euco Super Floor Coat.

2.11 CONSOLIDATION GROUT MIX

A. Composition: Portland cement, Type II, sand and water.

B. Minimum Compressive Strength: 3,500 psi at 14 days.

C. Water-Cement Ratio: Determined by Contractor.

D. Water Loss: Control by use of granular filler as required by Engineer.

2.12 GROUT FOR PRIMARY AND SECONDARY GROUTING FOR MULTIPLE TENDON UNITS

A. Grout free of aggregates to provide maximum penetration into small spaces between wires and strands.

B. 3,300 psi at 24 hours using 2-inch cubes cured and tested per CRD-C621.

C. Provide local representative of grout manufacturer to Site to train Contractor staff on mixing and pumping by actual demonstration and pumping grout into at least two tendon holes. Provide final job report to Engineer at conclusion of the Work.

D. Manufacturer and Product: Master Builders Co., Cleveland, OH; Master Flow 816 Cable Grout.
2.13 GROUT FOR PRIMARY AND SECONDARY GROUTING OF SINGLE BAR UNITS

A. Fluid, prepackaged, nonshrink grout requiring only addition of water.

B. Extended working time, fluid for at least 1 hour with fluid consistency of 20 seconds to 30 seconds per flow cone test of CRD-C611.

C. Pumpable nonshrink, nonmetallic, nonbleeding, and nongas forming.

D. Provide certification grout contains no chlorides or other elements corrosive to prestressing steel.

E. Strength: Minimum cube strength of 2,500 psi at 1 day and 7,000 psi at 28 days when sampled and tested per ASTM C942.

F. Manufacturers and Products:

1. Master Builders Co., Cleveland, OH; Master Flow 928.
2. Euclid Chemical Co., Cleveland, OH; Hi-Flow Grout.

2.14 DOUBLE CORROSION PROTECTED POST TENSIONING SYSTEM

A. First Layer of Protection: Primary or secondary grout.

B. Second Layer of Protection:

1. Primary Grout Zone: Centralized bare prestressing steel bar in primary and secondary grout zones and encapsulated in grout inside a corrugated polypropylene or polyethylene sheath. Sheath extended the full length of hole and covered with grout.
2. Top anchorage will be embedded in concrete.

C. Corrugated Sheathing:

1. Wall Thickness: Sufficient to protect against corrosion, prevent movement during tendon stressing, and to transfer the stress to the rock. Either polypropylene or polyethylene, at Contractor’s option.
2. Polypropylene: Designation Type PP210B5554211, ASTM D4101.
   a. Manufacturer and Model: Ashland Chemical Co.; PROFAX 6823 and 7823.
D. Corrosion Inhibitor:

1. Drop Point: 300 degrees F minimum, ASTM D566.
2. Flash Point: 300 degrees F minimum, ASTM D92.
3. Water Content: 0.1 percent maximum, ASTM D95, E1.
4. Oil Separation: 0.5 percent by weight maximum at 160 degrees F, FTMS 791B, Method 321.2.
5. Corrosion Test: 5 percent salt fog at 100 degrees F, 5 mils (Q panel Type S); normal conditions, rust Grade 7 or better after 720 hours; aggressive conditions, rust Grade 7 or better after 1,000 hours; ASTM B117 and ASTM D610, E1.
6. Soak Test: 5 percent salt fog at 100 degrees F, 5 mils (Q panel Type S), immerse panels in 50 percent salt solution and expose to 5 percent salt fog, no emulsification after 720 hours; ASTM B117.
7. Water Soluble Ions:
   b. Nitrates: 10 ppm maximum, ASTM D4327.
   c. Sulfides: 10 ppm maximum, APHA 427D (15th Ed.).
8. Sheathing Hardness and Volume Change: 10 percent maximum for volume, 15 percent maximum for hardness after 40 days at 150 degrees F, ASTM D4289.
9. Sheathing Tensile Strength Change: 30 percent maximum after 40 days at 150 degrees F, ASTM D638.

2.15 SOURCE QUALITY CONTROL

A. Performed by independent testing laboratory.

B. Grout Mixes: Mix a trail batch of proposed grout mix design and test grout strength using 2-inch cubes cured and tested per ASTM C942.

1. Trial Batch: Use actual cement and actual water that will be used at Site. Test cubes 28 days and proposed cure primary grout prior to scheduled tensioning of tendons.

PART 3 EXECUTION

3.01 DRILLING EQUIPMENT

A. Coring, rotary drilling, or percussion hammer type.

3.02 GROUTING EQUIPMENT

A. Continuous operation without interruption.
B. Mixer: High speed colloidal type mixer with a water meter for precise control. Provide dispensers with accurate controls for all admixtures.

C. Pumps: Progressive cavity type, capable of pumping grout as required to match working time of grout.
   1. Measure pumped grout quantity within 0.1 cubic foot.
   2. Pressure: 150 psi at top of hole.

D. Screen:
   1. Clear Openings: 0.125-inch maximum size.
   2. Easily accessible for inspection and cleaning.

E. Testing Equipment: Provide flow cone (for checking fluidity), containers (to check bleeding of grout), and cube molds (for sampling, clamping, and sealing of cube samples). Provide a mud balance (for maintaining the correct specific gravity and admixture and water-cement ratio).
   1. Dog Leg: A steel mandrel, 10 feet long and 1 inch smaller in diameter than anchor hole (for checking diameter and straightness of drilled hole).

3.03 TENDON TENSIONING EQUIPMENT

A. Hydraulic Jacks:
   1. Pressure Gauge:
      a. Reading Dial: At least 6 inches in diameter and accurate enough to read 100 psi changes in gauge pressure.
      b. Calibrated as unit with jack cylinder extension in approximate position for final jacking force within three weeks prior to stressing.
   2. Capable of applying each load increment in less than 60 seconds.

B. Incremental Measuring Devices: Capable of detecting tendon movement to nearest 0.001 inch.

3.04 DRILLING

A. Follow approved procedures.

B. General:
   1. Coring, rotary drilling, or percussion-air-hammer type drilling.
   2. Use water or air with sufficient moisture for dust control to remove drill cuttings.
3. Do not use rod dope, grease, or other lubricants during drilling.
4. Do not cause permanent structural damage to existing concrete sections.
5. If permanent damage occurs, discontinue method of drilling and substitute another method at no additional cost.
6. Repair structural damage by approved method.

C. Drill holes with appropriate size bit or core with diameter of bit or core not less than 1/8-inch smaller than designed or specified hole diameter.

D. Consolidation Grouting and Redrilling: Perform when watertightness test fails as specified hereinafter.

E. After completion of drilling, wash sides of holes with a nozzle that will impinge water on sides of hole.

F. During washing, provide water velocities in hole sufficient to remove loose material from hole.

G. If a hole is rejected by Engineer, due to failure to maintain required alignment or due to any fault or negligence of Contractor, fill hole with consolidation grout. Drill new hole in location determined by Engineer.

H. Test holes drilled for installation of tendons for watertightness as specified hereinafter.

I. Drilled Holes: After acceptance of hole, close each hole with a tapered, turned wooden plug to prevent entry of unwanted grout, dirt, or other deleterious substance prior to installation of assemblies and grouting.

J. Anchor Hole Tolerances:
   1. Depth: Within minus 0 inch to plus 6 inches.
   2. Location: Within 1-1/2 hole diameters from planned location.
   3. Verticality: Within 1-degree of vertical.

3.05 CONSOLIDATION GROUTING

A. Maximum 5 psi gauge measured at hole top.

B. Maintain pressure on grout until initial set.

C. Initial Setting Time: Minimum 8 hours prior to redrilling.
3.06 TENDON INSTALLATION AND PRIMARY GROUTING

A. Preparation: Immediately prior to tendon installation, flush hole with water to provide saturated rock and concrete surfaces, remove standing water in bottom of hole, and sound hole for compliance with required depth.

B. Tendons:
   1. Free of dirt, loose rust, grease, or other deleterious substances.
   2. Place in accordance with approved Shop Drawings.
   3. Provide with rigid and adequate support during placement of primary grout.
   4. Do not weld. Perform welding in vicinity of tendons or tendon materials with extreme caution to avoid touching tendon with electrode and to avoid electrical circuits that may cause resistance heating of tendon.

C. Primary Grout:
   1. Pump into bottom of hole through clean and leak-free grout pipes.
   2. Measure amount being pumped to avoid overfilling hole.
   3. Continuously sound the primary grout surface by positive measuring rod through the holes in tendon baseplate to verify that grout is at correct elevation and is not higher than shown or approved.
   4. Keep grout pipe below grout surface to avoid entrapping air.

D. If top elevation of primary grout exceeds specified elevation by 1 foot or more, perform following remedial action:
   1. Remove tendon, flush hole, and redrill if necessary or remove grout to the required elevation.
   2. Replace tendon with new tendon if damaged.

E. After primary and anchor plate leveling grout operation is complete, allow tendon to remain undisturbed until grout has cured for the time required to reach minimum specified strength, as determined by ASTM C942.

F. Tolerance: Minimum 0.50-inch grout cover for tendons.

3.07 TENDON STRESSING

A. Do not tension tendon before primary grout and anchor plate leveling grout have cured for minimum specified time and grout strength, required by design and as shown on approved Shop Drawings or in calculations, has been verified by testing laboratory when cured at appropriate temperatures.

B. Tension tendon by means of equipment required by tendon manufacturer.
C. Conduct so that tension being applied and elongation of prestressing steel may be measured at all times.

D. Monitor tensioning with incremental measuring devices.

E. Modify blockouts to access tendon bearing plate or a jack chair to allow physical checking of end anchorage at lift-off.

3.08 SECONDARY GROUTING

A. Successfully complete the following prior to starting tendon secondary grouting:

1. Tendon stressing.
2. Tendon performance test.
3. Tendon proof test.
4. Tendon approval by Engineer.

B. After acceptance of tendon by Engineer install secondary grout mix both inside and outside group sheath.

C. Grout Pipes: Keep below grout surface to avoid entrapping air.

3.09 CUTTING OF TENDON PROTRUSIONS

A. Perform upon completion of anchor installation.

B. Cut that portion of anchor tendon protruding beyond stressing anchorage in accordance with tendon manufacturer’s representative’s recommendations.

3.10 LEVELING AND TOPPING GROUTING

A. Upon completion of anchorage blockout, fill blockout with leveling grout.

B. Upon completion of tendon protrusion cutting, fill blockout for tendon anchorage to the surface with topping grout.

C. Match surface of topping grout to surrounding surface and coat with curing compound.

3.11 FIELD QUALITY CONTROL

A. Conduct in Engineer’s presence.

B. Perform at least one set of specified tests during each grouting phase for each anchor hole.
C. Watertightness Test:

1. Fill drilled hole with water and subject water to a pressure of 5 psi (11.5 feet) in excess of the hydrostatic head as measured at top of hole.
2. Maximum Leakage Rate: 0.001 gallon per inch diameter per foot depth of hole per minute. 10-minute minimum test duration.
3. Consolidation grout holes failing leakage rate for the entire length of the hole and redrill.
4. Retest and repeat process until acceptable leakage test.
5. Adjacent Holes: Observe during test to detect inter-hole connections.
6. Consolidation grout holes to seal inter-hole connections and retest.

D. Sounding: Perform prior to tendon stressing and prior to final hardening of the grout.

E. Grout Test: ASTM C942, use clamped and sealed molds. Perform strength tests, mud balance (specific gravity) tests, fluid (flow cone) tests, and bleed tests.

F. Tendon Performance Test:

1. Performance test one anchor out of 10 and spatially distributed across the project.
2. Incrementally load and unload anchor per performance test schedule.
3. At each increment, record gauge reading and movement of tendon to nearest 0.001 inch with respect to an independent fixed reference point.
4. Measure anchor load with pressure gauge calibrated with the jack.
5. P = Design load for anchor; (not to exceed 60 percent of guaranteed ultimate strength of tendon).
6. AL = Alignment load; refer to Shop Drawings.
7. Performance Test Schedule:
   a. AL
   b. 0.25 P
   c. AL
   d. 0.25 P
   e. 0.50 P
   f. AL
   g. 0.25 P
   h. 0.50 P
   i. 0.75 P
   j. AL
   k. 0.25 P
   l. 0.50 P
   m. 0.75 P
   n. 1.00 P
ZINK DAM IMPROVEMENTS

- o. AL.
- p. 0.25 P.
- q. 0.50 P.
- r. 1.00 P.
- s. 1.20 P.
- t. AL.
- u. 0.25 P.
- v. 0.50 P.
- w. 1.00 P.
- x. 1.20 P.
- y. 1.33 P test load (10-minute hold).
- z. AL.
- aa. Adjust to lockoff load.

8. Transfer (Lockoff) Load: Not to exceed 70 percent of Guaranteed Ultimate Tensile Strength (GUTS) of tendon (refer to approved Shop Drawing for transfer load information).

9. Anchor tendon may be completely unloaded prior to lockoff, if circumstances warrant, as final stressing then does not require further movement readings.

10. Hold load at each increment, just long enough to obtain movement reading.

11. Except for reading of residual movement at AL, no movement readings need to be taken during unloading of anchor.

12. Test Load: Hold for 10 minutes.

13. Record total movements with respect to a fixed reference point at 1 minute, 2, 3, 4, 5, 6, and 10 minutes.

14. If total movement between 1 minute and 10 minutes exceeds 0.04-inch (1 mm), hold test load for an additional 50 minutes.

15. Record total movements at 15 minutes, 20, 25, 30, 45, and 60 minutes.

16. Repump hydraulic jacks used to test anchors as required to maintain pressure during the creep test.

17. Take lift-off reading after transferring load to end anchorage and prior to removing jack.

18. Lift-Off Load: Within 5 percent of desired transfer load.

19. If lift-off load is less than 95 percent of transfer load, reset end anchorage and make another lift-off reading.

G. Tendon Proof Test:

1. Perform on all anchors.
2. Incrementally load anchor per proof test schedule below.
3. At each increment, record movement of tendon to nearest 0.001 inch (0.0025 cm) with respect to an independent fixed reference point.
4. Measure anchor load with pressure gauge calibrated with jack.
5. P = Design load for anchor shall not exceed 60 percent of guaranteed ultimate strength of tendon; see anchor schedule on Drawings.
6. AL = Alignment load (use monojack to set each strand).
7. Proof Test Schedule:
   a. AL
   b. 0.25 P
   c. 0.50 P
   d. 0.75 P
   e. 1.00 P
   f. 1.20 P
   g. 1.33 P test load (10-minute hold).
   h. AL
   i. Adjust to lockoff load.
8. Anchor tendon may be completely unloaded prior to lockoff, if circumstances warrant and final stressing will then not require further movement readings.
9. Transfer (Lockoff) Load: Not to exceed 70 percent of the GUTS; refer to approved Shop Drawing for transfer load information.
10. Hold load at each increment just long enough to obtain movement reading, but not more than 1 minute.
11. Test Load: Hold for 10 minutes.
12. Record total movements with respect to a fixed reference point at 1 minute, 2, 3, 4, 5, 6, and 10 minutes.
13. If movement between 1 minute and 10 minutes exceeds 0.04-inch (1 mm), maintain test load for 50 minutes or more.
14. Record additional anchor movements at 15 minutes, 20, 25, 30, 45, and 60 minutes.
15. Repump hydraulic jacks used to test anchors as required to maintain pressure during the creep test.
16. Compare proof test results to performance test results.
17. After transferring load to end anchorage and prior to removing jack, make a lift-off reading.
18. Lift-Off Load: Within 5 percent of the desired transfer load.
19. If lift-off load is less than 95 percent of transfer load, reset end anchorage and make another lift-off reading.

H. Anchor Acceptance Criteria:

1. Performance Test: Total elastic movement should exceed 80 percent of theoretical elastic elongation of stressing length and be less than theoretical elastic elongation of stressing length plus 50 percent of bond length.
2. Proof Test: Total movement between 50 percent of design load and test load, should exceed 80 percent of theoretical elastic elongation of free stressing length for this respective load range.
3. Initial Lift-Off Reading: Shows anchor load within 5 percent of specified lockoff load.

3.12 MANUFACTURER’S SERVICES

A. Inspect and approve onsite tendon and grout and sounding system fabrication and assembly prior to installation.

B. Be present onsite during tendon installation and grouting of at least the first five tendons.

C. Be present during tendon tensioning, performance and proof testing, and lift-off checks for at least the first five tendons.

D. Make necessary documentation to provide Manufacturer’s Certificate of Proper Installation.

END OF SECTION
SECTION 32 13 13.13
EXPOSED AGGREGATE CONCRETE PAVING

PART 1   GENERAL

1.01 RELATED DOCUMENTS

A. General provisions of Contract, including General and Supplementary Conditions, and Division 01, General Requirements, apply to work specified in this Section.

1.02 SUMMARY OF WORK

A. The work of this Section consists of all paving and related items as indicated on Drawings and/or as specified herein and includes, but is not limited to, the following:

1. Preparation of a concrete base course.
2. Exposed aggregate concrete produced by exposing the coarse aggregate of a gap graded concrete mix.

B. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 03 30 00, Cast-in-Place Concrete.
2. Section 05 52 10, Site Metal Railings.
3. Section 31 23 12, Subgrade Preparation.
4. Section 31 23 23, Fill and Backfill.
5. Section 31 37 00, Riprap.
6. **Section 32 13 13, Concrete Paving.**
7. Section 32 91 13.19, Planting Soil System Procurement.
9. Section 32 93 00, Planting and Fine Grading.
10. Section 33 46 00, Subsurface Drainage.
1.03 REFERENCES AND STANDARDS

A. General:

1. The following referenced standards and standard specifications, referred to thereafter by designation only, form a part of this Section. Materials and methods of construction shall comply with the following standards:
   b. In the case of conflict between the Standard Specifications and the requirements of this Section, the more stringent requirements shall apply.

B. All standards shall include the latest additions and amendments as of the date of advertisement for bids. For each type of packaged material required for the Work of this Section, provide manufacturer's certified analysis. For all other materials, provide complete analysis by a recognized approved laboratory made in strict compliance with the standards and procedures of the following:

1. American Association of State Highway and Transportation Officials (AASHTO).
2. American Concrete Institute (ACI).
   a. C31, Practice for Making and Curing Concrete Test Specimens in the Field.
   b. C33, Specification for Concrete Aggregates.
   d. C42, Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   g. C150, Specification for Portland Cement.
   h. C172, Practice for Sampling Freshly Mixed Concrete.
   i. C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
   k. C494, Specification for Chemical Admixtures for Concrete.
   l. D994, Specification for Preformed Expansion Joint Filler for Concrete.
5. Concrete Reinforcing Steel Institute (CRSI).
1.04 SUBMITTALS

A. Comply with Division 01, General Requirements.

B. Qualifications: Candidate Contractor shall submit at least three project references, including project address, dollar value, Owner's and Landscape Architect's contact information (name, phone, and email).

1. Exposed Aggregate Paving Contractor shall have at least 10 years' experience installing exposed aggregate concrete pavements.

C. Product Information:

1. Provide manufacturer's data showing installation and limitations in use. Supply Certificates of Compliance for all materials required for fabrication and installation, certifying that each material item complies with, or exceeds, specific requirements. Work includes, but is not limited to:
   a. Concrete products.
   b. Aggregates.
   c. Form materials and forming accessories.
   d. Admixtures.
   e. Patching compounds.
   f. Chemical surface retarders.
   g. Curing compound.
   h. Sealants.
   i. Bond breaker material.
   j. Expansion joint material.
   k. Liquid nail adhesive.

D. Samples:

1. Prior to ordering the below listed materials, submit representative samples to Landscape Architect for selection and approval as follows. Do not order materials until Landscape Architect's approval has been obtained. Delivered materials shall closely match the approved samples. Submit duplicate samples of each material listed below showing full range of color variation, finish, and texture that can be expected in the permanent work:
   a. Exposed Aggregate Concrete Paving: Stone mix, duplicate 1-gallon bag.
   b. Bond Breaker Material: 12-inch square.
   d. Chemical Surface Retarder: 1 gallon as packaged by manufacturer.
e. Sealant: 1 gallon as packaged by manufacturer.

E. Concrete Mix Design:

1. Submit certified mix designs at least 3 weeks prior to the beginning of work in accordance with ACI 301 for each class of concrete. Include the following information:
   a. Results of testing or test data used to establish mix proportions.
   b. Test to verify total chloride in content.
   c. Certificates of compliance for:
      1) Contractors design laboratory and ready-mix concrete suppliers certificate of plant inspection.
      2) Cement.
      3) Aggregates, each type.
      4) Admixtures.
      5) Air entrainment.
      6) Curing compounds.
      7) Form Coating.
   d. Reinforcement: Submit certified mill test reports for metal reinforcement and welded wire fabric.

F. Paving sample panels (Mockups): Construct full-size panel of concrete pavement as specified herein to demonstrate the proficiency of the Contractor as well as demonstrate typical joints, surface finish, texture, color, and degree of aggregate exposure. The quality of workmanship, joint treatment and cleanliness of paving sample panel shall be accepted by the Landscape Architect before permanent paving is started. If the original sample is not accepted, the Contractor shall provide additional samples, as required, at no cost to the Owner until an accepted sample is obtained. The approved sample shall become the standard for the entire job. Panel shall not be constructed on a location becoming part of the final paving and shall remain undisturbed until all paving is completed. Remove panel upon completion of paving.

1. Mock-up Panel: Prepare two mock-up panels at the project site approximately 12-foot by 12-foot (minimum).
   a. Contractor shall use the methods and materials proposed for use on the final installation. Uniformity in appearance of each panel shall be the responsibility of the Contractor.
   b. Include Expansion and Control Joints in each sample panel, as well as adjacent items of construction as indicated on Drawings.

G. Material Certificates: Provide copies of materials certificates signed by material producers and Contractor, certifying that each material item complies with, or exceeds, specific requirements.
H. Pour Schedule: Contractor to indicate on plans locations sequence of pours for review by Landscape Architect.

I. Field quality-control test reports.

1.05 QUALITY ASSURANCE

A. Comply with the requirements of ACI 301.

B. Manufacturer Qualifications:
   1. Manufacturer of ready-mixed concrete products complying with ASTM C94 requirements for production facilities and equipment.
      a. Manufacturer must be certified according to the National Ready Mix Concrete Association's Plant Certification Program.
   2. Manufacturer of with 10 years’ experience in manufacture of specified products.

C. Source Limitations:
   1. Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant and each aggregate from one source.
   2. Obtain each specified material from same source and maintain high degree of consistency in workmanship throughout Project.

D. Installer Qualifications: A qualified exposed aggregate concrete installer whose work has resulting in successful installation of exposed aggregate concrete pavements. Use adequate numbers of skilled workers who are trained in the necessary crafts and who are completely familiar with the specified requirements and methods needed for the proper performance of the work of this Section.

E. Workmanship: The Contractor is responsible for correction of concrete work that does not conform to the specified requirements, including strength, tolerances, grading and finishes.

F. Mockups: Cast mockups of full-size sections of concrete pavement to demonstrate typical joints, surface finish, texture, color, degree of aggregate exposure and standard of workmanship.
   1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Landscape Architect.
   2. Notify Landscape Architect 7 days in advance of dates and times when mockups will be constructed.
3. Obtain Landscape Architect's approval of mockups before starting construction.
4. Maintain approved mockups during construction in an undisturbed condition as a standard for judging the completed pavement.
5. Demolish and remove approved mockups from the site when directed by Landscape Architect.
6. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

G. Preinstallation Conference: One week prior to placement of concrete, a meeting shall be held to discuss the Project and application methods. Conduct conference at Project site to comply with requirements in Section Project Management and Coordination.

1. Before submitting design mixtures, review concrete pavement mixture design and examine procedures for ensuring quality of concrete materials and concrete pavement construction practices. Require representatives, including the following, of each entity directly concerned with concrete pavement, to attend conference:
   a. Landscape Architect.
   b. Construction Manager.
   c. General Contractor's superintendent.
   d. Independent testing agency responsible for concrete design mixtures.
   e. Ready-mix concrete producer.
   f. Concrete pavement subcontractor.
   g. Owner.

H. Provide a schedule of concrete placements to the Owner and Landscape Architect so that formwork and reinforcement installations can be reviewed prior to concrete placements.

1. Notify the Owner and Landscape Architect at least 72 hours before placement of concrete for review of forms, form liners, and reinforcement. No concrete shall be placed without this review and acceptance by Landscape Architect.

I. Notification of Landscape Architect shall be given at least 1-week before start of Work.

J. Layout and Grading: After staking out the work, and before beginning final construction, obtain the Landscape Architect's approval for layout and grades.

1. Contractor shall make adjustments as determined by the Landscape Architect. Landscape Architect may make adjustments to grades and
layout as is required to meet existing and proposed conditions without additional cost to the Contract price.

2. The Contractor shall not proceed with the work of this Section without obtaining the Landscape Architect's written acceptance of layout and grading.

3. Comply with Division 01, General Requirements, Section 31 23 16, Excavation, Section 31 23 23, Fill and Backfill, and Section 32 93 00, Planting and Fine Grading.

K. Tests for Concrete Materials: Materials and installed work may require testing and retesting, as directed by the Landscape Architect and the Construction Manager, at any time during the process of the work. Allow free access to material stockpiles and facilities at all times. Tests, not specifically indicated to be done at the Owner's expense, including the retesting of rejected materials and installed work, shall be done at the Contractor's expense.

L. Concrete Quality Control Testing During Construction:

1. An independent testing laboratory will be retained by the Construction Manager to perform all quality control tests and to submit test reports to the Landscape Architect and Construction Manager.
   a. The independent firm will perform inspections, tests, and other services specified and as required by the Landscape Architect and Construction Manager.
   b. Reports will be submitted by the independent firm to the Landscape Architect, Owner and Construction Manager indicating observations and results of tests and indicating compliance or noncompliance with Contract Documents.
   c. The Contractor shall cooperate with the independent testing firm; furnish samples of materials, design mix, equipment, tools, storage and assistance as requested.
      1) Notify Construction Manager, Landscape Architect, and independent firm 48 hours prior to expected time for operations requiring services.
      2) Make arrangements with independent firm and pay for additional samples and tests required for Contractor's use.
   d. Retesting required because of nonconformance to specified requirements shall be performed by the same independent firm on instruction by the Landscape Architect or Construction Manager. Payment for retesting will be charged to the Contractor by deducting inspection or testing charges from the Contract Sum/Price.
2. Sample and test concrete during placement of concrete as follows:
   a. Sampling Fresh Concrete: ASTM C172; except modified for slump to comply with ASTM C94.
   b. Slump: ASTM C143; one test for each concrete load at point of discharge and one for each set of compressive strength test specimens.
   c. Air Content: ASTM C231; pressure method; one for each set of compressive strength specimens.
   d. Compressive Strength Tests: ASTM C39; one set for each 150 cubic yards or fractions thereof, of each concrete class placed in any one day or for each 5,000 square feet of surface area placed; two specimens tested 7 days, three specimens tested 28 days and one specimen retained in reserve for later testing if required.

1.06 EXAMINATION OF CONDITIONS

   A. The Contractor shall fully inform himself of existing conditions of the site before submitting his bid and shall be fully responsible for carrying out all site work required to fully and properly execute the work of the Contract, regardless of the conditions encountered in the actual work. No claim for extra compensation or extension of time will be allowed on account of actual conditions inconsistent with those assumed.

   B. Plans, surveys, measurements and dimensions under which the work is to be performed are believed to be correct to the best of the Owner's knowledge, but the Contractor shall have examined them for himself during the bidding period, as no allowance will be made for any errors or inaccuracies that may be found therein.

1.07 JOB CONDITIONS

   A. Protection: The Contractor shall use all means necessary to protect the materials of this Section before, during, and after installation. In the event of damage, make all repairs and replacements necessary to the approval of the Landscape Architect and at no additional cost to the Owner. All work shall be executed in a manner so as to prevent any damage to existing wall, rails, paving, and plant materials.
B. Protection of Existing Planting Soils:

1. Planting soils next to paved areas will be in place. The Contractor shall take extreme measures to protect the planting soil at all times and shall adhere to the following procedures and precautions:
   a. The storage and driving of machinery and equipment over planting soils is expressly prohibited. Prevent workers from walking on the surface of the planting soils.
   b. No materials shall be stored or placed on the planting soils at any time.
   c. Protect planting soils to prevent the intermingling of concrete materials before, during and after concrete placement. Review methods of protection with the Construction Manager before beginning work.
   d. Where planting soils are damaged, contaminated, over compacted, or otherwise harmed, remove those soils and replace with the approved planting soils. The Landscape Architect and Owner shall be the sole authorities on determining the need for plant soil replacement.
   e. Also refer to Section 32 91 19.13, Planting Soil System Installation.

PART 2 PRODUCTS

2.01 SUBGRADE AND BASE MATERIALS

A. Subgrade preparation shall conform to the requirements of Section 32 12 00, Earthwork, and Section 32 91 19.13, Planting Soil System Installation.

B. Granular fill for subbase course shall conform to the requirements of Section 31 23 23, Fill and Backfill, and Section 32 11 23, Aggregate Base Course(s).

2.02 FORMS

A. Unless otherwise indicated, construct formwork with plywood, metal, metal framed plywood faced or other acceptable panel type materials to provide continuous, straight, smooth, exposed surfaces.

1. Provide form material with sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.
2. Provide forms that comply with US Product Standard PS 1 and the following:
   a. B-B High Density Overlaid Concrete Form, Class I.
b. B-B (Concrete Form) Plywood, Class I, exterior grade or better, mill oiled and edge sealed, with each piece bearing legible inspection trademark.

B. Form Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces.

C. Form Ties: Provide factory-fabricated, adjustable-length, removable or snapoff metal form ties, designed to prevent form deflection, and to prevent spalling concrete surfaces upon removal.

1. Unless otherwise indicated, provide ties so portion remaining within concrete after removal is at least 1/2-inch inside concrete for steel ties and 1/4-inch for wire ties.
2. Unless otherwise indicated, provide form ties that will not leave holes larger than 1-inch diameter in concrete surface.

2.03 REINFORCEMENT MATERIALS

A. General:

1. Where indicated on Drawings, all reinforcing shall be epoxy-coated steel unless otherwise indicated.
2. Certified copies of mill reports for all reinforcing shall be submitted before reinforcing is placed.
3. Bars shall be correctly rolled to section and free from surface defects.
4. Splices in reinforcing shall be as specified in Article Placing Reinforcement.
5. Reinforcement shall be kept clean from oil, dirt and loose mill scale or other coating.
6. Shop fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerances complying with ACI 315. In case of fabricating errors, do not rebend or straighten reinforcement in manner that will injure or weaken material.

B. Epoxy-Coated Welded Wire Fabric: Comply with ASTM A884/A884M, Class A, plain steel epoxy coated. Wire fabric shall have a minimum ultimate strength of 70,000 psi.

C. Epoxy-Coated Reinforcement Bars: Comply with ASTM A775/A775M; and with ASTM A615/A615M, Grade 60 (Grade 420), deformed new billet steel bars.
D. Epoxy-Coated Wire: Comply with ASTM A884/A884M, Class A coated, plain steel.

E. Epoxy-Coated Joint Dowel Bars: Comply with ASTM A775/A775M; and with ASTM A615/A615M, Grade 60 (Grade 420), plain steel bars, epoxy coated.

F. Epoxy Repair Coating: Liquid two-part epoxy repair coating, compatible with epoxy coating on reinforcement.

G. Reinforcement Accessories:
   1. Tie wire, plastic coated, for use with epoxy coated reinforcing.
   2. Mechanical Reinforcing Bar Connectors: Comply with ACI 301. Provide 125 percent minimum yield strength of the reinforcement bar. Coat connectors in accordance with the same requirements as reinforcing bars.

H. Other accessories, at the option of the Contractor, may be zinc coated, except on exposed surfaces which have plastic tipped accessories.

I. Supports for Reinforcement: Provide supports for reinforcement, including bolsters, chairs, spacers, and other devices for spacing, supporting and fastening reinforcing bars, and welded wire fabric in place.
   1. Use wire bar type supports complying with CRSI recommendations, unless otherwise indicated. Do not use wood, brick, stone, broken block or pieces of concrete.
   2. For concrete-on-grade, use supports with sand plates or horizontal runners if base material will not adequately support chair legs.
   3. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, provide supports with legs which are plastic protected, stainless steel protected, or special stainless complying with CRSI Classes C, D, or E respectively.
   4. The top wire of all spacers, bolsters and chairs shall be corrugated.

2.04 CONCRETE MATERIALS

A. Portland Cement: ASTM C150 Types I, II, and III, "Low-Alkali" cement, unless otherwise specified. Use one brand of cement from the same manufacturer throughout Project.
ZINK DAM IMPROVEMENTS

B. Aggregates: Aggregate for exposed aggregate concrete shall be 5/8-inch round, tan in color, as supplied by a source approved by Landscape Architect.

1. Aggregate to match Landscape Architect's sample.
2. Aggregate shall be 5/8-inch round, tan in color, with the following sieve graduation:

<table>
<thead>
<tr>
<th>U.S. Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1”</td>
<td>100</td>
</tr>
<tr>
<td>3/4”</td>
<td>100</td>
</tr>
<tr>
<td>5/8”</td>
<td>95 - 100</td>
</tr>
<tr>
<td>1/2”</td>
<td>50 - 65</td>
</tr>
<tr>
<td>3/8”</td>
<td>15 - 40</td>
</tr>
<tr>
<td>#4</td>
<td>0 - 10</td>
</tr>
<tr>
<td>#8</td>
<td>0 - 5</td>
</tr>
</tbody>
</table>

C. Water: Potable, clean, fresh, free from oil, acid, organic matter or other deleterious substances.

D. Admixtures: All admixtures shall be specified in the mix design.

2. Water-Reducing Admixture: ASTM C494, Type A.
3. Water-Reducing, Retarding Admixture: ASTM C494, Type D.
4. Chloride-containing admixtures are not permitted.

2.05 ACCESSORIES

A. Expansion joint material shall be Homex 300 Expansion Joint Filler, 1/2-inch thickness as manufactured by the Homasote Company, West Trenton, New Jersey, (800) 257-9491, “or-equal.”

B. Bond Breaker Fabric: Nonwoven type polypropylene geotextile fabric, 4 oz. weight, shall be Mirafi 140N, “or-equal.”

C. Bonding Agent: VOC compliant, high solids acrylic latex emulsion admixture, non-oxidizing, white pigment, dries clear.
D. Chemical Surface Retarders: Spray-applied, film forming top surface retarder, calibrated for specific sized aggregates and finish requirements without the use of a plastic covering.

1. Acceptable Materials:
   a. Top Cast 75 as manufactured by Dayton Superior Corporation, 1125 Byers Road, Miamisburg, OH 45342, www.daytonsuperior.com, (888) 977-9600.
   b. “Or-equal.”

E. Surface Sealer: A clear, non-yellowing, water-based curing and sealing compound with matte finish to protect surface from environmental effects and pedestrian and vehicular traffic.

1. Acceptable Materials:
   b. “Or-equal.”

2.06 CONCRETE MIX

A. Prepare design mixes, proportioned according to ACI 211.1 and ACI 301, for each type and strength of normal-weight concrete determined by laboratory trial mixes.

B. Use a qualified independent testing agency for preparing and reporting proposed mix designs for the trial batch method.

1. Do not use Owner's field quality-control testing agency as the independent testing agency.

C. Exposed Coarse Aggregate Concrete:

1. Use "Ready Mixed" concrete unless otherwise approved or specified; in accordance with ASTM C94. Exposed Coarse Aggregate Concrete should meet or exceed the following criteria:
   a. Compressive Strength: Minimum 4,500 psi strength at 28 days.
   b. Concrete shall be gap-graded with weathered rounded coarse aggregate.
   c. Water/Cement Ratio: Not greater than 0.40 by weight.
   d. Slump: 5 inches, plus or minus 1 inch.
   e. Air Content: Between 4.5 percent to 7.5 percent.
PART 3  EXECUTION

3.01  GENERAL
   A. Construct exposed aggregate paving true to line, elevation, pitch and section. All paving shall pitch to drain. Concrete pavement shall be brought to true plane surfaces with a finished tolerance of 1/8-inch total in 10 feet when measured with a 10-foot straight edge.

3.02  SURFACE CONDITIONS
   A. Examination: Prior to Work of this Section, carefully inspect the installed Work of other trades and verify that such Work is complete to the point where this installation may properly commence.

   B. Discrepancies:
      1. In the event of discrepancy, immediately notify the Landscape Architect.
      2. Do not proceed with installation in areas of discrepancy until such discrepancies have been fully resolved.

3.03  PREPARATION
   A. The installer shall examine previous work, related work, and conditions under which this work is to be performed and notify the Contractor in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means installer accepts previous work, and conditions.

   B. Preparation of subgrade and aggregate subbase shall be in accordance with Section 31 20 00, Earthwork.

   C. Remove loose material from compacted subbase surface immediately before placing concrete.

   D. Proof roll prepared subbase surface to check for unstable areas and areas requiring additional compaction.

   E. Confirm in writing that the Landscape Architect has accepted the layout and grades for walkways.

   F. Notify Construction Manager of unsatisfactory conditions. Do not begin paving work until deficient subbase areas have been corrected and are ready to receive paving.
3.04 FORM SETTING

A. Design, erect, support, brace and maintain formwork to support vertical and lateral loads that might be applied until such loads can be supported by concrete structure.

B. Fabricate formwork to be readily removable without impact, shock or damage to cast-in-place concrete surfaces and adjacent materials.

C. 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.

D. Clean forms after each use and coat with form release agent to ensure separation from concrete without damage.

E. All concrete edges for all pavement, foundations, curbs and other below grade work shall be formed or contained to prevent overpouring of concrete. Excess concrete shall be removed as directed by the Landscape Architect.

F. Set forms to provide the proper depth of compacted concrete as detailed on the Drawings, firmly stake in place, tops set at the exact finish grade.

G. Notify the Landscape Architect at least 72 hours before placement of concrete for review of forms, form liners, and reinforcement. Obtain Landscape Architect's approval of formwork prior to placing concrete. All formwork requires approval by Landscape Architect prior to placement of concrete. No concrete shall be placed without this review and acceptance.

1. Contractor shall make adjustments as determined by the Landscape Architect. Landscape Architect may make adjustments to grades and layout as is required to meet existing and proposed conditions without additional cost to the Contract price.

3.05 JOINTS

A. Control Joints: Contractor to provide a plan showing location of control joints to Landscape Architect for Approval before Concrete is placed. Saw cut to the depth shown on Drawings. Strictly adhere to the pattern agreed to with Landscape Architect. Review layout of control joints in the field with the Landscape Architect before proceeding with work.
B. General: Construct construction, expansion, and control 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. Joints in the topping slab above the joints in the base slab should match the locations of joints in the base slab, where possible.

C. 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. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.
2. Butt joint with dowels or use a thickened edge joint if construction joints occur at control joint locations.
3. Keyed joints with tie-bars shall be used if the joint occurs at any other location.
4. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
5. Review location of construction joints with the Landscape Architect.

D. Expansion Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

1. Contractor to provide a plan showing location of expansion joints to Landscape Architect for Approval before Concrete is placed. Strictly adhere to patterning and layout agreed to with Landscape Architect when formwork is in place but before concrete is placed. If pattern cannot be achieved, or is unclear, consult with Landscape Architect before placing concrete. Do not proceed with concrete placement without approval from Landscape Architect on patterning. Do not proceed in uncertainty.
2. Extend expansion joint the full width and depth of joint. Set top of expansion joint flush with finish grade.
3. Install expansion joints flush with the finish grade of the exposed aggregate concrete.
4. Install expansion joints around buildings, and other vertical structures adjacent to the concrete.
5. Chemically fasten one side of expansion joint materials to one side of materials requiring separation. Fasten with "Liquid Nail", or equivalent, using formula appropriate to materials being fastened.

6. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.

E. Control Joints:

1. Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
   a. 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.
   b. Contractor to provide a plan showing location of control joints to Landscape Architect for approval before Concrete is placed. Mark control joints on the form work. If pattern cannot be achieved, or is unclear, consult with Landscape Architect before placing concrete. Do not proceed with concrete placement without approval from Landscape Architect on patterning.

F. Edging: Tool edges of pavement and expansion joints in concrete after initial floating with a 1/4-inch radius edging tool. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces by lightly brooming or troweling. Window paning of concrete shall not be acceptable.

3.06 PLACING REINFORCING

A. General:

1. Where indicated on Drawings, place reinforcing as specified herein.
2. Wherever embedded items interfere with placing of reinforcement notify the Landscape Architect and obtain approval before placing any concrete. Do not bend or field cut bars around openings or sleeves.

B. Placing:

1. Do not exceed the tolerances specified in ACI 117.
2. Dowels shall be tied securely in place before concrete is deposited. In the event there are no bars in position to which dowel may be tied, No. 3 bars (minimum) shall be added to provide proper support and anchorage.
3. Install welded wire fabric in as long lengths 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.

C. Field bending or straightening in accordance with Section 3.3.2.8 of ACI 301.

D. Spacing of Reinforcing: Where Drawings do not show the spacing of the reinforcing, the minimum clear spacing shall conform to ACI 318 Section 7.6.

E. Concrete Cover: Place reinforcement to obtain as a minimum the coverages for concrete protection specified in Section 3.3.2.3 of ACI 301.

F. Splicing: Make splices only at those locations shown on Drawings or as accepted by the Landscape Architect. Stagger splices in adjacent bars wherever possible. Splicing shall conform to the requirements of ACI 310 and specified provisions.

G. Reinforcing Supports:
   1. Reinforcement shall be accurately located in the forms and held in place by means of supports adequate to prevent displacement and to maintain reinforcement at proper distance from form face. The use of wood supports and spacers inside the forms is not permitted.
   2. Support reinforcement supported from the ground on precast concrete reinforcement supports.
   3. Do not use reinforcing supports or reinforcing to support concrete conveying equipment and similar construction loads.

H. Tying:
   1. Reinforcing shall be rigidly and securely tied with steel tie wire. Tie wires, after cutting, shall be bent in such a manner that concrete placement will not force the wire ends to surface of exposed concrete.
   2. Set wire ties so that twisted ends are directed away from exposed concrete surfaces.
   3. Reinforcing in concrete members that have one or more surfaces exposed, whether painted or unpainted finish, shall be tied with galvanized wire. Uncoated tie wire in exposed members will not be accepted.

I. Install deformed bar anchors in accordance with the manufacturer's recommendations.

J. Install mechanical splices and reinforcing couplers in accordance with manufacturers' recommendations.
K. Installation of manufactured products as per Part 2 of this specification and according to manufacturers' recommendation.

L. Cleaning:
   1. Clean reinforcement to remove loose rust and mill scale, earth and other materials which might reduce or destroy bond with concrete.
   2. Where there is a potential of rust staining adjacent finish surfaces, take necessary steps to prevent staining.

3.07 MIXING CONCRETE

A. Ready Mix and Site Produced Concrete:
   1. Comply with ASTM C94.
   2. The batching plant shall be equipped with an electric metering device capable of determining moisture content of sand.
   3. The addition of water at the site is contingent upon full time inspection of the process by the owners testing laboratory and the acceptance of the Inspector, Comply with ACI 301, Section 4.3.2.1.
   4. Begin the mixing operation within thirty minutes after the cement has been intermingled with the aggregates.

3.08 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 requirements and with recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery, at Project site, or during placement without approval from the Landscape Architect and Owner's testing agency.
F. Deposit and spread concrete in a continuous operation between expansion joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

G. Consolidate concrete 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-spaying and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

H. Screed pavement surfaces with a straightedge and strike off. 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.

I. 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 degrees F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 degrees F and not more than 80 degrees 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.

J. Hot-Weather Placement:

1. Place concrete according to recommendations in ACI 305R and as follows when hot-weather conditions exist:
   a. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 degrees 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.
   b. Cover reinforcement steel with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
c. Fog-spray forms, reinforcement steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.09 EXPOSED AGGREGATE FINISHING PROCESS

A. General: Do not use tools such as jitterbugs that force the aggregate away from surface.
   1. After screeding and consolidating concrete slabs, do not work surface until ready for floating.
   2. As soon as concrete will support the mason on knee-boards, float the surface to bring grout to the surface, completely surrounding the aggregate and filling all surface voids. Float to a uniform appearance.

B. Exposing Aggregate: Proceed as soon as the surface grout can be removed by simultaneous brushing and flushing with water without overexposing or dislodging the aggregate. Avoid traffic on the concrete during this operation. High pressure water may be used if desired finish is more easily achieved without harm to the concrete. Use same method of exposure, either with or without retarder, throughout the job. The exposed aggregate shall have a 3/16-inch depth of exposure. The depth of exposure shall be measured by laying a straight edge across the plane of the surface and measuring down to the concrete matrix.

C. Edging: Tool edges of pavement and expansion joints in concrete after initial floating with a 1/4-inch radius edging tool. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces by lightly brooming or troweling. Windopaning of concrete shall not be acceptable.

3.10 CONCRETE PROTECTION AND CURING

A. General:
   1. Protect Paving by not allowing use for a minimum of 7 days after installation is complete.
   2. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and follow recommendations in ACI 305R for hot-weather protection during curing.
B. All rules and regulations governing respective utilities shall be observed in executing all work under this Section. All work shall be executed in such a manner as to prevent any damage to soils, curbs, paving, walls, stone work, utility lines, structures, plant materials and adjoining property.

1. For protection of soils, refer to Part 1 in this Section.

C. Strip forms 7 days after installation is complete.

D. Apply matte sealer as per approved mockup to protect surface from environmental effects and pedestrian and vehicular traffic.

3.11 REPAIRS

A. Patching Defective Areas: Immediately cut out honeycomb, rock pockets and voids over 1/4-inch (6mm) in any dimension as well as holes left by tie rods, bolts, etc. down to solid concrete but, in no case to a depth less than 1 inch (25 mm).

   1. Cut edges perpendicular to concrete surface.
   2. Thoroughly clean, dampen with water, and brush coat area to be patched with neat cement grout or proprietary bonding agent before placing cement mortar or proprietary patching compound.

B. Remove and replace concrete with defective surfaces if defects cannot be repaired to the satisfaction of the Landscape Architect.

   1. Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface as well as stains and other discolorations that cannot be removed by cleaning.
      a. Dampen concrete surfaces in contact with patching concrete and brush with neat cement grout or apply concrete bonding agent.
      b. Mix Patching concrete of same materials to provide concrete of same type of class as original concrete.
      c. Place, compact and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

C. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.

   1. Damaged concrete shall be removed to a full joint and replaced. Partial patching within the sidewalk shall not be accepted. Landscape Architect shall determine extent of removal and replacement.
D. Drill test cores where directed by Landscape Architect when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.

3.12 FINAL CORRECTION

A. The Landscape Architect reserves the right to inspect the work to determine if adjustments are necessary in grade, alignment or layout. The Contractor shall make such adjustments without further compensation.

3.13 PROTECTION OF FINISHED WORK

A. Protect concrete from damage until final inspection by the Landscape Architect and Final Acceptance of the Project.

B. Exclude traffic from pavement for at least 7 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.

C. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than 2 days before date scheduled for Substantial Completion inspections.

3.14 CLEAN-UP

A. The Contractor shall remove all debris, construction equipment and scrap material from all areas within the limit of work prior to the final inspection and acceptance.

B. The Contractor shall clean all stains from the surface of paving. Paving which cannot be cleaned shall be replaced. Landscape Architect shall be sole judge of whether staining is apparent and necessitates remediation.

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, General Requirements Specification Sections, apply to this Section.

B. Refer to other Divisions of these Specifications to determine the type and extent of work therein affecting the work of this trade, whether or not such work is specifically mentioned in this Section.

1.02 WORK OF THIS SECTION

A. The work of this Section consists of all site improvements and related items as indicated on Drawings and/or as specified herein and includes, but is not limited to, the following:

1. Gate at site entry.
2. Range fence and gates.
3. Snow fence.

1.03 RELATED SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 03 30 00, Cast-in-Place Concrete.
2. Section 31 23 16, Excavation.
3. Section 31 23 23, Fill and Backfill.
4. **Section 32 13 13, Concrete Paving.**
5. Section 32 13 13.13, Exposed Aggregate Concrete Paving.
7. Section 32 91 19.13, Planting Soil System Installation.
8. Section 32 92 01, Prairies, Meadows, and Wetlands.
9. Section 32 93 00, Planting and Fine Grading.
1.04 EXAMINATION OF CONDITIONS

A. The Contractor shall fully inform himself of existing conditions of the site before submitting his bid and shall be fully responsible for carrying out all site work required to fully and properly execute the work of the Contract, regardless of the conditions encountered in the actual work. No claim for extra compensation or extension of time will be allowed on account of actual conditions inconsistent with those assumed.

B. Plans, surveys, measurements and dimensions under which the work is to be performed are believed to be correct to the best of the Landscape Architect's knowledge, but the Contractor shall have examined them for himself during the bidding period, as no allowance will be made for any errors or inaccuracies that may be found therein.

1.05 SCHEDULING

A. Comply with Division 01, General Requirements.

B. The Contractor shall submit to the Landscape Architect, for approval by the Owner, a progress schedule for all work as specified herein in accordance with General Conditions.

1.06 QUALITY ASSURANCE

A. Comply with Division 01, General Requirements.

B. General: Materials, methods of fabrication, fitting, assembly bracing, supporting, fastening, operating devices, and erection shall be in accordance with Contract Documents, approved Shop Drawings, and shall be of highest quality practices in the industry. Use new and clean materials as specified, having structural properties sufficient to safely sustain or withstand stresses and strains to which materials and assembled work will be subjected. All work shall be accurately and neatly fabricated, assembled, and erected.

1. Parts not specifically identified shall be made of materials most appropriate for their intended use as approved by Landscape Architect.
2. Profiles and sizes of exposed surfaces shown shall be maintained as indicated.
3. Insofar as possible, all materials and equipment used in the installation of this work shall be of the same brand or manufacturer throughout all work and duration of total project for each class of material or equipment. Conform to Reference Standards as a minimum.
4. Comply with specified Performance Requirements as a minimum.
C. Materials and methods of construction shall comply with the following standards:

1. American Galvanizers Association (AGE):
   a. AGA T-IPAF: The Inspection of Products to be Hot-Dip Galvanized after Fabrication Including a New Section on Touch-Up and Repair.
   b. AGA D-PGAF: The Design of Products to be Hot-Dip Galvanized after Fabrication.

D. Qualifications for Fabrication and Installation: With respect to item or assembly, work of this Section shall be fabricated and installed by an experienced fabricator or manufacturer, who has been engaged in work of equivalent scope and fabrication standards for at least 5 years.

1. Qualifications of Welders: Welding shall be done only by certified welding operators currently qualified according to AWS D1.1.
2. Qualifications of Workmen: Use adequate numbers of skilled workers who are trained in the necessary crafts and who are completely familiar with the specified requirements and methods needed for the proper performance of the work of this Section.
3. Field Measurements: Take field measurements prior to preparation of Shop Drawings and fabrication, where possible. Do not delay job progress; allow for trimming and fitting where taking field measurements before fabrication might delay work.

E. Shop Assembly: Pre-assemble and fit items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for re-assembly and coordinated installation.

1. Connections for installation of assemblies in field shall be by approved mechanical fasteners. Welding of assemblies or components on-site shall not be permitted unless specifically shown on Drawings as a field
weld and/or is approved by Landscape Architect specific to a condition of installation.

F. Layout and Grading: After staking out the work, and before beginning final construction, obtain the Landscape Architect’s approval for layout and grades. Contractor shall make adjustments as determined by the Landscape Architect. The Landscape Architect may make adjustments to grades and layout as is required to meet existing and proposed conditions without additional cost to the Contract price.

1.07 SUBMITTALS

A. Comply with Division 01, General Requirements.

B. Product Information:

1. Provide manufacturer’s data showing installation and limitations in use. Supply Certificates of Compliance for all materials required for fabrication and installation, certifying that each material item complies with, or exceeds, specific requirements. Work includes but is not limited to:
   a. Metal components.
   b. Range fence cable system and hardware.
   c. Hot-dipped galvanizing.
   d. Gates, latches and hinges.
   e. Snow fence, T-posts and clips.

C. Samples:

1. Prior to ordering the below listed materials, submit representative samples to Landscape Architect for selection and approval as follows. Do not order materials until Landscape Architect's approval has been obtained. Delivered materials shall closely match the approved samples. Submit duplicate samples of each type listed below showing full range of color variation, finish and texture that can be expected in the permanent work:
   a. Snow fence, 2-foot wide, full height sample.
   b. Snow fence “T” Post, one full size sample.
   c. Service gates, all components.

D. Shop Drawings:

a. Field Measurements: Take accurate field measurements, if necessary, before preparation of Shop Drawings and fabrication. Do not delay job progress.
b. Shop Drawings shall show all details, including sizes, materials, quantities and manner of assembling the various members, properly coordinated with the related work. Shop Drawings shall show plans, elevations, true profiles, installation details, methods of anchoring hardware, if any, and all other necessary information. Work includes but is not limited to:
1) Range fence and gates.
2) Service gates.

E. Samples Panels: Upon approval of all material samples, the Contractor shall construct sample panels on site in the minimum size indicated below. Each sample panel shall be large enough to display typical characteristics of each item and type of work. The visual characteristics, quality of workmanship, and installation methods must be approved by the Landscape Architect before final work is started. If the original sample is not approved, the Contractor shall provide additional samples, as required, at no cost to the Owner until an approved sample is obtained. The approved sample shall become the standard for the entire job. Sample panel shall not be constructed on a location becoming part of the final work, unless otherwise noted, and shall remain undisturbed until all work is completed. Contractor shall completely remove any panels not set in place as part of the final work, from the site upon final acceptance of work.

1. Sample Panel Requirements:
   a. Range Fence: One full fence segment, including an end brace and corner condition and, if approved, components may be used in permanent installation at location designated by the Landscape Architect.
   b. Range Fence Gate: One full gate, showing latches, hinges and mid-support connections. If approved, components may be used in permanent installation at location designated by the Landscape Architect.

1.08 DELIVERY, STORAGE AND HANDLING

A. Clearly label contents of all packaging and crating delivered to site.

B. Finished Materials: Protect finishes of fabricated items against soiling, staining, or damage from scratches and abrasion. Maintain protection during construction and until Owner acceptance and use of Project.

C. Storage of Materials: Materials that are stored at the project site shall be above ground on platforms, skids, or other supports. Protect steel from corrosion. Store other materials in a weather-tight and dry place until ready for use.
D. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the approval of Landscape Architect at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 MATERIALS

A. Metals, General: Provide metal materials that have been selected for their surface flatness, smoothness, and freedom from surface blemishes. Surfaces that exhibit pitting, seam marks, roller marks, “oil-canning,” burrs, rough-ground ends, stains, discolorations, or other imperfections on the finished units shall not be used and will not be acceptable.

B. Carbon Steel:

1. Carbon Steel Plates, Shapes, and Bars: Conform to ASTM A36 unless otherwise indicated.
2. Steel Tubing: Cold formed, conforming to ASTM A500; or hot rolled, conforming to ASTM A501.
3. Steel Pipe: Conform to ASTM A53, standard weight (Schedule 40), unless otherwise indicated or required by engineering to suit condition.
4. Hot Dip Galvanizing: Refer to Article Galvanizing of this Section.

C. Corrosion Resisting Weathering Steel:

1. Pipe and tubing conforming to ASTM A847, structural tubing.
2. Plates, caps, tabs and shapes conforming to ASTM A588, Grade 50.

D. Welding Electrodes and Filler Metal: Type and alloy of filler metal and electrodes shall be as recommended by producer of metal to be welded, and as required for color match, strength, and compatibility in the fabricated item. Comply with AWS D1.1 or AWS D1.6 as applicable to item and as a minimum.

E. Galvanize Repair Coating: For touching up galvanized surfaces after erection, provide Z.R.C. Cold Galvanizing Compound by Z.R.C. Chemical Products Co. or approved equal. Galvanize repair coating/compound material shall contain a minimum 95 percent zinc by weight in dry film.

F. Supplementary Parts:

1. Provide as necessary to complete each item of work, even though such supplementary parts are not shown or specified.
2. Reference additional miscellaneous metal items and components required by fabrications specified herein.

2.02 GALVANIZING

A. Scope: Where indicated on Drawings or as specified herein, ferrous metal items shall be cleaned and then hot-dipped galvanized after fabrication.

B. Cleaning:

1. Thoroughly clean metal surfaces of all mill scale, rust, dirt, grease, oil, moisture and other contaminants prior to galvanizing.
2. Remove by blast cleaning or other proven method surface contaminants and coatings.

C. Application:

1. Hot-dip galvanizing shall be applied in accordance with the following Reference Standards as a minimum:
   b. ASTM A153: Galvanized Coating on Iron and Steel Hardware – Table 1.
   c. ASTM A385: Practice for Providing High Quality Zinc Coatings.
   d. ASTM A143: Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel.
   e. Minimum weight of galvanized coating shall be 2-ounce per square foot of surface.

D. To minimize surface imperfection (e.g.: flux inclusions), material to be galvanized shall be dipped into a solution of Zinc Ammonium Chloride (preflux) and oven dried immediately prior to galvanizing. The type of galvanizing process utilizing a flux blanket overlaying the molten zinc will not be permitted.

E. After galvanizing, all materials not exposed to view must be chromated by dipping material in a 0.2 percent chromic acid solution.

F. Galvanized surfaces, where exposed to view, must have a smooth, level surface finish. Where this does not occur, piece shall be rejected and replaced to the acceptance of the Architect.
G. Source Quality Control for Galvanizing Work:

1. Galvanizer shall verify that units to be galvanized have been correctly fabricated for galvanizing.
2. Inspection and testing of hot-dip galvanized coatings shall be done under the American Hot-Dip Galvanizers Association (AGA) guideline publication "Inspection of Products Hot-Dip Galvanized after Fabrication" (T-IPAF).
3. Include visual examination and tests in accordance with ASTM A123 or A153, as applicable, to determine weight or mass of zinc coating per unit area of metal.

2.03 METALWORK FABRICATION REQUIREMENTS

A. General: Provide steel members as indicated on Drawings which comply with the requirements of referenced standards and which are free from surface blemishes where exposed to view in the finished product. Exposed-to-view surfaces exhibiting pitting, seam marks, roller mark, “oil canning,” stains, discoloration’s or other imperfections on finished units are not acceptable.

B. Make straight sections free of bow or camber. Make bends to constant radii without causing buckle, collapse or cracking. Abrupt or sharp bends or transitions will not be accepted.

C. Notch and weld intersections all around. Make turns and easements by radius bends without buckle, collapse, or cracking. Prefabricated, flush, weld-on fittings may be used instead of shop fabricated bends and intersections where they conform to required design and function and can be finished to match adjoining work.

D. Joints: Make flush, tight, butt joints where not otherwise shown/specified. Locate joints where least conspicuous. Construct joints to prevent water entry; provide concealed weepholes to drain internal condensation. Construct sleeved, sliding rail joints as necessary to accommodate thermal movement. Construct rigid, field joints with internal expansion couplings and concealed tamper-proof set screws. Weld other joints all around.

E. Closures: Close ends of rail exposed ends of other hollow members with welded flush plugs.

F. Weepholes: Provide 3/8-inch diameter holes in the bottom of fence, gate, guardrail and handrail to allow water to escape.

G. Shear and punch Work cleanly accurately. Remove burrs, barbs, splinters and sharpness; all edges and ends rolled, rounded, or capped.
H. Fit and trial assemble work in the shop. Permanently shop assemble work into
the largest section that meet shipping and field conditions. Use connections
that maintain structural value of joined pieces.

I. Welding: Follow AWS recommendations. Use materials and methods that
minimize distortion and develop strength and corrosion resistance of base
metals. Obtain fusion without undercut or overlap. Remove welding flux
immediately. Grind exposed welds smooth so that no roughness shows after
finishing.

J. Welding Electrodes and Filler Metal: Type and alloy of filler metal and
electrodes as recommended by producer of metal to be welded, complying
with applicable AWS specifications.

K. Bolts and Fasteners: ASTM A307 and A325 of same basic metal and alloy as
fastened metal, unless otherwise indicated. Do not use metals that are
corrosive or otherwise incompatible with metals joined.

L. Provide anchors, bolts, sockets, sleeves, and other parts required for securing
each item of work to other construction. Furnish inserts and sleeves to be set
into concrete formwork and concrete under Section 03 30 00, Cast-in-Place
Concrete.

2.04 FENCES AND GATES

A. General: All materials shall be new, corrosion resisting “weathering steel,”
conforming to ASTM A847, structural tubing.

1. Posts and Rails: Schedule 40 and Schedule 80 pipe, sizes as indicated on
Drawings.
   a. Posts shall be of sufficient length to allow for installation into
      concrete footings to a minimum depth of 1 foot 6-inch below
      finish grade.

2. Plates, caps, tabs, and shapes shall be corrosion resisting “weathering
   steel” conforming to ASTM A588, Grade 50.

B. Bottom of all posts shall be hot dip galvanized subsequent to fabrication as
indicated on Drawings and in accordance with ASTM A153 and A123.

1. Submit supplier’s certification that hot dip galvanizing conforms to
   ASTM standards cited.

2. Provide sample of hot dipped galvanized before applying to sample
   panel. After acceptance of sample, provide hot dipped galvanized on
   sample panel.
3. Preparation for Shop Prime: Clean galvanized steel in accordance with SSPC-SP1 Solvent Clean methods.

C. Fence Wire and Hardware: All fence wire; cables and associated hardware components shall be hot-dipped galvanized.

1. Fence wire shall be Class 3, Single Strand, 12.5 Gauge, Barbless Cable as manufactured by Keystone Steel and Wire Company, Peoria, IL (Telephone: (800) 447-6444), “or-equal.”

2. Hardware shall as manufactured by Stay-Tuff Fence MFG, Inc., New Barunfels, TX, “or-equal.” Hardware components shall be as follows:
   b. Crimp Sleeve: Model JM 593.

D. Metal Range Fence Gates:

1. Provide metal gate as detailed and at locations indicated on Drawings and in strict accordance with the approved Shop Drawings.

2. Hinges: Provide ball bearing J-bolt hinges as indicated on Drawings.
   a. 3/4-inch diameter by 10-inch ball bearing hinge as supplied by Kodiak Black, 1675 West Yale Avenue, Englewood, CO 80110 (Telephone: (303) 799-9757; Fax: (303) 799-9756), “or-equal.”

3. Gate Latches:
   a. Single and Double Gates: Provide weld-in spring loaded corral gate latch with 1/2-inch diameter spring loaded pin and handle as supplied by Washburn Farm & Home, 172 N.E. 1st LN, Lamar, MO 64759 (Telephone: (417) 682-5551), “or-equal.”
   b. Double Gates: Shall include a drop rod bar arranged to engage the gate stop. Locking device shall be constructed so that the drop rod cannot be raised when the gate is locked. The locking device shall have provisions for a padlock. All necessary fittings and gate holders to lock gates in both OPEN and CLOSED positions shall be furnished. The locking device shall be as manufactured by Boundary Fence Co., Inc., Jamaica, New York, or an approved equal locking device.

E. Gate Hardware: Provide metal gate hardware and chains as indicated on Drawings. All hardware shall be hot dip galvanized subsequent to fabrication as indicated on Drawings and in accordance with ASTM A153 and A123.
2.05 SNOW FENCE

A. Snow fencing shall consist of wood slats woven together with five two-wire strands of galvanized wire.

1. Materials:
   a. Slats shall be made of No. 1 aspen or spruce, 3/8-inch-thick, 1-1/2-inch-wide and 48-inch high. Both ends shall be cut square. The slats shall be natural wood (no paint).
   b. Wire shall be 13-gauge minimum galvanized steel.

2. Fabrication:
   a. The slats shall be spaced 2-1/4-inch apart (plus or minus 1/4 inch), with not less than two 360-degree twist of the wire in the weave between the slats.
   b. The fabric must be tightly woven so that the wire is forced into the wood slats sufficiently to hold them tightly.
   c. The strands of wire shall be spaced 10 inches apart and 4 inches from the ends of the slat.

B. Accessories:

1. Posts: Provide 6 feet long, galvanized steel T-posts, 1-7/16-inch by 1-5/16-inch by 1/8-inch, 1.25-pound per foot minimum.
2. Provide sufficient quantity of posts to space 8 feet OC typical.
3. Post clips: galvanized clips to secure snow fence to T-posts.

2.06 SERVICE GATES

A. General: Provide steel members as indicated on Drawings which comply with the requirements of referenced standards and which are free from surface blemishes where exposed to view in the finished product. Exposed-to-view surfaces exhibiting pitting, seam marks, roller mark, “oil canning,” stains, discoloration’s or other imperfections on finished units are not acceptable.

B. Steel Pile: ASTM A53, Schedule 40, Type S (seamless), Grade A for cold-bending.

1. Notch and weld intersections all around. Make turns and easements by radius bends without buckle, collapse, or cracking. Prefabricated, flush, weld-on fittings may be used instead of shop fabricated bends and intersections where they conform to required design and function and can be finished to match adjoining work.
2. Joints: Construct joints in exterior railings to prevent water entry; provide concealed weep holes to drain internal condensation. Construct sleeved, sliding rail joints as necessary to accommodate thermal
movement. Construct rigid, field joints with internal expansion couplings and concealed tamper-proof set screws. Weld other joints all around.

3. Closures: Close ends of rail exposed ends of other hollow members with welded flush plugs.

4. Weep Holes: Provide 3/8-inch diameter holes in the bottom of fence and gate to allow water to escape.

5. Bolts and Fasteners: ASTM A307 and A325 of same basic metal and alloy as fastened metal, unless otherwise indicated. Do not use metals that are corrosive or otherwise incompatible with metals joined.

6. Posts shall be of sufficient length to allow for installation into concrete footings to a minimum depth below finish grade as indicated on Drawings.

7. Hinges: Provide extra strong, heavy-duty best quality hinges rated by the manufacturer for the weight and width of the supported gate panel. Hinges shall be intended by the manufacturer for exterior use.

PART 3 EXECUTION

3.01 EXAMINATION

A. Comply with Division 01, General Requirements.

B. The installer shall examine previous work, related work, and conditions under which this work is to be performed and notify the Contractor in writing of all deficiencies and conditions detrimental to the proper completion of this work.

C. Beginning work means installer accepts substrates, subgrades, previous work, and conditions.

3.02 INSTALLATION

A. The installer shall examine previous work, related work, and conditions under which this work is to be performed and notify the Contractor in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means installer accepts substrates, subgrades, previous work, and conditions.

3.03 INSTALLATION AND ERECTION OF ALL FENCES

A. Pre-Installation Examination Required: The Installer shall examine previous work, related work and conditions under which this work is to be performed and notify Contractor in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means Installer accepts substrate, previous work and conditions.
B. Manufacturer’s Instructions: Strictly comply with Manufacturer’s instructions and recommendations, except where more restrictive requirements are specified in this Section. Accurately locate fence as indicated on approved Shop Drawings and as field directed.

C. Install fence only after final grading is complete.

D. Install fence work, including fence over irregular terrain, with posts truly plumb and top of fence fabric and rails truly level to finish grade. Review layout of fence with the Landscape Architect prior to installation.

E. All work is to be performed in accordance with approved Shop Drawings as modified by field dimension. Anchorage shall be as shown on Drawings.

3.04 SNOW FENCE INSTALLATION

A. Snow fence shall be placed along the edges of all planted areas shown on Drawings, whether fences are indicated therein or not. The general alignment of the fences shall be as approved by the Landscape Architect in the field.

B. Install T-posts spaced every 8 feet OC (typical), except at ends where posts shall be spaced every 5 feet OC maximum.

C. Secure snow fence to T-posts using approved galvanized clips.

3.05 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

3.06 CLEAN-UP AND PROTECTION

A. Clean fences of all stains or marks and protect from damage. Replace any materials which are part of the final work that are broken or can not be cleaned to the satisfaction of the Landscape Architect.

B. After the fence work is installed, it shall be the responsibility of the Contractor to see that the fences and gates are properly and adequately protected from damage.

END OF SECTION
PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

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

B. Coordinate work of this Section with other underground utilities and with trades responsible for their installation. Refer to respective Drawings pertaining to other work.

C. All references in this Section to “Contractor” and/or “Irrigation Contractor” shall mean “Landscape Contractor or Irrigation Contractor.”

D. Carefully examine all of the Contract Documents for requirements that affect the Work of this Section.

1.02 WORK DESCRIPTION

A. The work under this Section consists of furnishing adequate numbers of skilled workmen who are thoroughly trained and experienced and installing all materials, equipment and services required to complete and provide a fully operational, automatic landscape irrigation system for the landscape areas depicted on the final approved landscape plans.

B. The system shall automatically irrigate, using spray or stream rotary sprinklers as needed, on all meadow grass areas as indicated on the landscape plan and as directed by the Owner.

1. The primary source of irrigation water is an irrigation water meter and RP-Type backflow preventer provided by other trades and are not included in the irrigation scope of work.

2. Install Irrigation Controller at location determined by Owner.

3. Trench excavation, back filling and bedding materials, together with the testing and proper scheduling of the completed installation shall be included as part of this scope of work.

4. The work shall be constructed and finished in every respect in a good, workmanlike and substantial manner, to the full intent and meaning of the Specifications. All parts necessary for the proper and complete execution of the work, whether the same may have been specifically mentioned or not, shall be done or furnished in a manner corresponding
with the rest of the work as if the same were specifically herein described.

5. Record Drawing (As-built) as well as generation of the Operating and Maintenance Manual in accordance to these specifications shall also be included in this work.

C. At the completion of work, Contractor shall perform and successfully complete the tests as outlined in Article System Testing, Start-Up, and Adjustment.

1.03 PERMITS AND INSPECTIONS

A. The work under this Section shall comply with all ordinances and regulations of authorities having jurisdiction.

B. Obtain and pay for all permits to any agency having jurisdiction over the work required for the execution of this Section.

C. Furnish copies of Permits and Approval Notices to the Owner's Representative before requesting final payment.

D. The Contractor shall include in their bid any charges by the Water Department, Utility Company, or other authorities for work done by them and charged to the Contractor.

1.04 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01, General Requirements Specification Sections.

B. The Contractor shall provide copies of product specification sheets on all proposed equipment to be installed to the Owner's Representative for approval prior to the start of work, in accordance with the parameters of Division 01, General Requirements. Work on the irrigation system may not commence until product sheets are submitted and approved. Submittals shall be highlighted to show proper model, nozzles, sizes, flows, etc. Submittals not properly highlighted or marked up will be rejected. As a minimum, the following equipment shall be included in the submittal:

1. Sprinkler heads.
3. Controllers and remote operators.
4. Valve boxes and enclosures.
5. Washed round river rock for valve enclosure sumps.
6. Pipe and fittings.
7. Wire and connectors.
8. Quick coupling valves.
10. Miscellaneous materials.

1.05 QUALITY ASSURANCE

A. Irrigation Contractor: A firm which has at least 5 years of experience in work of the type and size required by this Section and which is acceptable to the Owner’s Representative.

B. References: The Installation Contractor must supply three references for work of this type and size with their bid including names, phone numbers and email addresses of contact person(s).

C. Applicable requirements of accepted Standards and Codes shall apply to the Work of this Section and shall be so labeled or listed:

5. American Society of Agricultural Engineers (ASAE).
6. UL.
7. Occupational Safety and Health Regulations (OSHA).

1.06 DELIVERY, STORAGE AND HANDLING

A. Store and handle all materials in compliance with manufacturer instructions and recommendations. Protect from all possible damage. Minimize on-site storage. Contractor is responsible for the security of all stored materials on site.

1.07 GUARANTEE

A. The Contractor shall obtain in the Owner's name the standard written manufacturer's guarantee of all materials furnished under this Section where such guarantees are offered in the manufacturer's published product data. All these guarantees shall be in addition to, and not in lieu of, other liabilities that the Contractor may have by law.

B. In addition to the manufacturers guarantees the Contractor shall warrant the entire irrigation system, both parts and labor for a period of 1 year from the date of acceptance by the Owner.
C. As part of the 1-year warranty the Contractor shall perform the first year-end winterization and spring start-up for the irrigation system.

D. Should any problems develop within the warranty period because of inferior or faulty materials or workmanship, they shall be corrected to the satisfaction of the Owner’s Representative at no additional expense to the Owner.

E. A written warranty showing date of completion and period of warranty shall be supplied upon completion of each segment of the Project.

1.08 COORDINATION

A. The Contractor shall at all times coordinate his work closely with the Owner’s Representative to avoid misunderstandings and to efficiently bring the Project to completion. The Irrigation Contractor shall also coordinate their work with that of the electrical contractor, general contractor, plumbing contractor and landscape contractor. The Owner’s Representative shall be notified as to the start of work, progression and completion, as well as any changes to the Drawings before the change is made. The Contractor shall also coordinate his work with that of his subcontractors.

B. The Contractor shall be held responsible for and shall pay for all damage to other work caused by his work, workmen or subcontractors. Repairing of such damage shall be done by the Contractor who installed the work as directed by the Owner’s Representative.

1.09 MAINTENANCE AND OPERATING INSTRUCTIONS

A. Contractor shall include in their Bid an allowance for 8 hours of instruction of Owner and/or Owner's personnel upon completion of check/test/start-up/adjust operations by a competent operator (The Owner’s Representative office shall be notified at least 1 week in advance of system testing, start-up, and adjustment.

B. Upon completion of work and prior to application for acceptance and final payment, a minimum of three (3) three-ring, hard cover binders titled MAINTENANCE AND OPERATING INSTRUCTIONS FOR THE ZINK DAM IMPROVEMENTS IRRIGATION SYSTEM, shall be submitted to the Owner’s Representative office. After review and approval, the copies will be forwarded to the Owner. Included in the Maintenance and Operating binders shall be:

1. Table of Contents.
2. Written description of Irrigation System.
3. System Drawings:
   a. One copy of the approved irrigation plan.
   b. One copy of the Record Drawing (As-Built); Measurements on Record Drawings shall be surveyed or triangulated from permanent objects and recorded on Autocad compatible digital format.
   c. One reproducible of the Record Drawing.
   d. An Autocad compatible digital file of the record drawing.
4. A complete set of "Approved" submittals of all irrigation equipment.
5. A copy of the suggested "System Operating Schedule" which shall call out the controller program required (zone run time in minutes per day and days per week) in order to provide the desired amount of water to each area under "no-rain" conditions.
6. One copy of the controller/valve/rain/moisture/flow sensor system wiring diagram.

1.10 EXAMINATION OF CONDITIONS

   A. The Contractor shall fully inform himself of existing conditions on the site before submitting his bid, and shall be fully responsible for carrying out all work required to fully and properly execute the work of the Contract, regardless of the conditions encountered in the actual work. No claim for extra compensation or extension of time will be allowed on account of actual conditions inconsistent with those assumed, except those conditions described in the General Conditions.

1.11 PROCEDURE

   A. Notify all city departments and/or public utility owners concerned, of the time and location of any work that may affect them. Cooperate and coordinate with them in the protection and/or repairs of any utilities.

   B. Provide and install temporary support, adequate protection and maintenance of all structures, drains, sewers, and other obstructions encountered. Where grade or alignment is obstructed, the obstruction shall be permanently supported, relocated, removed or reconstructed as directed by the Architect.

PART 2 PRODUCTS

2.01 GENERAL

   A. All materials to be incorporated in this system shall be new and without flaws or defects and of quality and performance as specified and meeting the requirements of the system. All material overages at the completion of the installation are the property of the Contractor and shall be removed from the site.
B. No material substitutions from the irrigation products described in these specifications and shown on Drawings shall be made without prior approval and written acceptance from the Owner’s Representative.

2.02 PVC IRRIGATION PIPE AND FITTINGS

A. All pipe shall bear the following markings:

1. Manufacturer’s name, nominal pipe size, schedule or class, pressure rating in psi, and date of extrusion.

B. All lateral pipe 3/4-inch and larger shall be PVC, Class 200 Type 1120, SDR 21, solvent-weld PVC. Lateral pipe shall conform to ASTM D2241 as manufactured by PipeLife Jet Stream, “or-equal.”

C. All main line pipe shall be PVC, Schedule 40, Type 1120, solvent-weld PVC, conforming to ASTM D1784. Pipe shall be as manufactured by PipeLife Jet Stream, “or-equal.”

D. Fittings for solvent weld PVC pipe shall be Schedule 40 solvent weld PVC fittings as manufactured by Dura, Lasco, Spears, “or-equal.”

E. Fittings shall bear manufacturer’s name or trademark, material designation, size, and applicable I.P.S. schedule.

F. PVC Schedule 80 fittings and nipples shall be used on all fittings required between the mainline and the electric control valve as well as the threaded connection between the electric control valve and the lateral piping. Schedule 80 fittings shall be Spears Manufacturing, “or-equal.” Contractor shall use Teflon tape or other sealing method according to valve, sprinkler and fitting manufacturer’s recommended practice for the specific application. All Schedule 80 PVC nipples shall be supplied with machined threads.

G. PVC solvent shall be NSF approved, for Type I and Type II PVC pipe, and Schedule 40 and 80 fittings. Cement is to meet ASTM D2564 and FF493 for potable water pipes. PVC solvent cement shall be Rectorseal Gold, IPS Weld-ON 711, Oatey Medium Cement, “or-equal,” and shall be used in conjunction with the appropriate primer. Primer shall be NSF approved, and formulated for PVC and CPVC pipe applications. Primer is to meet ASTM F656. Primer shall be Rectorseal Jim PR-2, IPS Weld-ON P-68 Clear, Oatey Purple Primer for PVC and CPVC, “or-equal.”
2.03 PIPE SLEEVES

A. All pipe sleeves beneath nonsoil areas (with the exception of City of Tulsa streets) shall be PVC, Schedule 40 water pipe as manufactured by PipeLife Jet Stream, “or-equal.” Sleeves shall be two times larger than the total outside diameter of all the piping contained within the sleeve. All irrigation control wire shall be routed in a separate 2-inch minimum diameter sleeve.

B. Minimum pipe sleeve size shall be 4-inch diameter.

2.04 WIRE CONDUIT

A. Conduit for wiring beneath non-soil areas shall be PVC, Schedule 40 conduit with solvent-weld joints, as manufactured by Certainteed, Cresline, “or-equal.”

B. Sweep ells shall be standard electrical type PVC Schedule 40 long sweep elbows. Cap sweep ell with tri-plug with the ring for securing nylon pull rope.

C. Conduit for above ground wiring to environmental sensors, weather stations or controllers shall be galvanized, rigid metallic conduit.

2.05 SPRAY SPRINKLERS

A. Full and part circle pop up spray sprinklers shall be pressure regulating at 45 psi, plastic construction with ratcheting riser, removable nozzle and check valve. Nozzle size shall be as indicated on the drawing and in the legend. Pop-up height shall be 12-inch for meadow grasses. The sprinkler shall have 1/2-inch IPS water connection on the bottom and side of the sprinkler.

B. Nozzle size shall be as required to provide adequate coverage and avoid over spray onto walkways, roads, buildings and other permanent structures.

C. Sprinkler shall carry a minimum 5-year exchange warranty against defects. Sprinklers shall be manufactured by Rain Bird, Model 1800-SAM-P45.

2.06 ELECTRIC CONTROL VALVES

A. Electric control valves shall be remote control diaphragm type glass-filled nylon body valves with flow control and 200 psi pressure rating. Valve shall have globe configuration, 24-volt electric. Valve shall have a self-cleaning stainless steel screen designed for use in dirty water applications.

B. Valves shall be manufactured by Rain Bird Model PEB, “or-equal.”
2.07 AUTOMATIC DRAIN VALVES

A. Automatic drain valves shall be Model 22163 (1/2-inch) or 22167 (3/4-inch) as manufactured by King Innovation, Inc. At least four drains per piping zone shall be installed at the points of lowest elevation to permit proper drainage in areas susceptible to freezing.

2.08 QUICK COUPLING VALVES

A. Quick Coupling Valves and Keys: Valve equal to Rain Bird Model 44-NP, two-piece, 1-inch single lug, and lavender colored locking vinyl cover. The valve body shall be of cast brass construction with a working pressure range of 5 psi to 125 psi. The valve seat disc plunger body shall be spring loaded so that the valve is normally closed under all conditions when the key is not inserted. Quick coupling valve shall be prevented from rotation with Leemco Model LS-120 valve stabilizer.

B. The valve body construction shall be such that the coupler seal washer may be removed from the top for cleaning or replacement without disassembling any other parts of the valve. The quick coupling valve shall be equipped with a purple colored vinyl cover with "Do Not Drink" warnings in English and Spanish.

C. Keys shall be 1-inch male thread and 3/4-inch female thread at the top equal to Rain Bird Model 44-K, “or-equal.” Provide six quick coupler keys to Owner at project completion.

D. Hose swivels shall be 1-inch FPT by 1-inch MHT, Rain Bird Model SH-2, “or-equal.” Provide six hose swivels to Owner at project completion.

2.09 ISOLATION VALVES

A. Line isolation valves 2 inches and smaller in size and main line drain valves shall be gate type, of bronze construction, US Manufacture, 200 WOG with steel cross handle and 200 psi rating. Gate valves to be as manufactured by Nibco, Model T-113-K, “or-equal.”

B. Electric Control Valve Isolation Valves: 2-inch and smaller shall be of the ball type, plastic construction, tru-union threaded ends and have a maximum pressure rating of 235 psi at 73 degrees F. The valves shall be equal to Spears Model 3629-XX size the same as the control valve.
2.10 VALVE BOXES

A. All valve boxes and covers shall be injection molded of structural foam polyethylene with a melt index between 10 and 12 and shall be UV stabilized. All boxes and covers shall be green in color.

B. Valve box extensions shall be provided and installed as required for proper box depth. Valve box extensions shall be made by the same manufacturer.

C. Valve boxes for isolation valves, quick coupling valves, drip air release and isolation valves and in-line check valve locations shall be 10-inch round valve boxes with bolt down covers equal to Carson Industries, Inc., Model 910-12 or Rain Bird Model VB10RNDH with 8-inch I.D. corrugated polyethylene pipe, as manufactured by Advanced Drainage Systems, Inc. (ADS), cut to length as required for extensions.

D. Valve boxes for automatic electric control valves (nondrip zones) and master control valves shall be 13-inch by 20-inch ("jumbo") valve boxes with bolt down covers equal to Carson Industries, Inc., Model 1220-12 with Model 1220E-1 6-inch extensions or Rain Bird Model VBJMBH with Model VBJMB6EXTB 6-inch extensions.

E. Valve boxes for automatic electric control valves (drip zones) shall be 13-inch by 20-inch ("jumbo") valve boxes with bolt down covers equal to Carson Industries, Inc., Model 1220-12 with Model 1220E-1 6-inch extensions or Rain Bird Model VBJMBH with Model VBJMB6EXTB 6-inch extensions.

F. Valve boxes for wire splices shall be 10-inch round valve boxes with bolt down covers equal to Carson Industries, Inc., Model 910-12 or Rain Bird Model VB10RNDH with 8-inch I.D. corrugated polyethylene pipe, as manufactured by Advanced Drainage Systems, Inc. (ADS), cut to length as required for extensions. All splices shall be in separate valve boxes and not included with isolation valves.

2.11 AUTOMATIC CONTROLLER AND SENSORS

A. The controllers shall be of a hybrid type that combines electro-mechanical and microelectronic circuitry capable of fully automatic or manual operation. The controller shall be housed in a wall-mountable, weather-resistant plastic cabinet with a key-locking cabinet door suitable for either indoor or outdoor installation. The controller shall have a base station capacity of eight or 12 stations as well as three expansion slots capable of receiving station modules of four, eight, or 12 stations to create a controller capacity of up to 48 stations. All stations shall have the capability of independently obeying or ignoring the weather sensor as well as using or not using the master valve. Station timing shall be from 0 minutes to 12 hours. The controller shall have a
Seasonal Adjustment by program which adjusts the station run time from 0 to 300 percent in 1 percent increments. The controller shall also have a Monthly Seasonal Adjustment of 0 percent to 300 percent by month. Station timing with Seasonal Adjustment shall be from 1 second to 16 hours. The controller shall have four separate and independent programs which can have different start times, start day cycles, and station run times. Each program shall have up to eight start times per day for a total of 32 possible start times per day. The four programs shall be allowed to overlap operation based on user defined settings which control the number of simultaneous stations per program and total for the controller. The controller shall allow up to five valves to operate simultaneously per program and total for the controller including the master valve/pump start circuit. The controller shall have an electronic, diagnostic circuit breaker that shall sense a station with an electrical overload or short circuit and shall bypass that station and continue to operate all other stations. The controller shall have a 365-day calendar with Permanent Day Off feature that allows a day(s) of the week to be turned off on any user selected program day cycle. (Custom, Even, Odd, Odd 31, and Cyclical). Days set to Permanent Day Off shall override the normal repeating schedule and not water on the specified day(s) of the week. The controller shall also have a Calendar Day Off feature allowing the user to select up to five dates up to 365 days in the future when the controller shall not start programs. The controller shall incorporate a Rain Delay feature allowing the user to set the number of days the controller should remain off before automatically returning to the auto mode. The controller shall have Cycle+Soak water management software which is capable of operating each station for a maximum cycle time and a minimum soak time to reduce water run-off. The maximum cycle time shall not extended by Seasonal Adjustment. The controller shall incorporate a FloManager feature providing real-time flow, power, and station management. FloManager shall manage the number of stations operating at any point in time based on water source capacity, station flow rate, number of valves per station; user-defined simultaneous stations per program and for the controller. FloManager shall incorporate the ability to provide station priorities to determine the order in which stations shall operate. The controller shall ignore the station number and instead operate the highest priority stations first and the lower priority stations last when FloManager is enabled. FloManager shall be an option that is disabled by default and the controller shall operate zones in order of station number, started with the lowest numbered zone set to irrigate and ending with the highest number zone. The controller shall offer Water Windows for each program. This function sets the allowed start and stop time where watering is allowed. If the watering cannot be completed by the time the Water Window closes, the stations with remaining run time are paused and watering automatically resumes when the Water Window opens the next time. The controller shall have an alarm indicator light on the front panel visible through the outer door with the door closed and locked. The alarm light shall prompt the user to select the alarm soft key to review the
alarm condition(s). The controller shall be supplied with the optional stainless steel metal cabinet, Rain Bird Model LXMMSS and stainless steel pedestal, Rain Bird Model LXMMSSPED. The controller shall be Model ESP-LXME as manufactured by Rain Bird Corporation.

B. The rain sensor shall shut off the irrigation system when the measured rainfall equals or exceeds the shutoff setting of the sensor device. The freeze sensor shall be adjustable between 33 degrees F and 41 degrees F and shall shut off the irrigation system when the temperature reaches at or below the set point. The device shall be adjustable with positive stops from 1/8-inch to 1/2-inch. Sensor shall have quick shut-off capability to suspend irrigation during a rain event. The device shall be UL rated, maintenance free and shall absorb water and shall dry out at rates similar to turf. The device shall have a self-leveling bracket which can be mounted to flat surfaces or rain gutters. Sensor shall be installed within 700 feet line-of-sight between sensor and irrigation controller. The wireless device shall be manufactured by Rain Bird Mfg, Model WR2RFC, “or-equal.”

2.12 WIRE

A. Single Conductor Wire for direct burial applications, meeting UL Standard 493, UF-14/1 for "Control" wiring and UF-14/1 for "Common" wiring. Color code the common neutral wiring from all other wires.

B. In ground wire connections shall be UL listed, rated for 600 volts manufactured by Rain Bird Model DBRY20 or DBT020, “or-equal.” All wire connections shall be made in specified valve boxes.

C. Wire type and method of installation shall be in accordance with local codes for NEC Class II circuits of 30V ac or less.

2.13 SWING JOINTS

A. All 1/2-inch inlet spray heads shall be connected to the irrigation piping utilizing 1/2-inch thick walled polyethylene tubing (Rain Bird Model SPX-FLEX100) and appropriate insert fittings (Rain Bird Models SBE-050, SBE-075, SBA-050, SBA-075). Sufficient lengths of flexible pipe shall be used to form a sweeping arc to ensure that spray heads are supported properly and allow for vertical adjustment and movement during service.

B. Swing Joints: All 1-inch inlet quick coupling valves shall be installed on prefabricated, manufactured swing joint assembly rated for 315 psi with prelubricated buttress threads and O-ring seals equal to Spears Manufacturing Co. Series 5807-01012.
2.14 GROUNDING EQUIPMENT

A. The irrigation controller shall be grounded to the manufacturer's recommended resistance to ground.

B. Proper grounding practices shall include both the installation of ground rods and grounding plates. Ground rods shall be copper clad, 5/8-inch diameter by 10-foot long grounding rods and connected to the electrical equipment and grounding plate with minimum #6 AWG, solid, bare copper wire. Grounding plates shall be 4-inch by 96-inch by 0.0625-inch copper as outlined below. Minimum 20-foot separation between rod and plate. Minimum 12-foot separation between controller and ground rod. All connections to rods shall be with Cadweld connectors as specified. All connections to plates shall be performed by the plate manufacturer with 25 feet of bare copper wire already attached. Each grounding rod is to be covered by a 4-inch round, grated top, plastic valve cover and six inches of 4-inch SDR35 PVC. Plates shall be installed in ground enhancement material. Plates shall be covered with 4-inch plastic grated cover with detection and minimum 36 inches of 4-inch ADS drainage pipe. Ground rods and plates shall be UL listed.

2.15 SAND

A. Sand used for backfilling of trenches; under, around and over PVC lines shall be as specified in Section 31 23 23, Fill and Backfill.

2.16 CONCRETE BASES

A. All concrete bases shall be standard concrete mix. Sizes shall be as indicated on Drawings and cited in the Specifications.

2.17 SPARE PARTS

A. Contractor shall supply the following tools and equipment to the Owner’s Representative before final observation:

1. Two wrenches for disassembling and adjusting each type of sprinkler head provided.
2. Two quick coupler keys and hose swivels.
3. Four of each type sprinkler head and pattern (PC and FC) used in the Project.
4. Four of each type nozzle used in the Project.
5. Four diaphragms and solenoids for each type and size of control valve used in the Project.
B. Before final observation can occur, written evidence that the Owner’s Representative has received the tools and equipment must be shown to the Owner.

PART 3 EXECUTION

3.01 GENERAL

A. Before work is commenced, hold a conference with the Owner’s Representative to discuss general details of the work.

B. Examine all contract documents applying to this Section noting any discrepancies and bringing the same to the attention of the Owner’s Representative for timely resolution.

C. Verify dimensions and grades at job site before work is commenced. Do not proceed with installation of the landscape irrigation system when it is apparent that obstructions or grade differences exist or if conflicts in construction details, irrigation equipment legend or specific notes are discovered. All such obstructions, conflicts, or discrepancies shall be brought to the attention of the Owner’s Representative.

D. Make all field measurements necessary for the work noting the relationship of the irrigation work to the other trades. Coordinate with other trades (landscaping and other site work trades). Project shall be laid out essentially as indicated on the Irrigation Plans, making minor adjustments for variations in the planting arrangement. Major changes shall be reviewed with the Owner’s Representative prior to proceeding.

E. Coordinate installation of all sprinkler materials, including pipe, to avoid conflict with the trees, shrubs, or other plantings. Special attention shall be made to avoid damage to the root system of existing trees. Contractor shall contact Owner’s Representative for guidance on trenching in this area.

F. During progress of work, a competent superintendent and all assistants necessary shall be on site. All shall be satisfactory to the Owner’s Representative. The superintendent shall not be changed, except with the consent of the Owner’s Representative, unless that person proves unsatisfactory and ceases to be employed. The superintendent shall represent the Contractor in his absence and all directions given to the superintendent shall be as binding as if given to the Contractor.

G. At all times, protect existing irrigation, landscaping, paving, structures, walls, footings, etc. from damage. Any inadvertent damage to the work of another trade shall be reported at once.
H. Replace, or repair to the satisfaction of the Owner, all existing paving disturbed during course of work. New paving shall be the same type, strength, texture, finish, and be equal in every way to removed paving.

3.02 PIPE AND FITTINGS INSTALLATION

A. Using proper width trencher chain, excavate trenches to a depth of minimum pipe coverage plus 6 inches. Trenches shall have sides as nearly vertical as possible. Remove all lumber, rubbish and rocks larger than 1 inch from the trenches. Provide a uniform bearing for the entire length of each pipe line to prevent uneven settlement. Wedging or blocking of pipe will not be permitted. Make the width of the trench a minimum of 1-1/2 times the diameter of the piping but not less than 4 inches.

B. Loam or topsoil encountered within the limits of trench excavation for irrigation mains and branch lines shall be carefully removed to the lines and depths as shown on Drawings and stockpiled for subsequent replacement in the upper 6 inches of the trench from which it is excavated. Such removal and replacement of the quantities of loam shall be considered incidental to the irrigation system and no additional compensation will be allowed therefore.

C. Back filling shall be accomplished as follows:

1. The first 10-inch of backfill material shall contain no foreign matter and no rock larger than 1-inch in diameter. Carefully place material around pipe and wire and tamp in place. Remainder of backfill shall be laid-up in 6-inch (maximum) lifts and tamped to compaction with mechanical equipment. Compaction in paved areas shall be to 98 percent standard proctor. Compact backfill in trenches to dry density equal to the adjacent undisturbed soil, and conform to adjacent grades without dips, sunken area, humps, or other irregularities. Frozen material shall not be used for backfill.

D. Do backfilling when pipe is cool. During hot weather keep pipe cool by backfilling in the early part of the morning before the heat of the day.

E. Do not, under any circumstances, use truck wheels or flooding for compacting soil.

F. Restore grades and repair damage where settling occurs.
G. All solvent-weld joints shall be made in strict accordance with manufacturer's recommendations and ASTM D2855 Standard Practice. Make solvent welds with a nonsynthetic bristle brush in the following sequence:

1. Apply an even coat of solvent to the outside of the pipe. Then apply solvent to the inside of the fittings and then re-apply a light coat of solvent to the outside of the pipe, making sure that coated area on the pipe is equal to the depth of the fitting socket. Insert pipe quickly into the fitting and turn the pipe approximately 1/4 turn to distribute the solvent and remove air bubbles. Check all tees and ells for correct position, then hold joint for approximately 15 seconds so that pipe does not push out from the fitting. Wipe off any excess of primer or solvent from each connection. Allow at least 15-minute drying time for each weld joint before moving. When the temperature is above 80 degrees F, allow connections to set minimum 24 hours before pulling or pressure is applied to the system. When temperature is below 80 degrees F, follow manufacturer’s recommendations. Provide and install for expansion and contraction as recommended. Wire shall be laid in same trench as mainline and at pipe invert (see Article Wiring Installation).

H. The minimum cover over the pipe shall be as follows:

1. Mainline Pipe: 20 inches of cover over pipe.
2. Lateral Pipe: 15 inches of cover over pipe.

I. Cut plastic pipe with handsaw or pipe-cutting tool, removing all burrs at cut ends. All pipe cuts are to be square and true. Bevel cut end as required to conform to Manufacturer's Specifications.

J. Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the trench. At times, when installation of the piping is not in progress, the open end(s) of the pipe shall be closed by a watertight plug or other means. All piping, which cannot temporarily be joined, shall be sealed to make as watertight as possible. This provision shall apply during the lunch hour as well as overnight. Pipe not to be installed that day shall not be laid out. Should water enter the trench during or after installation of the piping, no additional piping may be installed or back filled until all water is removed from the trench. Pipe shall not be installed when water is in the trench, when precipitation is occurring, or when the ambient temperature is at 40 degrees F or below. Pipe installed at temperatures below 40 degrees F shall be removed and replaced at no cost to the Owner. PVC pipe shall be snaked in the trench to accommodate for expansion and contraction due to changes in temperature.
K. Carefully install system in areas of existing vegetation designated to remain to provide minimal disturbance feasible. When trenching under the drip-line of existing trees, extreme care must be given to avoid root damage. If at all possible avoid trenching inside the drip-line by going around the tree rather than under it. If trenching must occur under the drip-line, use either tunneling or hand-digging methods rather than a mechanical trencher. Minimize the impact of root severing by avoiding construction during hot, dry weather, keeping trees well watered before and after digging and covering roots with soil or mulch as soon as possible. Contractor shall contact Owner’s Representative for guidance on trenching in this area. Where excavation must occur near trees, the Contractor shall provide proper root pruning and sealing methods shown in the landscape plans and specifications and approved by Owner’s Representative.

L. Maintain 6-inch minimum clearance between sprinkler lines and lines of other trades. Do not install sprinkler lines directly above another line of any kind.

M. Maintain 1-inch minimum clearance between lines which cross at angles of 45 degrees to 90 degrees.

N. Exercise care when excavating, trenching and working near existing utilities.

O. Throughout the guarantee period it will be the responsibility of the Contractor to refill any trenches that have settled due to incomplete compaction.

P. Pulling of pipe will be allowed provided soil is suitable and specified depth of bury can be maintained.

3.03 ELECTRICAL WIRE CONDUIT INSTALLATION

A. Electrical conduit shall be installed in all nonsoil areas, as well as for all above ground wiring where wire passes under or through walls, walks and paving to controllers and other sensors.

B. Conduit shall extend 18 inches beyond edges of walls and pavement.

3.04 PIPE SLEEVEING INSTALLATION

A. Contractor is responsible for the supply and installation of sleeves whether shown on Drawings or not. Install sleeves under paving and other improvements prior to construction. Install where required to accommodate piping at proper depth to prevent damage by other construction activities and to provide specified burial depth for irrigation pipe. Location of sleeves to be recorded and marked.
B. Sleeving shall be installed wherever piping is going under a non-soil area, generally where indicated on Drawings. Cover over all sleeving pipe shall be appropriate for the specified depth of the pipe passing through the sleeve. Minimum coverage shall be 20 inches.

C. Sleeving shall extend 24 inches beyond edges of walls and pavement.

D. If finished pavement is in place, the Contractor shall bore under the pavement for sleeving installation using personnel experienced in the procedure. Contractor shall be responsible for all damage to finished paving due to improper boring.

3.05 ISOLATION VALVE INSTALLATION

A. Install isolation valves in 10-inch round valve boxes with extensions at locations shown on Irrigation Plan Drawings.

B. Install all isolation valves on a level crushed stone base so that they can be easily opened or closed with the appropriate valve wrench.

3.06 VALVE AND VALVE BOX INSTALLATION

A. Furnish and install a valve access box for each electric valve, quick coupling valve, isolation valve, wire splice, flushing valve, air/vacuum relief valve, in-line check valves, etc.

B. Valves and valve boxes shall be installed where shown or directed, and shall be set plumb. Valve boxes shall be centered on the valves. Where feasible, valves shall be located outside the area of natural walkways or paths. Earth fill shall be carefully tamped around each valve box. Valve boxes should be supported by concrete blocks to ensure that any surface loads on the valve boxes will not be transmitted below to the pipe or valves. All boxes shall have at least 6-inch depth of clean washed round river rock under the valve boxes for drainage.

C. Electric control valves shall be set plumb with adjusting handle and all bolts, screws and wiring accessible through the valve box opening. Valves shall be set in a plumb position with 24-inch minimum maintenance clearance from other equipment. Adjust zone valve operation after installation using flow control device on valve.

3.07 WIRING INSTALLATION

A. Wiring shall be installed along with the main distribution line. Multiple wire bundles shall be cinched together at maximum 12-foot centers using plastic cable cinches and shall be laid beside, and at the same invert as, the irrigation
lines. Sufficient slack for expansion and contraction shall be maintained and wiring shall at no point be installed tightly. Provide and install an additional 8 inches to 12 inches slack at all changes of direction. Wiring in valve boxes shall be a sufficient length to allow the decoder, valve solenoid, splice, and all connections to be brought above grade for servicing. This additional slack shall be coiled for neatness in the valve box.

B. All wire shall be laid in trenches and shall be carefully back-filled to avoid any damage to the wire insulation or wire conductors themselves. In areas of unsuitable material, the trench shall have a 3-inch layer of sand or stone dust on the bottom before the wires are laid into the trench and back-filled. The wires shall have a minimum of 15 inches of cover. Wire not to be installed that day shall not be laid out.

C. An expansion curl shall be provided and installed within 6 inches of each wire connection to a solenoid. Expansion curls can be formed by wrapping five turns of wire around a 1-inch diameter or larger pipe and then withdrawing the pipe.

D. Service wiring in connection with Drawings and local codes for 24-volt service. All in-ground wire connections shall be waterproofed with materials specified in Part 2. All splices shall be made in valve boxes (wire runs requiring splices between valve locations shall be provided and installed in splice box-valve box shall be used). Splice locations shall be shown on the Record Drawings.

E. Contractor shall provide a complete wiring diagram showing wire routing for the connections between the central controller, sensors, valve decoders, sensor decoders and valves. See Part 1 for the inclusion of wiring diagram in operation and maintenance manuals.

3.08 CONTROLLER AND SENSORS INSTALLATION

A. Coordinate with the General Contractor the exact location where the automatic controller will be located. Connect all wiring and grounding in accordance with manufacturer's instructions. Provide separate conduits for both power supply and control wiring.

B. Install the rain and freeze sensors in an open area where the device is exposed to rain water but not sprinkler water. Mount away from overhanging objects that may interfere with rainfall. Connect wiring in accordance with manufacturer's instructions.
3.09 SPRINKLER INSTALLATION

A. Spray sprinklers and rotary sprinklers shall be installed on flexible connections or swing joints as specified in Part 2 and shall be set plumb and level with the final grade and in accordance with manufacturer's recommendations. Locate part circle sprinklers to maintain a minimum of 4 inches from walls and 2 inches from other boundaries and borders.

3.10 QUICK COUPLING VALVE INSTALLATION

A. Provide quick coupling valves at locations shown on Drawings.

B. Quick coupling valves to be mounted on 1-inch inch PVC unitized swing joint with stabilizer.

3.11 GROUNDING INSTALLATION

A. Contractor shall ground all electrical equipment according to the irrigation manufacturer’s requirements and specifications. Each grounding rod shall be driven into the ground its full length within 8 feet of the controller and connected via a Cadweld connection to #6 solid, bare copper wire. The copper wire is to be installed in as straight a line as possible, and if it is necessary to make a turn or bend, it shall be done in a sweeping curve with a minimum radius of 8 inches and a minimum included angle of 90 degrees. There shall be no splices in the bare copper wire. The top of the ground rod shall be driven below the ground surface. A 4-inch grated cover as specified, set a minimum of 1-inch below grade, shall be placed over the ground rod and Cadweld connection for periodic maintenance. Cover shall be installed on a minimum of 6 inches of 4-inch SDR35 PVC drainage pipe. Plates shall be installed 36 inches below grade with 50 pounds of ground enhancement material spread evenly below the plate in accordance with the manufacturer’s requirements.

B. Grounding rods shall be separated a minimum of 20 feet between grids. Grids shall be installed in an irrigated area.

C. When tested, grounding grid shall have an earth resistance no greater than 5 ohms. If earth resistance is greater than 5 ohms, additional grounding plates and enhancement material shall be added to system until desired test results have been meet.
A. Flushing:

1. After all piping, valves, sprinkler bodies, pipe lines and risers are in place and connected, but prior to installation of sprinkler internals, open the control valves and flush out the system under a full head of water.
2. Initial flushing of lines shall never be through sprinkler heads. Sprinkler internals, flush caps, and riser nozzles shall be installed only after flushing of the system has been accomplished to the full satisfaction of the Owner’s Representative.
3. Contractor shall be responsible for flushing the entire system after installation is complete and will be responsible for any clogged nozzles for 30 days after substantial completion of this portion of the landscape irrigation system.

B. Testing:

1. Leakage Test: With zone valves closed, pressure test mainlines by supplying and maintaining full static pressure continuously for one full hour. Observe for evidence of leakage by monitoring flow meter and by visual inspection of the exposed lines. Repair all leaks and retest until no water flow is observed. Owner's Representative must be contacted to inspect and witness the leak testing procedures.
2. Coverage Test: Perform a coverage test in the presence of the Owner's Representative (notify Landscape Architect at least 7 days in advance of scheduled coverage test). Owner's representative will determine if the water coverage and dispersion is complete and adequate. Readjust heads and/or head locations as necessary or directed to achieve proper coverage. After landscape finish grading is accomplished, install heads to finished grade in lawn and shrub areas and backfill with clean topsoil so head is stabilized and no lateral motion is exhibited during operation. Heads shall be set so the tip of the heads are 1/2-inch above the top of the mulch in planting beds. Heads in the turf areas shall be set flush with the finished grade and not a hazard to pedestrians and/or maintenance machinery. Set sprinkler heads to plumb within 1/16-inch and a minimum of 4 inches and a maximum of 6 inches from walls, walks and curbs.
3. Sprinkler heads to be spaced so as not to throw water on the buildings, walks or driveways. Heads shall be adjusted as required so that foliage of plants will not obstruct the spray and that the system has 100 percent coverage.
4. Contractor shall conduct a performance test of the complete system to ensure that all components are functioning properly. Performance test shall consist of operating the system through a complete irrigation cycle.
per day for 2 consecutive days. Contractor shall be at the site to monitor the performance test and make any adjustments and corrections as needed during the testing period.

5. All testing shall be at the expense of the Contractor.

3.13 CLEANING AND ADJUSTING

A. At the completion of the work, all parts of the installation shall be thoroughly cleaned. All equipment, pipe, valves and fittings shall be cleaned of grease, metal cuttings and sludge which may have accumulated by the operation of the system for testing.

B. Adjust sprinkler heads, valve boxes, and quick coupling valves to grade as required, so that they will not be damaged by mowing operations.

C. Continue sprinkler coverage adjustment as required by settlement, etc., throughout the guarantee period.

D. Each control zone shall be operated for a minimum of 5 minutes and all heads checked for consistency of delivering water. Adjustments shall be made to sprinklers that are not consistent to the point that they match the manufacturer's standards. All sprinklers, valves, timing devices or other mechanical or electrical components, which fail to meet these standards, shall be rejected, replaced and tested until they meet the manufacturer's standards.

3.14 ACCEPTANCE AND OPERATION BY OWNER

A. Upon completion of the work and acceptance by the Owner, the Contractor shall be responsible for the training of the Owner’s Representative in the operation of the system (provide minimum 72 hours written notice in advance of test). The Contractor shall furnish, in addition to the Record Drawings and operational manuals, copies of all available specification sheets and catalog sheets to the Owner's personnel responsible for the operation of the irrigation system. The Contractor shall guarantee all parts and labor for a minimum period of 1 year from date of acceptance.

B. Conditions for acceptability of work for start of maintenance by Owner issued by Owner or Owner’s Representative shall include, but not be limited to:

1. Punch list items complete and approved by Owner or Owner’s Representative.
2. Landscape irrigation system complete and in place.
3. Record Drawings complete.
4. Maintain installation and watering schedules until all conditions noted above have been completed.
3.15 CLEAN UP

A. Upon completion of all installation work, Contractor shall remove all leftover materials and equipment from the site in a safe and legal manner.

B. Contractor shall remove all debris resulting from work of this Section.

C. Contractor shall regrade, lightly compact, and replant around sprinkler heads where necessary to maintain proper vertical positioning in relation to established grade.

D. Contractor shall fill all depressions and eroded channels with sufficient soil mix to adjust grade to ensure proper drainage. Compact lightly, and replant filled areas in accord with Owner’s Representative’s requirements.

END OF SECTION
SECTION 32 91 13.19
PLANTING SOIL SYSTEM PROCUREMENT

PART 1   GENERAL

1.01   GENERAL

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

B. Examine all Drawings and other Sections of the Specifications for requirements therein affecting the work of this trade and equipment for Planting Soil Mix manufacturing and shipping, or as may be reasonably inferred from the Drawings and as described in the Specifications.

1.02   WORK OF THIS SECTION

A. The scope of work intended under this section includes furnishing all labor, materials, tools and equipment for planting soil components and soil mix manufacturing and shipping, or as may be reasonably inferred from the Drawings and as described in the Specifications. Such work shall include, but is not limited to, the following:

1. Furnish the Planting Soil Components:
   a. Base planting soil (base loam).
   b. Compost.
   c. Processed sand.
   d. Geofiber stabilization material.
   e. Gravel.

2. Blend the planting soil mixes that when installed will constitute the planting soil profiles.
   a. Horticultural subsoil.
   b. Planting soil.
   c. Gravel mix soil.

3. Testing and analysis for specification conformance.

1.03   RELATED SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 31 23 13, Subgrade Preparation.
2. Section 31 23 16, Excavation.
3. Section 31 23 23, Fill and Backfill.
4. Section 31 32 19.16, Geotextile.
5. Section 31 37 00, Riprap.
6. Section 32 84 00, Landscape Irrigation.
7. Section 32 91 19.13, Planting Soil System Installation.
8. Section 32 92 01, Prairies, Meadows and Wetlands.
9. Section 32 93 00, Planting and Fine Grading.

1.04 DEFINITIONS

A. Compaction: Compaction of the soil fabric is any force applied to the soil that reduces porosity and where 90 percent of all compaction can be accomplished with only three applications of force under optimum soil moisture conditions.

B. Contractor: The Contractor performing the work specified herein.

C. Dry Soil: The condition of the soil at or below the wilting point of plant available water in which the soil is powdery and subject to blowing.

D. Frozen Soil: The point at which the soil water has frozen and the soil has become very hard and cloddy. Ice crystals can be seen in the pore spaces of the soil.

E. Field Capacity: The percentage of water remaining in a soil 2 or 3 days after having been saturated and after free gravimetric drainage has ceased.

F. Moist Soil: The condition of the soil in where it can be formed into a ball and maintain its shape. Deformation of the soil is difficult with hand pressure. Free water is not visible and is usually considered the point between the wilting point and field capacity of the soil.

G. Planting Soils for Soil Types: Soil produced off-site by homogeneously blending mineral soils with mature stabilized organic compost and/or geofibers to produce a specified planting soil mix.

H. Planting Soil Profile: The assembly of planting soil types in a defined sequence and to specified depths to meet specific horticultural or engineering objectives.

I. Saturated: All the pore space within a soil is filled with water and the remaining water is under gravitational forces to drain through the profile.
J. Scarification: The loosening of the surface of a soil lift by mechanical or manual means to alleviate compaction or smoothed surfaces of the soil. Depth of scarification is dependent on material and extent of compaction. Depths are noted within the specifications.

K. Subsoil: The soil horizon directly below topsoil that provides water holding and structural support to plants. Source of the majority of micro-nutrients.

L. Subgrade: The in-situ soil material that the planting soil will be installed upon.

M. Topsoil:

1. The mineral surface layer of soil that exhibit obliteration of all or much of the original rock structure and must show the following: (1) an accumulation of humified organic matter closely mixed with the mineral fraction and not dominated by properties characteristic of subsurface horizons; (2) has reasonable tilth (biological, chemical and physical properties) to support plant growth; as well as the following qualities:
   a. A bulk density of less than 1.4 g/cc installed.
   b. Less than 10 percent by weight coarse fragments greater than 2 mm.
   c. Loose, friable structure (easily broken into crumbs or peds), no massive structure.
   d. No contamination (i.e., Toxic weeds, chemicals, heavy metals, construction debris).

N. USDA: United States Department of Agriculture.

O. Wet Soils: Soils that are considered wet will easily be deformed by hand pressure, maintain their shape, and free water will be visible within the pore spaces. The water content at this soil condition is considered at field capacity or wetter.

1.05 REFERENCES AND STANDARDS

A. All standards shall include the latest additions and amendments as of the date of advertisement for bids. For each type of packaged material required for the Work of this Section, provide manufacturer’s certified analysis. For all other materials, provide complete analysis by a recognized approved laboratory made in strict compliance with the standards and procedures of the following:

3. ASTM International (ASTM):
   e. D854-02, Specific Gravity of Soil.
   i. D3665, Random Sampling of Construction Materials.

   b. Percent Fiber Analysis.
   c. Infiltration Rate.

5. Soil Science Society of America.


1.06 SUBMITTALS

A. Qualifications: Candidate Contractor shall submit at least three project references. including project address, dollar value, owner’s, and Landscape Architect’s contact information (name, phone, and email).

1. Contractor shall have at least 5 years’ experience in blending designed soil mixes. Candidate Contractor shall submit written documentation of at least 5 years of contracting and landscape construction experience completing projects of similar scope, complexity and value.
B. Sources for Soil Components and Planting Soil Mixes: Submit information identifying sources for all soil components and the Contractor responsible for mixing of planting soil mixes.

1. Owner or Landscape Architect shall have the right to reject any soil supplier.
2. Soil mix supplier shall have a minimum of 5 years’ experience at supplying custom planting soil mixes.
3. Submit for approval all Soil Suppliers that may provide required planting soil mixes or components.
   a. Provide name, address, telephone number and contact name.
4. Submit certification that accepted supplier is able to provide sufficient quantities of materials and mixes for the entire project. Indicate quantity and type of material from each supplier.

C. Product Data: Submit technical descriptive data for each manufactured or packaged product of this Section. Include manufacturer’s product testing and analysis and installation instructions for manufactured or processed items and materials.

D. Laboratory Test Reports: Submit certified reports from approved laboratories for tests as described in this Section.

E. Physical Samples:

1. Concurrently with the submission of laboratory test reports, the Contractor shall submit to the Landscape Architect duplicate one 1-gallon sample bags for:
   a. Base planting soil(s).
   b. Compost.
   c. Processed sand.
   d. Geofiber stabilization material.
   e. Planting Soil Mixes:
      1) Horticultural subsoil.
      2) Planting soil.
      3) Gravel mix soil.

F. Certificates: Provide certificates of compost completion/maturation/stability as specified by the U.S. Composting Council.
1.07 QUALITY ASSURANCE

A. Long Lead Time Item: The Contractor shall be advised that the sourcing, testing, procurement and installation of planting soil is a CRITICAL PATH item, requiring timely attention to meet the requirements of the Documents. Having been informed that all aspects of planting soil, the Contractor shall consider this to be A LONG LEAD TIME ITEM. Contractor’s failure to heed this notice shall not be a reason for substitution of unacceptable material(s). Materials that do not meet requirements will not be accepted.

B. Construction Conferences:

1. Presubmittal Conference: In addition to the requirements of Section 01 31 13, Project Coordination, and Section 01 31 19, Project Meetings, a Conference to discuss the work of this section shall be held with the Landscape Architect and Soil Scientist prior to beginning submittals for this Section.

2. Preblending Conference: A preblending conference with the Landscape Architect and Soil Scientist is required for the work of this section and shall be held prior to starting full production blending.

C. Qualifications:

1. In addition to the requirements of Section 01 45 16.13, Contractor Quality Control:
   a. Contractor shall have at least 5 years’ experience in blending designed soil mixes. Candidate Contractor shall submit written documentation of at least 5 years of contracting and landscape construction experience completing projects of similar scope, complexity and value.
   b. Sources for planting soil materials shall have a minimum of 5 years’ experience at supplying custom planting soil mixes and shall be able to certify that they are able to provide sufficient quantities of materials and mixes, including indicating quantities available.
   c. Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
      1) Employ a qualified independent testing and inspection laboratory acceptable to the Landscape Architect and Owner to perform tests and certifications indicated. It is the responsibility of Contractor in conjunction with the Soil Supplier to submit material for the soil and compost tests.
Tests shall be made in strict compliance with the standards of the Association of Official Analytical Chemists and follow standards from ASTM, EPA, and/or Methods of Soil Analysis, Soil Science Society of America.

D. Record-keeping Log:

1. Maintain an activity log tracking the following:
   a. Planting Soil Mix Production: Date, weather, type of soil produced, volume, in cubic yards of soil produced.
   b. Record-keeping log is cumulative; every bi-weekly update is appended to the previous submission.
   c. Volume of planting soil materials on hand at the Contractor’s mixing/blending facility:
      1) Base planting soil(s).
      2) Compost.
      3) Processed sand.
      4) Planting soil mixes, all types.
   d. Volume of Planting Soil Delivered to the Project Site:
      1) Record:
         a) Type(s) of planting soil mixes delivered.
         b) Total volume in cubic yards, for each planting soil mix delivered.
   e. Testing:
      1) Include for each soil material:
         a) Include material type, test type, date, and interval or location. Record both acceptable and unacceptable findings. Immediately report unacceptable test reports to the Landscape Architect. Submit all test reports to the Owner’s Representative and Landscape Architect.
      f. Submit updates to the Owner’s Representative and Landscape Architect on a bi-weekly basis.
      g. Submit a complete record-keeping log to the Owner’s Representative and Landscape Architect at closeout.

1.08 TESTING

A. General:

1. Samples of all soil materials shall be submitted for testing and analysis to the approved testing laboratory. All soil materials shall be tested to confirm to the specified characteristics.
2. No planting soil components or mixes shall be used until certified test reports by an approved testing laboratory have been received and approved by the Landscape Architect.

3. Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
   a. Employ at Contractor’s expense a qualified independent testing and inspection laboratory acceptable to the Landscape Architect, Soil Scientist, and Owner to perform tests and certifications indicated. Tests shall be made in strict compliance with the standards of the Association of Official Analytical Chemists and ASTM.

4. Maintain clear, concise records for all testing and sampling procedures and log activities and results in the record keeping log.

5. All tests shall be made on the specific materials proposed for use on this Project.

B. Testing Facilities:

1. For each test type, use the same testing laboratory throughout the work. Notify Owner’s Representative and Landscape Architect of any change in laboratory and do not proceed until Landscape Architect has approved the change.

2. Laboratory shall be an independent laboratory with experience and capability to conduct the testing indicated and that specializes in the types of tests to be performed.

3. The following testing facilities have been pre-approved for testing of planting soil components and blended planting soil mixes. Testing agencies not listed below shall be approved by the Landscape Architect.
   a. Soil Physical Parameters:
      2) University of Massachusetts, West Experiment Station, Amherst, MA 01003, Telephone: (413) 545-2311, Fax: (413) 545-1931.
      3) “Or-equal.”
   b. Compost Testing:
      1) Woods End Research Laboratory, 290 Belgrade Road, Mt. Vernon ME 04352, Telephone: (207) 293-2457, Fax: (207) 293-2488, www.woodsend.org.
2) University of Missouri Soil and Plant Testing Laboratory, 23 Mumford Hall, Columbia, MO 65211, Telephone: (573) 882-0623.
3) “Or-equal.”

c. Soil Chemical Properties/Micronutrient Testing:
1) Midwest Testing Laboratories, 2645 Gravois Avenue, Saint Louis, MO 63118, Telephone: (314) 773-3035.
2) University of Missouri, Soil and Plant Testing Laboratory, 23 Mumford Hall, Columbia, MO 65211, Telephone: (573) 882-0623.
3) “Or-equal.”

d. Biological Testing:
2) Earthfort Laboratory, 635 S.W. Western Blvd, Corvallis, OR 97333, Telephone: (541) 257-2612.
3) “Or-equal.”

C. Test Definitions and Methods:

1. Soil Physical Properties: Particle size distribution by ASTM D422-63 for all planting soil components, mixes and existing silt loam.
   a. Mechanical gradation (sieve analysis) shall be performed and compared to the USDA Soil Classification System for sieve screen sizes 4, 10, 18, 35, 60, 140, and 270.
   b. Tests for silt and clay shall be by combined hydrometer and wet sieving in compliance with ASTM D422-63, hydrometer method. Percent clay and silt shall be tested and reported as separate particles.
   c. The results of gradation must be reported at the specified particle size breaks listed in this Section and by plotting as a particle size distribution curve on a five cycle semi-log graph.

2. Soil Chemical Properties:
   a. General: Testing shall be conducted in accordance with Methods and Method References in association with the Missouri Soil Testing Association Accreditation Program.
b. Testing for soil chemistry shall include Total Nitrogen, Ammonium Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Aluminum, Manganese, Lead, Cation Exchange Capacity (CEC), Soluble Salts, and acidity (pH).

1) Nutrient content shall be determined by the “Soil Test of Missouri Extension Office – St. Louis County” or equivalent laboratory.
   a) Available phosphorus shall be determined by the Melich-3 Method.
   b) ppm equals mg.kg-1.

2) Test for soil Soluble Salts shall be by the 1:2 (v:v) soil-water Extract Method as described in Test for Buffer pH by the SMP method.
   a) Reference:
      (1) Soluble Salts: Recommended Chemical Soil Test Procedures for the North Central Region.
   b) ds equals deciSiemens (Conductivity) equals mnhos.cm-1.

3) Test for soil CEC (Cation Exchange Capacity) by exchangeable acidity method.

4) Test for soil pH shall be determined from a 1:1 soil-distilled water suspension using a glass electrode pH meter.

c. Total Organic Matter:
   1) Test for soil organic matter content.
   2) References:

3. Biological Properties (Direct Microscopy):
   a. Active bacterial biomass.
   b. Total bacterial biomass.
   c. Active fungal biomass.
   d. Total fungal biomass.
   e. Protozoa, to include flagellates, amoebae, and ciliates.
   f. Total nematode numbers.
g. Hyphal diameter.
h. Total available N from biological cycling, reported as pounds per acre.

4. Compost: Maturity Index:
   a. Maturity shall be assessed in one of the following methods. Protocols for each method are specified by the “U.S. Composting Council Seal of Testing Assurance” and the Solvita manual (version 3.5).
      1) CO2 Evolution test (respirometry).
      2) Reheating Test: Use the Dewar self-heating test.
      3) Solvita test.

5. Compost:
   a. Physical and Chemical Requirements:
      1) Reaction (pH) in 1:1 water.
      2) Carbon/Nitrogen ratio (C:N).
      3) Foreign material on a dry weight basis.
      4) Organic matter percent on a dry weight basis.
      5) Ammonium-N using an extract method.
      6) Salinity using a 1:1 water paste method.
      7) Basic Nutrient content of macro nutrients (P, K, Ca, Mg).
      8) The compost material must be tested to meet EPA Chapter 503 and/or applicable Oklahoma Department of Environmental Quality levels for human use.
      9) E. coli, in conformance with USDA testing procedures.

6. Geofibers: The application rate of fiber reinforcement shall be verified by a Percentage of Fiber Analysis, a test developed by Turf Diagnostics and Design.

7. Gravel: Test for Physical and Chemical properties in accordance with the requirements of this Article.

1.09 SAMPLING AND TESTING FOR APPROVAL

A. Sampling:

1. Sample and perform soil tests to demonstrate that materials meet the specifications. Approved tests shall become the standard for the job.
   a. No base loam, planting soil component or planting soil mix shall be used until certified test reports by an approved Testing Agency have been approved by the Landscape Architect.
   b. The Landscape Architect may request additional testing by the Contractor for confirmation of mix quality and/or soil mix amendments at any time until delivery to the site.
   c. If, at any time during the project, the planting soil components, base loam or planting soil mixes require adjustment to meet the
specifications and/or performance criteria then the Contractor shall submit the adjusted soil components and/or mixes for testing as specified herein.

d. Additional testing for re-approval shall be required should any of the material sources change after initial approval.

2. Sampling Methods:
   a. Compost and Planting Soil Mixes: All samples shall be composite samples that are assembled from a minimum of six subsamples taken from the stockpiled material. Blend samples together and submit for testing the quantity required by the testing agency.
      1) Compost samples shall be taken from the interior of the stockpile.

B. Testing shall be Sequenced such that Approvals Build upon prior Successful Tests, as follows:

   1. Gain the Landscape Architect’s acceptance of testing for planting soil components (source loam, compost, and dry screened sand) prior to testing base loam(s) for approval.
   2. Gain the Landscape Architect’s acceptance of the base loam testing prior to testing planting soil mixes for approval.
   3. Gain the Landscape Architect’s acceptance of each planting soil mix test Specified in Article Planting Soil Mixes of this Section prior to producing a particular planting soil mix.

C. Testing of Planting Soil Components:

   1. Base loams shall be tested for mechanical gradation (Article 1.8.C.1) and soil chemical properties (Article 1.8.C.2).
      a. Samples shall be collected from each 12-inch depth interval of source area and labeled with source name, sample location (at source), and depth interval. Samples should be collected from each 10 acres of soil source area.
   2. Compost shall be tested for compost maturity (Article 1.8.C.4), compost chemical and physical requirements (Article 1.8.C.5), and biological properties (Article 1.8.C.3).

D. Testing of Base Loams: After tests for planting soil components have been accepted, create sample mixes of the Base Loams and test for mechanical gradation (Article 1.8.C.1) and soil chemical properties (Article 1.8.C.2).
E. Testing of Planting Soil Mixes:

1. After tests for Base Loams have been accepted, create sample mixes of each planting soil mix for approval. Tests required shall include:

1.10 ONGOING SAMPLING AND TESTING OF APPROVED MATERIAL (PRODUCTION RUN)

A. Sampling:

1. During soil blending operations, samples shall be collected for quality assurance. Collect samples in accordance with this Specification. Each sample shall be labeled with the planting soil mix, batch number, and date of sample. Collect samples and test at the following interval:
   a. Base Loam: Samples shall be collected and tested for every 1,000 cubic yards. Test shall be for mechanical gradation (Article 1.8.C.1).
   b. Planting Soil Mixes: Samples shall be collected and tested for every 1,000 cubic yards of planting soil mix during soil blending production.
      1) Required Tests:
         a) Horticultural Subsoil: Chemical properties (Article 1.8.C.2).
         b) Planting Soil (A1 and A1F) and Gravel Mix Soil (GMX): Mechanical gradation (Article 1.8.C.1) and chemical properties (Article 1.8.C.2).
   c. Compost:
      1) Samples shall be collected and tested for every 1,000 cubic yards of compost used during soil blending production. Required tests:
         a) Biological properties (direct, microscopy) (Article 1.8.C.3).
         c) Compost: Physical and chemical requirements (Article 1.8.C.5).
   d. For each 1,000-cubic yard Batch of Production Run Tests:
      1) Tests for salvage loam shall be approved prior to blending into base loam or blending into planting soil mixes.
2) Tests for base loam and compost shall be approved prior to blending into planting soil mixes.

3) Tests for planting soil mixes shall be completed and approved prior to delivering to the Project site and/or installation.

e. After base loams, compost and planting soil mixes (per type) have successfully passed three consecutive tests, frequency for testing of that particular item may be decreased to one test every 2,500 cubic yards.

1.11 ACCEPTANCE

A. The Landscape Architect and Soil Scientist shall evaluate all of the test results and reserve the right to reject, at any time, any soil that does not meet the baseline criteria for acceptance.

1. The baseline criterion for acceptance is established by the Landscape Architect when the initial tests for components, base loam and planting soil mixes are approved.

2. Physical soil samples shall be submitted to the Landscape Architect for physical examination. Examination will be for evidence of petroleum contamination, sulfur, mineralized organics including but not limited to slag, presence of saline components, construction debris, gravel beyond the specified limits, and other deleterious elements. The presence of these contaminants and/or materials will be cause for rejection of the soils despite acceptable test results for gradation and chemistry.

B. Rejected planting soil components or mixes shall not be delivered to or installed on the Project site.

1.12 GUARANTY

A. The work in this Specification shall be subject to the guaranty requirements as described within Division 01, General Requirements of the Project Manual.
PART 2  PRODUCTS

2.01  PLANTING SOIL COMPONENTS

A.  Base Loam A:

1.  Base Loam A soil shall consist of a uniform sandy loam soil from a clean source with the following requirements:
   a.  Gradations shall conform to the following grain size distribution for material passing the No. 4 sieve:

<table>
<thead>
<tr>
<th>U.S. Sieve Size</th>
<th>% Passing Minimum</th>
<th>% Passing Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (gravel)</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>10 (small gravel)</td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>18 (very coarse sand)</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>35 (coarse sand)</td>
<td>85</td>
<td>95</td>
</tr>
<tr>
<td>60 (medium sand)</td>
<td>55</td>
<td>70</td>
</tr>
<tr>
<td>140 (fine sand)</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>270 (very fine sand)</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td>0.05 mm to 0.002 mm</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>(silt)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 0.002 mm (clay-</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>retained)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   b.  Chemical Properties:

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>6.5 – 7.8</td>
</tr>
<tr>
<td>Salt concentration</td>
<td>mmhos/cm (dS/m)</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>ppm</td>
<td>10 – 50</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>ppm</td>
<td>2 – 30</td>
</tr>
<tr>
<td>CEC</td>
<td></td>
<td>&gt;15</td>
</tr>
<tr>
<td>Aluminum (available)</td>
<td>ppm</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Manganese</td>
<td>ppm</td>
<td>100 – 2,000</td>
</tr>
</tbody>
</table>
2. Base Loam A shall have organic matter content between 0.25 percent and 2.5 percent on a dry weight basis.

3. Base Loam A soil shall not contain objects larger than 1/2-inch in any dimension, including clay clods, gravel, or other foreign matter.

B. Dry Screened Sand:

1. Sand for amending existing (salvaged) loam or Base Loam A soil shall be a naturally occurring, uniformly graded coarse sand consisting of clean, inert, rounded to sub-angular grains of quartz or other durable rock free from loam or clay, surface coatings, mica, and other deleterious materials. There shall be no coarse fragments over 2.5 cm in size or visible organic matter present in this layer. Particle size distribution for material passing a No. 4 Sieve shall be:

<table>
<thead>
<tr>
<th>U.S. Sieve Size</th>
<th>% Passing Minimum</th>
<th>% Passing Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>75</td>
<td>95</td>
</tr>
<tr>
<td>18</td>
<td>65</td>
<td>85</td>
</tr>
<tr>
<td>35</td>
<td>65</td>
<td>80</td>
</tr>
<tr>
<td>60</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>140</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>270</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.002 mm</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

2. The pH shall not exceed 7.2.

C. Compost:

1. Compost shall be a stable, humus-like material produced from the aerobic decomposition and curing of organic vegetative residues derived from feedstock consisting of woody stems, leaves, grass cuttings, and livestock manure (up to 10 percent of the compost mix by volume). The compost shall be a dark brown to black color and be capable of...
supporting plant growth with appropriate management practices with no visible free water or dust, with no unpleasant odor.

2. Chemical Properties:
   a. Compost shall conform to the following values:

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Range</th>
<th>Final Target in Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total nitrogen</td>
<td>ppm</td>
<td>2,000 – 8,000</td>
<td>50 – 3,000</td>
</tr>
<tr>
<td>Extractable nitrate</td>
<td>ppm</td>
<td>20 – 200</td>
<td>2 - 10</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>ppm</td>
<td>5 – 2000</td>
<td></td>
</tr>
<tr>
<td>Available phosphorus</td>
<td>ppm</td>
<td>5 - 200</td>
<td>2 - 15</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>5.5 – 8.0</td>
<td></td>
</tr>
<tr>
<td>Salt concentration</td>
<td>dS.m-1</td>
<td>&lt;6</td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>% wt</td>
<td>30 – 55</td>
<td></td>
</tr>
</tbody>
</table>

b. The ratio of carbon to nitrogen (C:N) shall range from 10:1 to 25:1.

c. Organic matter content of compost shall be at least 40 percent (dry weight). One hundred percent of the material shall pass a 1/2-inch (or smaller) screen. Debris such as metal, glass, plastic, wood (other than residual chips), asphalt or masonry shall not be visible and shall not exceed one percent dry weight.

d. The compost shall be screened to 1/2-inch maximum particle size and shall contain no more that 3 percent material finer than 1.0 mm (No. 18 sieve) as determined by sieve analysis.

e. Additional tests defined in Part I as chemical properties shall be performed, and the results will be utilized to evaluate amendments to the planting soil mixes that may be required.

3. Maturity:
   a. CO² Test: Compost respiration shall be no more than 6 mg CO²-ClgBVS day.
   b. Reheating Test: The maximum heat rise shall be no greater than 9 degrees C above room temperature (20 degrees C to 25 degrees C).
   c. Solvita Test: The compost must achieve a maturity index of six or more.

4. Biological Values:
   a. Active bacteria and fungi are not to be higher than 10 percent of total bacteria and fungi respectfully.
   b. Total bacteria to be a minimum of 500 ug/g.
c. Total fungi to be a minimum of 400 ug/g.
d. Protozoa to be 100,000 (amoeba and flagellates with no more 3,000 ciliates).
e. Nematodes minimum of 10 beneficial, no root feeders.


6. Total Available N from Biological Cycling: 150 pounds per acre.

D. Gravel:

1. Gravel for gravel mix horizon in meadow planting soil shall consist of sound, tough, durable crushed or uncrushed gravel; free from soft, thin, elongated or laminated pieces and organic or other deleterious substances. The gravel mix shall consist of angular, well-graded stone. Gravel color shall be approved by the Landscape Architect. Gravel shall be washed. Gradation requirements shall be as follows:
   a. Gravel: 3/4-inch angular crushed stone.

E. Geofiber Reinforcement: Provide 100 percent polypropylene fiber reinforcement as supplied by Fiber Soils, LLC, P.O. Box 80198, Baton Rouge, LA 70898, Telephone: (225) 757-9136; Fax: (225) 752-7975.

1. Geofiber Reinforcement:
   a. Provide 3620BF fiber reinforcement batch mixed with soil profiles as specified herein to the area(s) designated on Drawings. Fiber reinforcement shall conform to the following minimum specifications:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Typical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polypropylene</td>
<td>ASTM D4101</td>
<td>99%</td>
</tr>
<tr>
<td>Color</td>
<td>--</td>
<td>Black</td>
</tr>
<tr>
<td>Moisture Absorption</td>
<td>--</td>
<td>Nil</td>
</tr>
<tr>
<td>Fiber Length</td>
<td>--</td>
<td>2-inch min.</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>ASTM D792</td>
<td>0.91 gr./cm³</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D2256</td>
<td>40,000 psi min.</td>
</tr>
<tr>
<td>Tensile Elongation</td>
<td>ASTM D226</td>
<td>15%</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td>ASTM D2101</td>
<td>600,000 psi min.</td>
</tr>
<tr>
<td>Denier</td>
<td>--</td>
<td>2,600</td>
</tr>
<tr>
<td>Estimated Mixing</td>
<td>--</td>
<td>6 – 8 lb/CY of soil</td>
</tr>
</tbody>
</table>
F. Sources for Soil Components and Planting Soil Mixes.

1. All planting soil mix materials shall fulfill the requirements as specified and be tested to confirm the specified characteristics. Submit certification that accepted supplier is able to provide sufficient quantities of materials and mixes for the entire project.

2. Sources for planting soil components may include the providers listed below. No guarantee is made or implied that the sources listed will be able to meet the soil material specifications. The listing of sources does not pre-approve the soil material.
   a. Base Loam A Soil (Sandy Loam):
      1) Gem Dirt Sales, LLC, 2526 W. 101st St., Tulsa, OK 74132, Telephone: (918) 298-0299.
      2) Enterprise Dirt Sales, 5909 W. Hilton Rd, Sapulpa, OK 74066, Telephone: (918) 224-6440.
      3) “Or-equal.”
   b. Compost:
      1) Gem Dirt Sales, LLC, 2526 W. 101st St, Tulsa, OK 74132, Telephone: (918) 298-0299.
      2) “Or-equal.”

2.02 PLANTING SOIL MIXES – REFERENCE CHART

A. Planting soils shall consist of base loam soils or dry screened sand blended with compost in the ratios presented in the following chart and specified herein. Mix ratios are approximate and shall be adjusted as required to meet the specific requirements of the planting soil mixes.

<table>
<thead>
<tr>
<th>Planting Soils Mix</th>
<th>Base Material</th>
<th>Second Component</th>
<th>Third Component</th>
<th>Ratio by Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horticultural Subsoil (HS)</td>
<td>Base Loam A</td>
<td>Compost</td>
<td>--</td>
<td>9:1</td>
</tr>
<tr>
<td>Planting Soil (A1)</td>
<td>Base Loam A</td>
<td>Compost</td>
<td>--</td>
<td>3:1</td>
</tr>
<tr>
<td>Gravel Mix Soil</td>
<td>Dry Screened Sand</td>
<td>Gravel</td>
<td>Compost</td>
<td>2:1:1</td>
</tr>
</tbody>
</table>
2.03 PLANTING SOIL MIXES

A. Horticultural Subsoil (HS):

1. Horticultural subsoil shall consist of nine parts Base Loam A soil and one part compost by volume (9:1 Ratio). Horticultural subsoil shall be free of solids larger than 1/2-inch in any dimension and not consisting of such solids more than 2 percent by volume.

2. Mechanical Gradation: The horticultural subsoil shall be a uniform, homogenized mixture of the soil components with a gradation conforming to the approved Base Loam A soil.

3. Properties shall meet the following:
   a. Organic Content: Between 0.5 percent and 2.0 percent on a dry weight basis.
   b. pH: 6.5 to 7.5.
   c. Total nitrogen (all forms) between 50 mg/kg to 200 mg/kg soil.
   d. Available nitrogen (NH4 and NO3) between 10 mg/kg to 80 mg/kg.
   e. Total available P content between 5 mg/kg to 50 mg/kg.

B. Planting Soil (A1):

1. Planting soil shall consist of a blend of Base Loam A (sandy loam) soil combined with compost, both meeting the requirements specified herein, at an approximate mix ratio of three parts by volume Base Loam A to one part by volume compost to create a uniform blend.
   a. Total nitrogen (all forms) content of the planting soil (including blended compost) shall range from 150 mg/kg to 400 mg/kg soil, with available nitrogen (NH4 and NO3) content between 50 mg/kg to 100 mg/kg. Total available P content shall be in the range of 20 mg/kg to 40 mg/kg.

C. Gravel Mix Soil (GMX): Gravel mix soil shall consist of a blend of compost, sand and gravel all meeting the requirements specified herein, at an approximate mix ratio of two parts by volume dry screened sand to one part by volume compost to one part by volume gravel.

PART 3 EXECUTION

3.01 GENERAL

A. Material should not be handled or hauled, placed or compacted when it is wet as after a heavy rainfall or is frozen. Soil should be handled only when the moisture content is less than at field capacity. The Landscape Architect shall be consulted to determine if the soil is too wet to handle.
B. Delivery of all soil types referred to in this Section will be coordinated and sequenced to minimize stocking time on Owner’s site. Only requested volumes will be delivered on agreed-upon dates.

C. Care will be taken to prevent co-mixing and contamination of soil materials before and during delivery.

D. The final prepared planting soil mixes will be delivered to the site where the Landscape Architect will review them for approval prior to installation.

3.02 BLENDING OF PLANTING SOIL MIXES

A. All planting soils will be blended to a uniform, homogenous mix as specified in Part 2 of this Section.

B. All mixing shall be accomplished when the soil moisture content is less than 20 percent by weight.

C. All planting soil mixes must be blended to a uniform mixture using a rotating Trommel screen or equivalent with 3/8-inch screen openings to produce the final planting soil mix. Bucket blending of soil mixes is only acceptable as a PRELIMINARY mixing of individual planting soil components if necessary prior to blending the planting soil mixes specified in Article Planting Soil Mixes of this Section.

D. Hammer mills or blending knives are not permitted in preparation of the soil as these processes pulverize the soils and reduce soil structural stability.

E. Compost shall be maintained dry to moist, not wet, during mixing.

F. No amendments shall be added unless approved by the Landscape Architect and Soil Scientist and additional tests have been conducted to verify type and quantity of amendments acceptable.

3.03 STORAGE AND HANDLING

A. Material should not be handled or hauled, when it is wet or frozen. Soil should be handled only when the moisture content is less than at field capacity. The Landscape Architect shall be consulted to determine if the soil is too wet to handle.

1. Soil Material that is handled wet shall be discarded.
B. Invasive Species Control: Inspect all stockpiles weekly for the presence of invasive or weedy species. Remove material within 14 days with hand pulling. If visibly flowering, the weed must be physically removed.

C. Stockpiles: Stockpile each soil material separately and provide large, clear signage identifying the contents of each pile, for example; “Sand” or “Base Loam A” or “Tree Planting Soil.” Provide perforated aeration pipe within the soil stockpiles.

1. Height of Pile: Soil stockpiles shall not exceed 12 feet in height.
   a. Layout: Lay aeration pipe horizontally in the soil stockpile. Pipe shall extend from the face of the stockpile by a minimum of 18 inches. Provide three layers of pipes: one at ground level, one at 4 feet height, and one at 8 feet height. Provide pipes 15 feet on center for each layer. Stagger each layer by 1/3 the distance between pipes. Slope pipes at 1 percent.
   b. The requirement for Aeration pipe will be waived if the height of the stockpile does not exceed 6 feet.
3. Protection:
   a. Construct storage piles to allow free drainage of surface water. Slope top of pile a minimum of 3 percent.
   b. Cover storage piles if required to prevent windblown dust and protect against erosion.
   c. Protect stockpiles from contamination of any sort.
   d. Prohibit vehicles and pedestrian traffic on or around stockpiled soil materials.
      1) Only low ground pressure vehicles are permitted to drive on stockpiles. psi shall be below 4.
4. In no case shall the stockpiled soil be allowed to go anaerobic as this condition is irreversible and renders the soil unusable for planting. The Contractor shall keep logs for soil management while it is in stockpiles. If the Contractor suspects that stockpiled soils have become anaerobic, notify the Landscape Architect and wait for further instructions before aerating stockpiles.

3.04 SEQUENCING AND SCHEDULING

A. The Contractor is responsible for coordinating blending, shipping and delivery of planting soils so that the components of stockpiled mixes do not segregate, comingle or become contaminated.

B. Sequence deliveries to avoid delay.
3.05 PLACEMENT OF PLANTING SOIL MIXES
   A. Refer to Section 32 91 19.13, Planting Soil System - Installation.

3.06 EXCESS MATERIALS
   A. After all work for the Project is completed and accepted, the Contractor shall
      be responsible for legal disposal of all unused soil components and mixes that
      are stored on site or at the Contractor’s facility.

END OF SECTION
PART 1 GENERAL

1.01 GENERAL

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

B. Examine all Drawings and other Sections of the Specifications for requirements therein affecting the work of this trade and equipment for Planting Soil Mix manufacturing and shipping, or as may be reasonably inferred from the Drawings and as described in the Specifications.

1.02 WORK OF THE SECTION

A. This section includes furnishing all labor, materials, tools, and equipment for Planting Soil installation, or as may be reasonably inferred from the Contract Documents. Such work shall include but is not limited to the following:

1. Preparation of subgrade.
2. Evaluation and testing of rough subgrade water infiltration.
3. Coordination of sequencing, supply, testing and delivery of imported/manufactured soil materials.
   a. Refer to Section 32 91 13.19, Planting Soil System Procurement.
4. Installation and placement of soils.
5. Testing and analysis for specification conformance.
6. Record-keeping Log.
7. Coordination with other trades.
8. Clean-up.

1.03 RELATED SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 31 10 00, Site Clearing.
2. Section 31 23 13, Subgrade Preparation.
3. Section 31 23 16, Excavation.
4. Section 31 23 23, Fill and Backfill.
5. Section 32 84 00, Landscape Irrigation.
7. Section 32 92 01, Prairies, Meadows, and Wetlands.
8. Section 32 93 00, Planting and Fine Grading.

1.04 REFERENCE STANDARDS FOR ANALYSIS AND TESTING

A. All standards shall include the latest editions and amendments as of the date of advertisement for bids. For each type of packaged material required for the work of this Section, provide manufacturer’s certified analysis. For all other materials, provide complete analysis by a recognized laboratory made in strict compliance with the standards and procedures of the following:

3. ASTM International (ASTM):
   d. D698, Standard Proctor Test.
   e. D3385, Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer.

1.05 DEFINITIONS

A. Contractor: The Contractor performing the work specified herein.

B. Compaction: Compaction is the comparison of the physical qualities of a soil in its “at rest” (uncompacted) state verses its state after forces have been applied to the soil. Compaction results in a denser packing arrangement of soil particles that result in a reduction of porosity, an increase in bulk density, and a decrease in soil hydrologic conductivity. Over compaction of soil is the condition where the soil porosity is reduced below 40 percent pore space, the bulk density exceeds 1.4 g/cc, and hydraulic conductivity is above one.

C. Dry Soil: The condition of the soil at or below the wilting point of plant available water in which the soil is powdery and subject to blowing.

D. Frozen Soil: The point at which the soil water has frozen and the soil has become very hard and cloddy. Ice crystals can be seen in the pore spaces of the soil.
E. Field Capacity: The percentage of water remaining in a soil two or three days after having been saturated and after free gravimetric drainage has ceased. Soil that is worked above its field capacity is subject to over-compaction and damage to its structure.

F. Final Acceptance: Final Acceptance shall be the day on which the project is 100 percent complete and accepted by the Landscape Architect and Owner, including “Punch List” items. Maintenance and Warranty work shall commence at Final Acceptance.

G. Finish Grade: Elevation of finished surface of planting soil after settlement.

H. Kjeldahl Nitrogen: In chemical soil testing, the sum of organic nitrogen, ammonia (NH3), and ammonium (NH4+).

I. Moist Soil: The condition of the soil in where it can be formed into a ball and maintain its shape. Deformation of the soil is difficult with hand pressure. Free water is not visible and is usually considered the point between the wilting point and field capacity of the soil.

J. Planting Soils for Soil Profiles: Soil produced off-site or on-site from off-site sources by homogeneously blending mineral soils or sand with mature stabilized organic compost to produce specified planting soil blends.

K. Project: Refers to The Gathering Place for Tulsa construction site.

L. Saturated: All the pore space within a soil is filled with water and the remaining water is under gravitational forces to drain through the profile.

M. Scarification: The loosening of the surface of a soil lift by mechanical or manual means to alleviate crusted, minimal compaction, or smoothed surfaces of the soil. Depth of scarification is dependent on material and extent of compaction. Depths are noted within the Specifications.

N. Subsoil: The soil horizon directly below topsoil that provides water holding and structural support to plants. Source of the majority of micro-nutrients.

O. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soils.

P. Topsoil:

1. The mineral surface layer of soil that exhibit obliteration of all or much of the original rock structure and must show the following: (1) an accumulation of humified organic matter closely mixed with the mineral
fraction and not dominated by properties characteristic of subsurface
horizons; (2) has reasonable tilth (biological, chemical and physical
properties) to support plant growth; as well as the following qualities:
a. A bulk density of less than 1.4 g/cc installed.
b. Less than 10 percent by weight coarse fragments greater than
2 mm.
c. Loose, friable structure (easily broken into crumbs or peds), no
massive structure.
d. No contamination (e.g., toxic weeds, chemicals, heavy metals,
construction debris).

Q. Wet Soils: Soils that are considered wet will easily be deformed by hand
pressure, maintain their shape, and free water will be visible within the pore
spaces. The water content at this soil condition is considered at field capacity
or wetter.

R. Redoximorphic Features: The iron staining or gray depletion of soil colors due
to anaerobic soil conditions in association with a seasonal high water table.

1.06 SUBMITTALS

A. Informational Submittals:

1. In addition to the requirements of Section 01 33 00, Submittal
 Procedures, submit the following:
   a. In-situ Test Reports: Submit certified reports for tests as described
      in this Section.
   b. Laboratory Test Reports: Submit certified reports for tests as
described in this Section.
   c. Schedule: In addition to the requirements of Section 01 32 00,
      Construction Progress Documentation, the Contractor shall submit
      a schedule of soil needs within 4 weeks of beginning Work, and
      shall resubmit the schedule when dates change.
   d. Soil mix samples collected before or during installation.
   e. Qualification Data: The Landscape Contractor shall have at least
      5 years’ experience in installing designed soil mixes, completing
      projects similar in scope, complexity and value.
       1) Candidate Landscape Contractor shall submit at least three
          project references, including project address, construction
dollar value, project Owner’s and Landscape Architect’s
          contact information (name, company, phone, and email).
   f. Record-keeping Log: Submit to Landscape Architect two times
      per month. Refer to Article 1.7, D.
1.07 QUALITY ASSURANCE

A. Contractor’s Experience:
   1. Candidate Contractor shall submit written documentation demonstrating at least 5 years of contracting and landscape construction experience completing projects of similar scope, complexity and value.
   2. Candidate Contractor shall submit at least three project references including project address, dollar value, Owner’s and Landscape Architect’s contact information (name, phone, and email).

B. Pre-Installation Conference: In addition to the requirements of Section 01 31 00, Project Management and Coordination, a Conference with the Landscape Architect to discuss the work of this Section shall be held prior to beginning the work of this Section.
   1. Conference shall also include the Soil Scientist. Schedule of required planting soil needs shall be discussed.

C. Planting Soil Quality Assurance: Refer to Article 1.8 for soil testing requirements.

D. Record-keeping Log:
   1. Maintain an activity log tracking the following:
      a. Dates of planting soil installation including soil mix, installation time, approximate quantity, location, and weather (temperature, humidity, precipitation, cloud cover).
      b. Schedule of in-situ field testing, including date, type of test, planting soil layer and profile tested, location of test, number of tests, and weather (temperature, humidity, precipitation, cloud cover).
      c. Schedule of sampling (soil sample collection) and laboratory testing of planting soils, including date, type, lab name, location of sampling, number of tests, and weather (temperature, humidity, precipitation, cloud cover).
      d. For all tests, number each test and indicate locations of tests on a plan graphic of the Project site.

E. Planting Soil Quality Assurance: During the placement of planting soils, sample each layer of the planting soil mix for every defined planting area. Keep these samples on site for review by the Landscape Architect during the construction process. Label each sample with the planting soil mix, date of installation, general location of where it was placed, and any other notations that would be relevant such as if it was raining that day or the planting soil
was too wet or dry. If there are questions or concerns with a certain mix, the Landscape Architect shall require the QA sample to be tested.

F. Record both acceptable and unacceptable findings. Immediately report unacceptable test reports to the Landscape Architect. Submit all test reports to the Landscape Architect.

G. Provide written guaranty agreeing to remove and replace work that exhibits defects in materials or workmanship. Defects shall include settlement, poor drainage, anaerobic soils, compacted soils, or any other conditions that are detrimental to healthy plant growth.

H. Furnish certificates of inspection of landscape materials to accompany shipments, as required by governmental authorities. Comply with applicable Federal, State, County, and local regulations governing landscape materials.

1.08 TESTING

A. General:

1. Record-keeping Log for Testing: Maintain clear, concise records for all testing and sampling procedures. Log activities and results in the record-keeping log.
   a. Refer to Article 1.7, D. for requirements.

2. Testing of soil biology and soil chemical properties for the purposes of promoting plant growth shall be required.

B. Testing Laboratory Qualifications: Refer to Section 32 91 13.19, Planting Soil System Procurement.

C. Testing Definitions and Methods:

1. Grab Samples:
   a. Refer to Article 1.7, E.
   b. A grab sample shall consist of five discrete collections of soil homogenized into the final 1-gallon sample for submittal to the Landscape Architect.
      1) Discrete collections of soil shall be a minimum of 25 feet apart.
   c. Label each grab sample to identify planting soil mix, date of sample collection, and the location of installation.
   d. Keep these samples on site for review by the Landscape Architect and Soil Scientist during the construction process.

2. Mechanical Gradation: Refer to Section 32 91 13.19, Planting Soil System Procurement.
3. Chemical Properties: Refer to Section 32 91 13.19, Planting Soil System Procurement.
5. In-Situ Tests:
   b. Density Tests (Compaction):
      1) Nuclear Method: ASTM D6938, 10 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
   c. Infiltration Test: In-place percolation tests shall be performed utilizing a double ring infiltrometer, falling head, conforming to ASTM D3385-09 utilizing Turf-Tech IN2-W Infiltrometer as manufactured by Turf Tec International, 1471 Capital Circle N.W., Suite #13, Tallahassee, FL 32303, or approved alternate.
      1) Unless otherwise specified herein, in-place infiltration tests shall be carried out at a rate of one test per area (minimum) at a rate of one test per 5,000 square feet for each type of material placed.

1.09 SAMPLING AND TESTING FREQUENCY

A. Planting soil shall be sampled at the following intervals:
   1. Grab Sampling: Refer to Article 1.7, E for requirements. Keep the grab samples organized and provide the Landscape Architect and Soil Scientist access to the samples upon request. If there are questions or concerns with a planting mix, the Landscape Architect or Soil Scientist shall require the sample to be tested.

B. Testing for Subgrade:
   1. Testing is required at the following intervals:
      a. In-place Tests: Prior to placement of the planting soil profile, test the subgrade for compaction/density and infiltration in accordance with Article 1.9, C, of this Section. Coordinate the testing of the subgrade before the planting soil profile is placed.
C. Testing for Subgrade and Planting Soil Mixes:

1. Density Testing, Nuclear Method:
   a. One test per 20,000 square feet, for each of the following soil horizons:
      1) Subgrade.
      2) Horticultural Subsoil (HS).
      3) Planting Soil (A1).
      4) Gravel Soil (GMX).

2. Density Testing, Static Cone Penetrometer:
   a. Two tests per 5,000 square feet. One test shall be at the depth of 0 inch to 6-inch, and the second test shall be at the depth of 6-inch to 18-inch, for each of the following soil profiles:
      1) Subgrade.
      2) Rip Rap Planting Soil Profile (SP-RR).

3. Infiltration Test:
   a. One test per 10,000 square feet of the following soil profiles:
      1) Subgrade.
      2) Rip Rap Planting Soil Profile (SP-RR).

1.10 DELIVERY, STORAGE AND HANDLING

A. Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery, and while stored at the site.

B. Material shall not be handled or hauled, placed or compacted when it is wet as after a heavy rainfall nor when frozen. Soil should be handled only when the moisture content is less than at field capacity. The Landscape Architect, the Soil Scientist and the Construction Manager shall be consulted to determine if the soil is too wet to handle.

C. Store and handle packaged materials in strict compliance with manufacturer’s instructions and recommendations. Protect all materials from weather, damage, injury and theft.

D. Sequence deliveries to avoid delay. On-site storage space is permissible only with written notice from Construction Manager. Deliver materials only after preparations for placement of planting soils have been completed.

E. Prohibit vehicular and pedestrian traffic on or around stockpiled planting soil.

F. Soil that is to be stockpiled longer than 2 weeks, whether on or off site, shall not be placed in mounds greater than 6 feet high. If soil stockpiles greater than 6 feet high are present longer than 2 weeks then the Contractor shall break
down and disperse soil so that mounds do not exceed the six-foot height restriction for longer than 2 weeks.

G. Invasive Species Control: Inspect all stockpiles weekly for the presence of invasive or weedy species. Remove material within 14 days with hand pulling. If visibly flowering, the weed must be physically removed.

H. Vehicular access to the site is restricted. Before construction, the Contractor shall submit for approval a plan showing proposed routing for deliveries and site access.

1.11 SEQUENCING AND SCHEDULING

A. The Contractor is responsible for coordinating so that the following conditions are met:

1. Components of stockpiled mixes do not segregate, comingle or become contaminated.
2. Placement and compaction of the soils shall be coordinated to avoid damage to other installed work, such as underdrainage, aeration or irrigation systems.

1.12 GUARANTY

A. The work in this specification shall be subject to the guaranty requirements as described within Division 01, General Requirements.

1.13 ACCEPTANCE

A. If, at any time during the project, placed planting soil does not meet the specifications and/or performance criteria for density or infiltration, then the Contractor shall stop placement of all planting soil and schedule a meeting with the Landscape Architect and Soil Scientist. Steps for amending the soil in place or replacement of noncompliant planting soil shall be determined by the Landscape Architect depending on the results of the testing and site observations.

B. Request for Acceptance: In writing, request from Landscape Architect inspection for acceptance at least 10 days in advance of preferred inspection date. Do not request inspection for acceptance until work is 100 percent complete and in compliance with the Contract requirements.

C. Partial Acceptance: Acceptance of partial areas or portions of the total work may be granted, at the Landscape Architect’s option, if the area to be inspected for acceptance is large, well defined, and easily described. The
Landscape Architect is not obligated to provide partial acceptance of the work.

D. Final Acceptance is defined as the time at which all work has been performed and accepted by the Landscape Architect including any work noted on the “Punch List.”

**PART 2 PRODUCTS**

**2.01 SUBGRADE**

A. Subgrade conforming to the requirements of Section 31 23 16, Excavation, Section 31 23 23, Fill and Backfill, Section 31 37 00, Riprap, and the Drawings.

**2.02 SUBGRADE AMENDMENT**

A. Subgrade amendment components shall consist of:

1. 70 percent Standard Agricultural Course Grade Humates:
   a. Shall be a naturally occurring, unaltered oxidized lignite.
2. Coarse Grade Soft-Rock Phosphate: Soft-Rock Phosphate shall not be MAP or DAP.

B. Subgrade Amendment Mix: The Contractor shall provide a subgrade amendment mix composed of 80 percent Humates and 20 percent Soft Rock Phosphates.

**2.03 PLANTING SOIL MIXES**

A. Planting soil mixes shall conform to the requirements of Section 32 91 13.19, Planting Soil Procurement.

B. Existing Soils within Tree Driplines (SC): Existing soils within tree driplines shall be existing soils under tree canopies that will not be disturbed or graded except for seeding, aeration, or coring tools/machines for incorporation of soil treatments.
2.04 PLANTING SOIL PROFILES

A. Soil Profiles are as shown on Drawings and are composed of the planting soil mixes conforming to the requirements of Section 32 91 13.19, Planting Soil System Procurement, and as described herein. In the event of a conflict between the Drawings and the Specifications, Drawings shall take precedence.

1. Rip Rap Planting Soil Profile (SP-RR): The rip rap planting soil profile shall consist of two soil horizons (layers) as indicated on Drawings and shall be comprised of planting soil mixes conforming to the requirements of Section 32 91 13.19, Planting Soil System Procurement. This profile shall be installed in areas as indicated on Drawings. The A1 horizon (upper layer) shall be 10 inches of Gravel Mix Soil (GMX) placed over an underlying A2 horizon (middle layer) of 6 inches of Planting Soil (A1) placed over an underlying B horizon (lower layer) of 30 inches of Horticultural Subsoil (HS), over a scarified and correctly pitched subgrade.

2.05 WOVEN FILTER FABRIC

A. Filter fabric shall be a woven drainage geotextile, nonbiodegradable.

B. The permeability of the drainage fabric shall be a minimum of 110 gallons minimum per square foot.

C. Filter fabric shall meet the following Minimum Average Roll Value (MARV) specifications across the weave:

1. Weight (Typical): 5.6-ounce per square yard, according to ASTM D5261.
2. Grab Tensile Strength: 370 by 200 pounds, according to ASTM D4632.
3. Grab Elongation: 15 percent maximum, according to ASTM D4632.
4. Trapezoidal Tear Strength: 115 by 75 pounds, according to ASTM D4533.
5. Puncture Resistance: 675 pounds, according to ASTM D4833.
7. Permittivity: 2.1 gpm per square foot, according to ASTM 4491.
8. A.O.S: 40 U.S. Sieve, according to ASTM D4751.
9. Percent Open Area: 10-ounce per square yard, according to ASTM D4751.
10. UV Resistance: 70 percent, 500 hours, according to ASTM D4355.

2.06 SLOPE REINFORCEMENT SYSTEM

A. Refer to Section 31 32 00, Soil Stabilization.
PART 3  EXECUTION

3.01  PREPARATION AND COORDINATION

A. Coordinate activities with other project contractors so that there is no soil disturbance from traffic or other construction activities subsequent to placement.

B. The Contractor shall ensure that the delivery of the planting soil mixes to the On-site Planting Soil Collection Area meets the Project Schedule.

C. Coordination with Weather: Planting Soil Mixes shall not be worked (including hauled, handled, placed, compacted, or tracked over) when soil is wet or frozen. Refer to Article Definitions herein for definitions of moist, wet, and frozen soil.

   1. Contractor shall take precautions to limit schedule interruptions caused by rain or freezing temperatures by tarping on-site soil stockpiles if rain is anticipated. The Landscape Architect shall be consulted to determine if the soil is too wet to work.

3.02  ON-SITE SOIL STOCKPILES WITHIN PROJECT AREAS

A. Stockpile areas within the project area are extremely limited. The Contractor shall carefully coordinate and time planting soil mix installation, obtaining and installing soil only after preparations for placement of planting soil have been completed and accepted.

   1. Coordinate activities with other Project contractors so that there is no soil disturbance from traffic or other construction activities subsequent to placement.
   2. Coordinate deliveries and installation to limit the amount of soil stockpiled stored within the project area at any one time.

B. Provide large, clear signage at each stockpile indicating the contents of each pile, for example; “Sand” or “Base Loam A” or “Tree Soil TS1.”

C. Do not locate stockpiles adjacent to unfinished work where soils can become contaminated.

D. Maximum height of stockpiles shall be 6 feet.
E. Protection: Construct storage piles to allow free drainage of surface water and provide adequate drainage around soil stockpiles. Slope top of pile a minimum of 3 percent.

1. Cover storage piles if required to prevent windblown dust and protect against erosion.
2. Protect stockpiles from contamination of any sort.
3. Prohibit vehicles and pedestrian traffic on or around stockpiled soil materials.
   a. Only low ground pressure vehicles are permitted to drive on stockpiles. psi shall be below four.

3.03 EXAMINATION, VERIFICATION AND ACCEPTANCE

A. The Contractor shall examine previous work, related work, and conditions under which this work is to be performed and shall notify the Landscape Architect in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means Contractor accepts substrates, previous work, and conditions.

B. Upon receipt of delivery of planting soil mixes, the Contractor shall visually inspect the soil for moisture content, non-aggregated soil particles, clumping, debris, deleterious or foreign materials, or any other physical conditions that could affect the quality of the planting soil and the Contractor’s installation operations.

1. The Contractor shall immediately notify the Landscape Architect of any soil deliveries that exhibit any of the physical conditions noted above.
2. The Contractor shall not accept or use soil that exhibits any of the physical conditions noted above.

C. The Contractor shall be responsible for verification that all of the planting areas receiving planting soil mixes have been prepared in conformance with the Contract Documents.

1. Verify that underdrainage system has been installed and accepted.
2. Verify that the aeration system has been installed and accepted.
3. Verify that utilities have been installed and accepted.
4. Verify that slope stabilization system has been installed and accepted.
5. Verify that irrigation mainlines have been installed.
6. Verify that there is a sufficient means for on-site watering of installed plants.
D. Examination of Subgrade:

1. The subgrade shall be examined by the Contractor prior to the start of soil placement and planting for conformance with Drawings for elevations of subgrade relative to finish grade. Deficiencies include, but not be limited to, the following:
   a. Construction debris present within the area to received planting soil mix.
   b. Puddling of water, muddy soil conditions, or expressing of water from the subgrade or adjacent areas.
   c. The subgrade is not at the correct depths for installing the designated planting soil mix.
   d. The subgrade is at incorrect depths for installing the designed soil profile.
   e. Incomplete utility, irrigation and/or subsurface drainage (landscape underdrainage) installation.
   f. Subgrade not compacted as specified. Refer to Section 31 23 23, Fill and Backfill.

E. Submit all noted deficiencies that will impact the proper installation or execution of the Work to the Landscape Architect in writing prior to beginning soil installation operations. The Contractor assumes responsibility for all subgrade work and conditions upon beginning soil installation operations.

3.04 PREPARATION OF SUBGRADE

A. The subgrade will be scarified (roughened) to a depth of 4 inches to create an uneven, broken surface in which the subgrade can be mixed with the first lift of planting soil placed. Scarification can be accomplished manually or using rototillers or equivalent machinery that does not result in the formation of subsoil pans or slickened faces.

B. Perform infiltration and density tests on subsoil as described in Part 1 of this Section.

1. Infiltration Rate for Subgrade, Minimum: 0.25 inch per hour.
2. Compaction Rate for Subgrade, Nuclear Density Method: Refer to Section 31 23 23, Fill and Backfill.
3. Compaction Rate for Subgrade, Static Cone Penetrometer Method:
   a. 0 inch to 6 inch Depth: Range 120 pounds to 125 pounds per square inch (psi).
   b. 6 inch to 12 inch Depth: Range 100 psi to 200 psi.
C. Application of Subgrade Amendment Mix: Broadcast subgrade amendment mix directly to the subgrade for all areas to be planted except lawns.

1. Coordinate application of amendment with installation of horticultural subsoil. Blend material into the subgrade concurrently with installation of horticultural subsoil.
2. Application rate shall be 200 pounds per acre of coarse grade humates (80 percent of mixture) and 50 pounds per acre of soft-rock phosphate (20 percent of mixture).

3.05 SOIL PLACEMENT, GENERAL

A. Notify the Landscape Architect of soil placement operations at least 7 calendar days prior to the beginning of work or a new phase of work.

1. Delineate the limits of soil extents for review and approval by the Landscape Architect.

B. Soil types shall be installed by order of their place within the soil profiles, as shown on Drawings.

C. Plan work to limit traffic on and compaction of soil during and after installation.

1. Prevention of compacted soils can be accomplished by beginning the work in the center of planting area locations, against walls, or the center of isolated beds, and progressing outwards towards the borders.
2. If traffic is necessary, use tracked equipment that exerts less than 5 psi pressure and limit traffic to defined pathways.
3. Traffic on or installation of wet or frozen soils is expressly prohibited.

D. Coordinate soil mix placement activities with the requirements of Section 32 93 00, Planting and Fine Grading. Placement of horticultural subsoil and plant stock shall be carried out simultaneously in order to limit soil compaction.

1. The A soil horizons (e.g. A1) shall not be installed before all woody plants are installed and accepted by the Landscape Architect.
2. The Contractor shall not remove tree location stakes until trees and/or shrubs have been placed on site for review by the Landscape Architect.
ZINK DAM IMPROVEMENTS

E. Soil Moisture: Placement of planting soil mixes will not occur when soil moisture content is greater than 10 percent by weight and 12 percent volumetric water content.

1. Verify that the surface moisture content is suitable for placement operations. Under no circumstances shall the Contractor place planting soil mixes on subgrade when equipment ruts are present or conditions are favorable for rutting of the subgrade. Do not place or install any planting soil mix during precipitation events, or when the subgrade is in a frozen condition.

F. Placement of soil by back blading is not acceptable.

3.06 PLACEMENT OF HORTICULTURAL SUBSOIL AND PLANTING SOILS

A. In addition to the requirements of Section 01 73 40, Execution Requirements, stake the limits of soil extents for approval by the Landscape Architect.

B. Placement of horticultural subsoil and plant stock shall be carried out simultaneously to prevent excessive traffic over soil lifts and the final grade so as to prevent compaction of planting soil. The Contractor shall install plants simultaneously with the installation of the horticultural subsoil. The A Horizon (upper layer) planting soils shall not be installed before all plants are installed and before the acceptance by the Landscape Architect.

C. The soil shall be placed in lifts not to exceed 8 inches in thickness and only moderately hand-tamped not to exceed between 84 percent and 87 percent Standard Proctor with the following exception:

1. Rake each lift smooth to break or remove clods, and fill low spots or voids.
2. Soil shall be scarified between lifts to prevent slickened faces occurring between soil lifts and profiles.
3. Rootball Pedestals: In those cases where the final soil profile depth exceeds the height of the plant rootball, the entire horticultural subsoil depth beneath the rootball shall be compacted to between 88 percent and 92 percent Standard Proctor to create a firm pedestal and prevent settlement of the rootball.
4. Compaction:
   a. All Soil Profiles:
      1) Compact each lift to between 84 percent and 87 percent Standard Proctor, measured by the nuclear density method. Contractor shall anticipate that soil placement alone, or moderate hand-tamping, will be sufficient to meet this value. Care shall be taken to not over compact soil.
cases, the moisture of the planting soil being placed shall not occur when soil moisture content is greater than 12 percent volumetric water content. Optimum moisture content for compaction shall not exceed 0.15 g/g as measured by the nuclear density method.

a) Compaction rate for completed soil profile, static cone penetrometer method:
   (1) 0 inch to 6 inch Depth: Range 60 psi to 100 psi.
   (2) 6 inch to 12 inch Depth: Range 80 psi to 120 psi.

b. After installation, perform in-situ soil density and double-ring infiltrometer tests in conformance with Part 1 of this Specification. Remediate any areas that exceed the specified compaction rate or that fail to drain within the specified rate. Remediation shall include de-compaction, aeration, or full replacement of the affected soil areas.
   1) Infiltration rate for Soil Profiles, Minimum: 0.5 inch per hour.

c. After compaction and testing, scarify each lift and/or soil horizon to prevent the formation of slickened faces. Depth of scarification shall be 2 inches.
   1) Do not scarify final lift of soil profile. At structural soil profile, install woven filter fabric as indicated on Drawings.

5. Prevention of over-compacted soils can be accomplished by beginning the Work in the center of planting area locations, against walls, or the center of isolated beds, and progressing outwards towards the borders.

3.07 PROTECTION AND REPAIRS

A. The Contractor shall take every precaution to ensure the integrity of the underdrainage, aeration and irrigation systems during and after soil placement. Any damage caused by the Landscape Contractor shall be repaired at no additional expense to the Owner.

B. The Contractor shall be responsible to ensure that no soil disturbance will occur from construction traffic or other construction activities after placement of planting soil mixes is complete. Disturbance shall be repaired by the Contractor at no additional expense to the Owner.

1. The Contractor shall place barricades to prevent compaction of planting soil mixes from vehicles, equipment, or pedestrian traffic.
2. Coordinate activities with other project contractors so that there is no soil disturbance from traffic or other construction activities subsequent to placement.
C. Protect newly graded areas from traffic and erosion. Keep free of trash, debris or construction materials from other work.

D. Repair and re-establish grades where completed or partially competed surfaces become eroded, rutted or compacted. Scarify, or, if directed by the Landscape Architect, remove and replace soil to a depth as directed by the Landscape Architect. Reshape and recompact at optimum moisture content to the required density.

E. Where settling occurs, before Final Acceptance or during the warranty period, remove finish surfacing, backfill with additional approved material, compact to specified rates, and restore any disturbed areas to a condition acceptable to the Landscape Architect.

3.08 EXCESS MATERIALS

A. Excess Planting Soil Mixes: Remove the excess planting soil mixture and materials from the project area at no additional cost to the Owner.

END OF SECTION
SECTION 32 92 01
PRAIRIES, MEADOWS, AND WETLANDS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. All of the Contract Documents, including General and Supplementary Conditions, and Division 01, General Requirements, apply to the work of this Section and are hereby made a part of this Section.

B. Examine all Drawings and other Sections of the Specifications for requirements therein affecting the work of this trade.

1.02 WORK OF THIS SECTION

A. The Work of this section includes, but is not limited to:

1. Review of conditions and materials affecting planting.
2. Seeding meadow mix.
4. Establishment of meadow.
5. Management of meadow.
6. Coordination with other trades.
7. Testing.
8. Clean-up.
9. Restoring all planted areas within the limit of work or adjacent to the work area that are disturbed by the work of the Contract.

1.03 RELATED SECTIONS

A. Other Specification Sections which directly relate to the work of this Section include, but are not limited to, the following:

1. The following items of related work are specified and included in other Sections of the Specifications:
   a. Section 01 50 00, Temporary Facilities and Controls.
   b. Section 32 84 00, Landscape Irrigation.
   c. Section 32 91 13.19, Planting Soil System Procurement.
   d. Section 32 91 19.13, Planting Soil System Installation.
   e. Section 32 93 00, Planting and Fine Grading.
1.04 DEFINITIONS

A. Establishment Period: The time frame to complete a specific Planting Window (from start date to acceptance of final milestone activity), which if successful shall be Final Acceptance. The establishment period includes management activities including but not limited to watering, weeding, replanting, etc.

B. Planting Window: Range of time in which Milestone Activities occur, order of which is noted in Part 3 in this section.

C. Final Acceptance: The time at which all Milestone Activities for a particular establishment train have been performed and accepted by the Landscape Architect including any work noted on the “Punch List.” Warranty periods do not begin until Final Acceptance.

D. Management Period: Time frame that begins after the establishment period ends (as marked by Final Acceptance) within which the Contractor shall be required to complete management activities to ensure health of all plantings.

E. Milestone Activity: Critical step listed in the planting window that requires acceptance by the Landscape Architect prior to continuing to the next step.

F. Planting Window: Range of time and specific sequence of planting and maintenance activities.

G. Plug: A seedling raised in a manufactured soil mix in individual cells ready for transplanting.

H. Pure Live Seed (PLS): PLS is a means of expressing seed quality. PLS is the percentage of seed (i.e. good viable seed) that has the potential to germinate within a measured 1 pound weight of any seed lot, expressed in pounds per acre as the basis for the calculation of seeding rates.

1.05 SUBMITTALS

A. Product and Installation Data: Provide for each element of construction listed.

1. Meadow Mix Seed:
   a. Indicate certification of mix proportions, Pure Live Seed percentages, installation methods (including equipment), installation schedule, and viability date.
   b. Installation methods (including equipment) and schedule.

2. Plugs: Provide photographs of the plugs at the source: overall pictures of plug trays, close up of four trays, and close up photographs of plugs pulled out of the trays and showing root condition.
3. Soil Tests to analyze poor performing meadow before Final Acceptance. Refer to Article Testing and Article Milestone and Final Acceptances of this Section. For soil tests required for soil manufacturing and installation of soil, refer to Section 32 91 13.19, Planting Soil System Procurement, and Section 32 91 19.13, Planting Soil System Installation.


B. Samples: Provide for each element of construction listed.
   1. Meadow Mix Seed: Two pint bags of seed mix with seed mix label.
   2. Sand: Two pint bags of sand to be used for mixing with seed mix for overseeding.

C. Seed Certification: Provide certification showing seed mix species and source. Certification shall clearly indicate deviations from the specified seed mix and any proposed substitutions.

D. Plug Certifications:
   1. Plugs: Documentation of source and species identification.

E. Installer Qualifications:
   1. Submit the following information for a minimum of three projects of a similar size and complexity:
      a. The project name, Client, General Contractor if applicable, dates of construction, cost of the project, contact information for the Owner/Client, the Architect/Landscape Architect, and the General Contractor if applicable.

F. Installer Certificates: In addition to requirements of Section 01 33 00, Submittals Procedures, provide information requested in this section.

1.06 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Seed Installer: In addition to the requirements of Section 01 45 16.13, Contractor Quality Control, a qualified landscape installer whose work has resulted in successful establishment of native grass meadows from seed on at least three projects of similar size and complexity.
   2. Minimum experience for Foreman and Installer shall be 5 years.
B. Supplier Qualifications: Minimum 10 years providing material to be used under this scope of work.

C. Pre-installation Conference: A pre-installation conference with the Installer, Owner, Landscape Architect and Owner’s Representative is required for the work of this Section. Schedule pre-installation conference within 60 days of contract award or 30 days prior to the start of the work of this section, whichever is sooner.

D. Inspection:

1. The Landscape Architect shall have the right to reject any seed supplier if he/she determines, before, during or after inspecting or receipt of seed, any of the following:
   a. The seed and/or plug does not meet the quality standards set forth herein.
   b. The seed and/or plug supplier cannot supply the specified seed and/or plug or an acceptable substitute.
   c. The seed and/or plug supplier’s cultural practices or management procedures do not meet specified standards.

E. The Landscape Architect has endeavored to locate sources for the seed and plugs indicated. However, the Landscape Architect makes no claim that the materials will be available at the sources researched. The Contractor shall submit to the Landscape Architect any questions regarding the source of seed or plugs.

1. Acceptable suppliers, or approved equivalent, include:
   a. GRASSLANDER
      Rt 1, Box 56
      Hennessey, OK 73742
      Telephone: (405) 853-2607
   b. Johnston Seed Company
      319 West Chestnut
      Enid, OK 73701
      Telephone: (800) 375-4613
   c. Kaw River Restoration Nurseries
      1269 N. 222nd
      Baldwin City, KS 66006
      Telephone: (785) 594-2245
   d. Douglas W. King Company
      4627 Emil Road
      San Antonio, TX 78219
      Telephone: (210) 661-4191
1.07 DELIVERY, STORAGE AND HANDLING

A. In addition to the requirements of Section 01 61 00, Common Product Requirements, provide the following:

1. General:
   a. Deliver materials only after preparation for on-site seeding have been completed and accepted, including but not limited to: irrigation, rough grading, utilities, and planting soil placement.
   b. Prohibit vehicular and pedestrian traffic on or around areas to be seeded or plugged.

2. Seed:
   a. Seed shall be stored at temperatures between 40 degrees F and 60 degrees F and with a relative humidity of between 25 percent to 60 percent.
   b. Store seed in sealed bags in a dry location on raised palettes.
   c. Seed that has become wet or moldy shall not be accepted.
   d. Transport: Temperature shall not exceed 105 degrees F at any time. If transit from cold storage to sowing is greater than 10 days, seed must be kept under storage temperatures and relative humidity described above.
3. Store plugs in original containers and protect from cold and heat. Do not allow plugs to dry out.

1.08 PROJECT CONDITIONS

A. Limits of Work: The limits of work for prairies, meadows and wetlands or as shown on Drawings. All areas beyond the limits of work that are disturbed shall be restored to the satisfaction of the Owner and Landscape Architect.

B. Lines and Grades:

1. The Contractor shall verify that the subgrade and finish grade lines and grade are consistent with the Drawings and acceptable to the Landscape Architect. The Contractor shall make adjustments as necessary to establish finish grades.

2. Grades: If present, protect and maintain grade stakes and location stakes until removal is acceptable to Landscape Architect and all parties involved in this project. If grade stakes are not present, establish grade stakes to ensure that grades shown on Drawings are being met.

C. Utilities: Determine and mark the location of below grade utilities before project staking. The Contractor shall field locate all utilities before starting work. Hand excavate as necessary to avoid damage. Repair all damage and restore items to their original condition as approved by the Landscape Architect and authorities having jurisdiction at no change in Contract Amount.

D. Concealed Conditions: Notify Construction Manager before planting when below grade conditions detrimental to proper plant growth are encountered.

E. If planting, soil, irrigation and hardscape work is underway during seeding, the contractor shall coordinate his/ her work with other Trades. The Contractor shall take care to avoid damaging any adjacent work or work beyond the limit of work. Should damage occur, the Contractor shall repair elements to the Landscape Architect’s satisfaction.

F. Sequence of Planting: Sequence installation so that trees and shrubs that are within seeded and or plugged areas are installed before prairies, meadows and wetland planting, unless otherwise approved by the Landscape Architect. Restore damaged prairies, meadows and wetlands if tree and shrub planting is delayed. Complete planting work as quickly as possible on portions of the site as they become available for planting.

G. Coordinate installation of seeded or plugged areas with installation of planting soils.
H. Verify that irrigation work is installed and available for watering at time of installation. Do not proceed with work until irrigation is available.

1. In the absence of the permanent irrigation system, verify that potable water is available. Provide all hoses and equipment to distribute water to area of landscape work and areas needing watering. See Division 01, General Requirements, for availability of water for irrigation. Provide water tank trucks if water service is interrupted. Prior to providing water tank trucks, submit to the Landscape Architect for approval. If water service is discontinued, for any reason, before Final Acceptance, provide water as needed to maintain seeded areas in healthy condition.

1.09 TESTING

A. General:

1. Soil testing is required at areas exhibiting unsatisfactory growth of seed for diagnostic purposes. Contractor shall be responsible for the costs of testing including sampling, testing, and retrieval and distribution of test results. Adhere to Landscape Architects recommended amendment(s) for unsatisfactory areas.
2. Landscape Architect shall determine which locations require soil testing.
3. Record-keeping Log for Testing: Maintain clear, concise records for all testing and sampling procedures. Log actives and results in the record-keeping log.
4. For soil testing procedures, refer to Section 32 91 13.19, Planting Soil System Procurement, and Section 32 91 19.13, Planting Soil System Installation.

1.10 PLANTING WINDOW

A. Refer to Article Planting Windows in Part 3 of this section.

1.11 MILESTONE AND FINAL ACCEPTANCES

A. General:

1. Two types of acceptance are required for the meadow:
   a. Milestone Acceptance occurs as part of Article Planting Windows described in Part 3 of this Section.
   b. Final Acceptance occurs after all Milestone Acceptances have been approved by the Landscape Architect and the meadow is established.
   c. Partial acceptance will not be granted.
B. Acceptance Criteria: Acceptance criteria for the work of this Section are defined below. The Contractor shall over-seed unacceptable areas until acceptance criteria are satisfied and Final Acceptance is provided by the Landscape Architect.

1. Acceptance Criteria for Seeded and Plugged Meadow Mix:
   a. Create an acceptable stand of meadow, which is defined to mean a uniform coverage with well established, close stands of plants that meeting the following criteria:
      1) Minimum of 12 to 24 thriving grass plants per square foot.
      2) No bare or dead spots over 8-inch maximum in any dimension.
      3) No more than one bare spot for each square yard of planting.
      4) Free from weeds, disease, and detrimental insect infestation.
      5) Roots extending 6 inches into new root zone layer.

2. Management during Establishment Period: Begin management practices immediately after start of planting window. Length of time necessary for establishment shall not be limited. At Final Acceptance, the establishment period is concluded and the management period begins.

C. Prairie, Meadow and Wetland Maintenance During Establishment: Begin maintenance practices immediately after planting – and start of planting window. Length of time necessary for establishment shall not be limited.

1. Provide complete, organic maintenance and service as required to promote and maintain healthy growth including, without limitation, watering, and per the Landscape Architect’s specifications, weeding, invasive species removal, fallen leaf removal, treating for insects and disease, resetting plugs and other operations and maintenance work.

2. Hand-pull weeds on a weekly basis. Inform Landscape Architect of noxious weeds to determine method of eradication. Refer to Article Management Procedures and Activities, Paragraph High Priority Weed Control of this section for a partial list of high priority common weeds and additional requirements.

3. Application of insecticides and herbicides is expressly prohibited. Confer with Landscape Architect for organic methods of controlling insect infestation or disease.

D. Request for Milestone Activity Acceptance: Make the request for Milestone Acceptance in writing at least 5 days in advance of preferred inspection date. Do not request inspection for acceptance until installation work for the activity is 100 percent complete and in compliance with the Contract requirements.
E. Request for Final Acceptance: Make the request for Final Acceptance in writing at least 10 days in advance of preferred inspection date. Do not request inspection for acceptance until installation work for the activity is 100 percent complete and in compliance with the Contract requirements.

1.12 WARRANTY

A. Provide written warranty agreeing to remove and replace work that exhibits defects in materials or workmanship for the specified periods. “Defects” is defined to include, but is not limited to, death, unsatisfactory growth, failure to adequately root into soil, disease, abnormal foliage density, abnormal size, abnormal color, failure to thrive, and other unsatisfactory characteristics.

B. Meadow Replacement: Replace defective meadow with new seeding that will provide plants of same type, species, character, and quality of originally accepted work. If a replacement is unacceptable during its one year warranty, the Contractor shall provide another replacement or, when approved by the Owner, equivalent cash payment.

1. Perform soil tests for soil biology, compaction, and infiltration to determine the reason for failure and correct any defects before replacing meadow. Refer to Section 32 91 13.19, Planting Soil System Procurement, and Section 32 91 19.13, Planting Soil System Installation, for soil testing. Provide as many tests as needed to determine cause for failure and evaluation of remediation measures taken.

2. Replacement Planting Seasons: Planting for replacement and warranty work for meadows shall comply with the planting windows specified herein.

C. Warranty Period for Meadows:

1. If Owner does not elect to hire Contractor for the management period activities, the warranty period shall start at Final Acceptance.

2. If the Owner elects to hire the Contractor for the management period activities, the warranty period shall start at the end of the management period.

3. Warranty period shall be 1 year after Final Acceptance.

4. Owner Responsibility and Warranty Exclusions:

   a. The Contractor’s warranty shall exclude problems due to improper or inadequate management, vandalism, or acts of nature.

      1) During the warranty period, the Contractor shall visit the site at least three times during the growing seasons to review the conditions of the accepted work. The Contractor
shall submit in writing to the Owner regarding the Owner’s management practices and/or any vandalism. The content of this notice shall include a list of specific plants involved, the presumed problem, and a method of remedy for the problem(s) cited. The Owner shall make reasonable efforts to correct the problems cited by the Contractor’s defects in materials or workmanship that resulted in decline or death to plants.

2) Failure of the Contractor to make the required reviews of the site during the warranty period and to submit written notice to the Owner of the management defects shall negate the Contractor’s ability to make a claim against the Owner for negligence of management.

1.13 MANAGEMENT PERIOD

A. As an option to the Owner, the Contractor shall maintain the meadow planting for a period of 1 year following Final Acceptance. Management activities shall be on a bi-weekly basis and are described in Part 3 of this section.

PART 2 PRODUCTS

2.01 PLANTING SOIL

A. Refer to Section 32 91 13.19, Planting Soil System Procurement, for planting soil materials and handling requirements.

B. Coordinate installation of soil mixes and plants to meet requirements of Section 32 91 13.19, Planting Soil System Procurement, and Section 32 91 19.13, Planting Soil System Installation.

2.02 MEADOW MIX SEED

A. General: Provide fresh, new crop seed that is 98 percent pure live seed or better. In no case shall weed seed content exceed 1 percent by weight. All seed shall comply with Federal and State seed laws. Seed shall not be coated with herbicides and/or fungicides.

B. Seed Mix: See Drawings.

1. Cover crop seed is incorporated into the meadow mix seed as noted on Drawings.

C. Seeding Rate: 225 pounds per acre unless otherwise indicated on Drawings or in approved submittals.
D. Species list are shown on Drawings.

E. See planting window for specific times for seeding of meadow.

2.03 PLUGS

A. Plugs: Custom-grown plants that shall be typical of their species or variety and exhibiting normal habit of growth and vigorous root development.

1. Provide plugs in 50-cell packs (1-3/4-inch width by 2-1/4-inch depth) unless otherwise indicated on Drawings. Height of vegetation above basal collar shall be 12 inches at the time of installation, unless written acceptance is provided by the Landscape Architect prior to planting. If plugs are undersized, Contractor shall provide an additional 25 percent of total quantity specified for each species.

2. Plant species to be installed are listed on Drawings.

3. Plants shall be legibly tagged with the proper name.

2.04 HYDROGEL FOR PLUGS

A. Provide hydrogel from a single source:

1. STOCKOSORB 600 for dip, powder form as manufactured by Evonik Corporation, 3606 Highway 44, Garyville, LA 70051.

2.05 SAND FOR TOPDRESSING

A. Provide sand that complies with ASTM C33.

2.06 SOIL AMENDMENTS

A. Soil amendments shall not be used for meadow plantings. Prohibited amendments include Liquide Biological Amendment, granular humates, feather meal, and organic fertilizer or any other amendment no listed herein.

2.07 MISCELLANEOUS MATERIALS

A. Soil and Pavement Protection: The driving of vehicles over planted areas is expressly prohibited.

1. Protect pavements using one of the following:
   a. Plywood: Provide 3/4-inch Grade C or better plywood for use as planking when driving vehicles or moving equipment over areas to be planted.
   b. Oriented Strand Board (OSB): Two layers of 3/4-inch OSB on top of 6-inch mulch. Provide Filter Fabric under mulch layer.
PART 3 EXECUTION

3.01 EXAMINATION

A. Pre-Installation Examination Required:

1. Before beginning any Establishment Train, the Contractor shall examine previous work, related work, and conditions under which this work is to be performed and notify the Landscape Architect in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means Contractor accepts substrates, previous work, and conditions. The Contractor shall not commence work associated with the installation of Meadows until all work in the work areas is complete and accepted by the Landscape Architect. The Contractor shall confirm that:
   a. Planting soil is installed and has been accepted.
   b. Fine grading is accepted and remains free of debris.
   c. Area is free of weeds.
   d. Landscape surface and subdrainage systems are installed and accepted.
   e. Utilities have been installed and accepted.
   f. Permanent and Temporary Irrigation has been installed and accepted.
   g. Verify that irrigation system can be activated. If not, verify that sufficient means for on-site watering of installed seed is available.

3.02 PLANTING SOIL PLACEMENT

A. See Section 32 91 00, Planting Soil, for execution requirements.

3.03 PRAIRIE, MEADOW AND WETLAND SEEDING

A. Prairies, Meadows, and Wetland Seeding:

1. Seeding: Seed only when areas are in a friable condition and neither hard nor muddy, after the planting areas have been prepared and treated, as described herein. Do not seed in windy weather. Uniformly seed areas in two direction at right angles to each other for planting using a hand spreader or other approved method.

2. Verify with the Landscape Architect the extent and distribution of seeding and/or plugs. Stake out areas with wood stakes and survey lines and provide labeled 4-foot high wood stakes that identify seed/plug type for each area.
   a. Do Not proceed with installation until layout and distribution has been accepted by the Landscape Architect.
3. All newly seeded and plugged areas will receive 0.25 inches of water per day for the first 10 days to prevent germinating seeds from drying out. Thereafter, a deep watering to maintain soil moisture to at least 6 inches every week for the next 2 months. This will require a 1-inch irrigation event every week or twice a week under hot dry conditions. For the remainder of the growing season, there should be a minimum watering of 1 inch every 2 weeks.

4. Irrigation should occur during times when water loss from evaporation is lowest, but without potentially creating a disease prone environment. Irrigation should not occur after a sufficient rain event or when otherwise unnecessary. Use watering regimes that prevent erosion.

5. Planting season for seed shall be as indicated herein. The actual planting of seed shall be done; however, only during periods within this season that are normal for such work as determined by weather conditions and by accepted practice in this locality. At their option and on their responsibility the Contractor may plant seed under unseasonable conditions without additional compensation.

6. Only experience workers under the supervision of a qualified foreman shall do seeding. Seeding shall consist of soil preparation, seed drilling, rolling, pegging, weeding, watering and otherwise providing all labor and materials necessary to secure the establishment of acceptable vegetative layer.

7. Seed only when areas are in a friable condition and neither hard, muddy, excessively wet or frozen.

8. Prior to seeding, dampen surface of soil to 1.5 inches with potable water meeting the requirements of water quality listed in this specification.

9. Do not seed when wind velocity exceeds 5 mph.

10. Prior to seeding, seed mix should be mixed with sand.
   a. Ratio of mix (by volume) shall be 10 parts sand to 1 part seed.

11. Hydraulic mulch seeding is not allowed.

12. Adhere to planting installation dates as defined in Part 1 of this Section.

3.04 PRAIRIE, MEADOW, AND WETLAND PLUGS

A. Install meadow seed mix during the timeline established by the establishment trains specified in Article 3.7 of this Section.

B. Contractor shall minimize foot traffic for trimming and the installation of the plugs. Before beginning work, the Contractor shall discuss the method of minimizing disturbance with the Landscape Architect.
C. Planting Plugs: Plantings shall be made according to the location indicated on Drawings, and shall consist of species as indicated on Drawings. Landscape Architect shall review the installation of the plugs.

   1. Dip plug roots into hydrated hydrogel mix. Ensure even coating. Strictly follow manufacturer’s instructions for dipping plug roots.
   2. Install the plug so the stem base is at or slightly above finish grade.
   3. Install plugs to their full depth without bending the plug. Plugs demonstrating “J-Roots” within cell-packs shall not be acceptable.
   4. Backfill planting holes and tamp the soil around each plug in place so that it is firmly seated in the soil, with no air pockets.
   5. Unless otherwise indicated on Drawings, plugs shall be planted 12 inches on center.

3.05 PLANTING WINDOWS

A. General: Planting window for meadow seed shall be as described in this Article of the Specification. The actual planting, however, shall be done only during periods within the season that are normal for such work as determined by weather conditions, moisture content of the soil, and by accepted practice in this locality. Planting windows apply to both top 2-inch horizon of .

B. Prior to seeding verify meadow area is prepared and ready for vegetation installation. Review area with Landscape Architect before beginning work.

   1. Removal all weeds from meadow prior to start of any planting window.
   2. Fine grading has been accepted by Landscape Architect.
   3. Water is available for establishment.

C. Each step listed for each planting window is a Milestone Activity that cannot be started until approval is given by the Landscape Architect. See Article Acceptance Criteria in Part 1 of this Section.

D. During each planting window, the Contractor shall perform management activities as described in other parts of this Section.

   1. Weeds shall not exceed 8 inches in height during the establishment period.
   2. If Meadow Seed mix is installed between February 15 and March 15, the cover crop shall be cut back to 6 inches prior to April 1.

E. Soil to receive seed or plugs shall be weed free at the start of each milestone activity. The Contractor shall remove weeds from the site by one of the pre-approved methods described in this Section.
F. Planting Windows: Contractor shall review planting windows outline below, and based upon completion date of final grading, determine which Planting Window shall be followed. Completion of any one planting window is required. Prior to starting the Planting Window, verify selected Window, and review procedure with Landscape Architect.

1. Planting Window 1:
   a. Milestone 1: Fine Grading is completed between November 1 – February 15.
      1) No Planting allowed.
      2) Evenly spread 2-inch thick profile of compost over entire meadow.
   b. Milestone 2: Till in compost to top 3 inches to 4 inches of gravel soil profile (February 15 – February 28).
   c. Milestone 3: Install Meadow Seed (February 15 – March 15).
   d. Milestone 4: Cut back Cover Crop (March 15 – April 1).
   e. Request Acceptance. See Article Acceptance Criteria in Part 1 of this section.
   f. After receiving acceptance, immediately begin management procedures and activities per Article Management Procedures and Activities outlined in Part 3 of this Section.

2. Planting Window 2:
   a. Milestone 1: Fine Grading is completed between February 15 and October 31.
   b. Milestone 2: Install Meadow Seed (February 15 – July 15).
   c. Milestone 3: Cut back Cover Crop (March 15 – April 1).
      1) If meadow seed is installed after April 1 or the soil temperatures average 65 degrees over a 1 week observation period, cover crop cut back is not necessary.
   d. Request Acceptance. See Article Acceptance Criteria in Part 1 of this section.
   e. After receiving acceptance, immediately begin management procedures and activities per Article Management Procedures and Activities outlined in Part 3 of this section.

3. Planting Window 3:
   a. Milestone 1: Fine Grading is completed between July 15 and August 31.
      1) No Planting allowed.
      2) Evenly spread 2-inch thick profile of compost over entire meadow.
   b. Milestone 2: Till in compost to top 3 inches to 4 inches of gravel soil provide (July 15 – August 31).
   c. Milestone 3: Install Meadow Seed (September 1 – November 1).
d. Request Acceptance. See Article Acceptance Criteria in Part 1 of this section.

e. After receiving acceptance, immediately begin management procedures and activities per Article Management Procedures and Activities outlined in Part 3 of this section.

3.06 MANAGEMENT PROCEDURES AND ACTIVITIES

A. General: At the start of the management procedures and activities, conduct biweekly meadow inspections with the Landscape Architect and Owner (February 15 – November 1) to review the progress of the meadow. Discuss “look-ahead” schedule and determine, what, if any, actions need to be taken.

1. Maintain observations and discussions in a Management Log.

B. Management Log:

1. At each visit to the site, record the following items:
   a. Date and time of visit.
   b. Attendees.
   c. Weather.
   d. Indicate high priority species and planned date for removal.
      1) Landscape Architect and Owner will provide aggressive species list at the start of the Management Period. See Article Management Procedures and Activities, Paragraph High Priority Weed Control of this Section for preliminary high priority weed species list.
   e. List management activities performed and diagrammatically map where each activity occurred and locations of weed species.
   f. Record discussion in the form of action items and list responsible party.
      1) Submit up to date Management Log to the Owner and Landscape Architect on the last day of each month.

C. Erosion Control: For soil left bare prior to seeding, refer to Section 32 91 19.13, Planting Soil System Installation.

D. Watering:

1. General:
   a. The Contractor shall provide all labor and arrange for all watering necessary to establish an acceptable final meadow.
   b. Irrigate as required to promote growth. Maintain proper soil moisture to germinate seeds. Maintain proper soil moisture post emergence.
c. Irrigation shall occur during times when water loss from evaporation is lowest, but without potentially creating a disease prone environment. Irrigation should not occur after a sufficient rain event or when otherwise unnecessary. Use watering regimes that prevent erosion. Monitor soil moisture to ensure that grass seedlings are not overwatered.

d. Watering shall be done in a manner which will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment. The Contractor shall furnish sufficient watering equipment to apply one complete coverage to the seeded areas in an 8-hour period.

e. Meadow Mix: All newly seeded areas shall receive 0.25 inches of water per day for the first 15 days to prevent germinating seeds from drying out. For the next 2 months a deep watering three times per week to maintain soil moisture to at least 6 inches shall be performed.

2. Temporary Irrigation System: This Project anticipates fixed irrigation. Should the project description change, a temporary irrigation system shall include above ground piping and spray heads or misters that can easily be removed after establishment.

   a. Contractor shall design system for complete meadow coverage and certify that the application rate meets the requirements listed as part of this article. Submit design to Landscape Architect for approval.

E. General Weed Control:

1. General:
   a. For weeding techniques (cutting, trimming, pulling) see Appendix A.
   b. Cut or trim weeds to the height in accordance with the Management Year as described in Part 3.
      1) Weeds shall never exceed 12 inches in height during the management period.
   c. Weed species shall never be allowed to set seed.
      1) Should a weed set seed, place a plastic bag over the weed and cut the weed at its base. Turn over the bag with the weed inside. Dispose of the bag and weed. Review procedure with Landscape Architect at the start of maintenance operations.
   d. After cutting or trimming, remove all cut down plants from the site. Do not compost the waste plant material.
e. Do not trim when plants are wet. This makes debris removal more difficult.

f. Overseeding of the meadow can occur between February 15 – October 31. Top-dress may include the whole meadow or patches. This work will be required as indicated by the acceptance criteria outlined in Article Milestone and Final Acceptances, Paragraph Acceptance Criteria in Part 1 of this Section.

F. High Priority Weed Control:

1. Selectively cut or trim aggressive weed plants from the meadow on a bi-weekly basis. The following weeds are aggressive species; however, the final list shall be finalized by the Landscape Architect and provided to the Contractor at the start of the Management Period:
   b. *Artemisia vulgaris*, Mugwort.
   e. *Cyperus esculentus*, Yellow Nutsedge.
   f. *Daucus carota*, Queen Anne’s Lace.
   g. *Fallopia japonica*, Japanese Knotweed.
   h. *Lythrum salicaria*, Purple Loosestrife.
   i. *Melilotus sp.*, Sweet Clover sp.
   k. *Phalaris arundinacea*, Reed Canary Grass.
   m. *Solanum carolinense*, Horsenettle.
   n. *Vitis sp.*, Wild Grape.

G. Use of Herbicides: No herbicide of any kind can be used on this Project.

H. Repair of Meadows:

1. If meadow is damaged, remove damaged materials if necessary. Reestablish meadow (and soil horizons) as originally installed following the establishment train time frames. Request Landscape Architect approval prior to beginning repairs.

2. If meadow exhibits unsatisfactory growth, perform soil testing for chemical properties, compaction and infiltration rates. Adhere to Landscape Architect’s recommended remediation. Remediation may include soil additives or Topdressing.
I. Topdressing:

1. Topdressing shall be performed at the request of the Landscape Architect. Topdressing shall be required if meadow establishment/performance is poor, dead spots are apparent, or other unsuitable conditions are present.
2. Topdressing shall be performed March 1 – May 1 and September 1 – October 15. Work outside this window is not permitted.
3. Cut or trim vegetation to maximum of 4 inches prior to topdressing. Remove cut vegetation from the meadow.
4. Irrigate meadow just prior to Topdressing so that moisture reaches to at least 6 inches below grade.
5. Apply sand/seed mixture to a depth of 1/4-inch across the area to be treated.
   a. Sand shall comply with ASTM C33 for mechanical gradation. Sand shall be wet at the time of mixing and during application. Mist dry sand with hose as necessary prior to mixing.
   b. Seed shall be the approved meadow seed mix.
      1) Ratio of mix (by volume) shall be 10 parts sand to 1 part seed.

J. Management Period (1 Year):

1. At no more than 12 inches, all weeds are to be cut back or pulled (species dependent).
2. Contractor shall be responsible for at least four weedings (June, July, August, and September). Rate of growth shall dictate number of cuttings.
3. End of Season Cutting: Cut back all meadow growth for the season to 4-inch to 6-inch between November 30 – December 15.
4. Overseed meadow following end of season cutting using the specified, submitted and approved seed mix(es).

3.07 CLEANUP, PROTECTION AND EXCESS MATERIALS

A. Store materials and equipment remaining on site in locations which do not interfere with construction operations or management activities.

B. The Contractor shall be responsible for keeping all paving surfaces clean during placement of seeding, sodding and plugging operations. Remove equipment from the site promptly when no longer in use.

C. Provide temporary protection to ensure work is without damage or deterioration after installation.
D. Protection of Drainage System: Protect existing drainage protection system at all drain inlets to prevent silt, materials or debris caused by planting operations from entering the drainage system.

END OF SECTION
PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. All of the Contract Documents, including General and Supplementary Conditions, and Division 01, General Requirements, apply to the work of this Section and are hereby made a part of this Section.

B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the work of this trade.

1.02 WORK OF THIS SECTION

A. The work of this Section includes, but is not limited to:

1. Woody plants, balled, and burlapped and containerized.
2. Herbaceous plants, pots and plugs.
3. Liquid biological amendments.
4. Plant anchoring systems.
5. Post-installation maintenance.
6. Coordination with other trades.
7. Warranty and maintenance.
8. Temporary erosion control.
10. Clean up.

B. Extent of Landscaping Work: In addition to the work indicated, Landscape work includes restoring all areas within the limit of work disturbed by work of the Contract and coordination of work with other subcontractors.

1.03 RELATED SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 01 33 00, Submittal Procedures.
2. Section 01 50 00, Temporary Facilities and Controls.
3. Section 31 23 16, Excavation.
4. Section 31 23 23, Fill and Backfill.
5. Section 31 32 19.16, Geotextile.
6. Section 31 37 00, Riprap.
ZINK DAM IMPROVEMENTS

7. **Section 32 15 00, Granular Paving.**
8. **Section 32 84 00, Landscape Irrigation.**
9. **Section 32 91 13.19, Planting Soil System Procurement.**
10. **Section 32 91 19.13. Planting Soil System Installation.**
11. **Section 32 92 01, Prairies, Meadows, and Wetlands.**

1.04 REFERENCES


B. Standardized Plant Names, American Joint Committee on Horticultural Nomenclature, latest edition.

1.05 APPLICABLE STANDARDS

A. The references listed herein shall be the standards used for the Work, unless noted otherwise:

1. All standards shall include the latest additions and amendments as of the date of advertisement for bids.


1.06 DEFINITIONS

A. Balled and Burlapped Stock (B&B): Exterior plants dug with firm, natural balls of earth in which they are grown; wrapped, tied, rigidly supported, drum-laced and sized as recommended by ANSI Z60.1.

B. Containerized or Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold rootball shape and protect root mass during shipping and shall be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.

C. Final Acceptance: Date at which all Work, including work identified in the "Punch List," is completed and accepted by the Landscape Architect. Warranty periods do not begin until Final Acceptance.
D. Finish Grade: Elevation of finished fine graded surface of planting soil.

E. Girdling Root: A root that has become wrapped around the trunk of the plant that over time will inhibit the uptake of nutrients and produce structural failure, eventually leading to death of the plant.

F. Long Term Storage (of Plants): Equal to a period of 3 weeks or more after digging of the plants at the nursery, or a period of 1 week or more after receipt of plants at the Project Site.

G. Planting Soil for Soil Profiles: Soil produced on-site or off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil. See Section 32 91 19.13, Planting Soil System Installation.

H. Plugs: A seedling raised in a manufactured soil mix in individual cells ready for transplanting.

I. Root Flare: Also referred to as trunk flare, root crown, or root collar. The transition zone between the main stem and the root system, visible as the outwardly curving base of a tree where it joins the roots, often distinguishable as individual root buttresses.

J. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

K. Tagging/Tagged/Tag: The Landscape Architect’s selection of plant material at the nursery. An individually numbered seal is placed on the north-facing branches of a tagged plant.

1.07 ACTION SUBMITTALS

A. Product Data: Provide for each element of construction listed.
   1. Plant anchoring systems.
   2. Natural burlap.

B. Samples: Provide for each element of construction listed.
   1. Tree stakes.
   2. Arbor ties.
   3. Plant anchoring system, all components.
C. Installer Qualifications: In addition to requirements of Section 01 33 00, Submittal Procedures, provide qualifications for the Project Manager and Foreman/Site Supervisor showing years of experience, and a minimum of three project references. For each reference list client, design or engineering professional hired by the client, type, cost and duration of project and role of personnel.

D. Planting Schedule: Indicating anticipated planting dates for performing all Work within this Section, coordinated with the Project. Coordinate and incorporate work in Section 32 91 19.13, Planting Soil System Installation, and Section 32 84 00, Landscape Irrigation.

E. Plant Species and Source List: The Contractor shall submit for approval plant species and source list indicating the plant botanical and common name, size, quantity, form, rootball, identification of fall dig hazards, limb height (if applicable), nursery source, including contact information, and Landscape Architect’s seal number.

1. Plant list shall clearly indicate deviations from the specified plant list and any proposed substitutions.
2. Contractor shall confirm nursery source prior to scheduling tagging trip.
3. As the project progresses and plants are located and sealed, revise and resubmit the plant list submittal.

F. Photographs of Plants taken at the Nursery Source: Provide representative images of plants prior to scheduling tagging trips and as the basis for the Landscape Architect to select plants.

1. Contractor shall label each photograph with the plant species botanical name, nursery name, and date of photograph.
2. Photographs shall include images showing the full range of characteristics of each plant, including detailed photographs of the bark, the base of the tree (rootball crown), leaves if present, branching structure, form, and habit.
3. Images shall include a scale figure or measuring device to indicate true size.
4. Photographs may be transmitted electronically but the title of electronic files must bear the plant name, nursery, and date.
5. For container plants, also provide close up photographs of the rootball with the container removed.
   a. Quantity: 10 percent of the total number specified.
1.08 INFORMATIONAL SUBMITTALS

A. Periodic Construction Images:

1. In addition to the requirements in Section 01 32 00, Construction Progress Documentation, provide the following images:
   a. Rootball immediately prior to backfill.
      1) Frequency: During planting operations, provide images of a half-dozen trees two times a week during planting activities.

B. Plant Species and Source List: As the project progresses and plants are located and sealed, revise and re-submit the plant source list submittal. The Contractor shall maintain an up-to-date plant species and source list indicating the plant botanical and common name, size, quantity, form, rootball, identification of fall dig hazards, limb height (if applicable), nursery source, including contact information, and Landscape Architect’s seal number.

C. Planting Schedule Updates: As the project progresses, resubmit approved planting schedule updated to indicate anticipated planting dates for performing all Work within this Section, coordinated with the Project. Coordinate and incorporate work in Section 32 91 19.13, Planting Soil System Installation, and Section 32 84 00, Landscape Irrigation.

1.09 QUALITY ASSURANCE

A. Pre-installation Conference: A pre-installation conference with the Landscape Architect is required for the work of this Section.

B. Installer Qualifications:

1. In addition to the requirements of Section 01 40 00, Quality Requirements, provide the following:
   a. The Contractor shall have been in business a minimum of 2 years.
   b. The Contractor’s record of successful in-service performance shall include the installation of manufactured planting soils similar to the specification in Section 32 91 19.13, Planting Soil System Installation.
   c. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress. Field Supervisor shall have a minimum of 5 years’ experience.
C. Labeling: Label at least one specimen of each variety and size with a securely attached, waterproof tag bearing legible designation of botanical and common name in compliance with the recommendations of the American Nursery & Landscape Association.

D. Tree and Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

E. Pruning: Unless otherwise noted, pruning of plants before, during or after installation shall be prohibited except to remove dead or broken branches and limbs. Confer with the Landscape Architect before any pruning.

1. Pruning plants after the Landscape Architect’s selection and prior to delivery to the site shall be cause for rejection.

1.10 PROJECT CONDITIONS AND COORDINATION

A. Utilities: The Contractor shall locate and verify all existing and new underground utilities including subdrainage, before project staking and planting. Report any conflicts to Construction Manager. Hand excavate as necessary to avoid damage to unground utilities.

B. Concealed Conditions: Notify Landscape Architect before planting when below grade conditions detrimental to proper plant growth are encountered. Do not proceed with planting without specific written instructions from the Landscape Architect.

C. Sequence of Planting: Plant trees and shrubs after finish grades are established and before planting prairies or meadows, unless otherwise approved by the Landscape Architect. Complete landscaping work as quickly as possible on portions of the site as they become available for landscaping.

1. If the Contractor is permitted by the Landscape Architect to plant trees and shrubs after prairies meadows, protect these areas and promptly repair damage caused by planting operations.
D. Planting Seasons and Weather Restrictions:

1. Work only within seasonal limitations for proper planting noted below. The Contractor shall, however, take into consideration seasonal weather conditions that would affect the planting period and shall not proceed if planting in these conditions would affect the short and/or long term health of the plants:

<table>
<thead>
<tr>
<th>Item</th>
<th>Spring Season</th>
<th>Fall / Winter Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous (Container)</td>
<td>2/15 to 15</td>
<td>10/1 to 2/15</td>
</tr>
<tr>
<td>Deciduous (Balled and Burlapped)</td>
<td>2/15 to 15</td>
<td>10/1 to 2/15</td>
</tr>
<tr>
<td>Deciduous (Bare Root)</td>
<td>2/15 to 15</td>
<td>N/A</td>
</tr>
<tr>
<td>Broad Leaf Evergreens</td>
<td>2/15 to 15</td>
<td>N/A</td>
</tr>
<tr>
<td>Evergreens</td>
<td>2/15 to 15</td>
<td>10/1 to 2/15</td>
</tr>
<tr>
<td>Groundcover</td>
<td>3/1 to 5/30</td>
<td>10/1 to 10/31</td>
</tr>
<tr>
<td>Perennials</td>
<td>3/1 to 5/30</td>
<td>10/1 to 10/31</td>
</tr>
<tr>
<td>Bulbs</td>
<td>N/A</td>
<td>10/1 to 12/1</td>
</tr>
</tbody>
</table>

2. Regardless of the specified planting season dates, suspend work when the temperature is below 25 degrees F, the wind velocity is over 25 mph, the ground or planting soil is frozen or wet, or the continuation of prevailing weather will damage plant materials, including sustained periods of above-normal high temperatures. Complete planting operations as early in the specified season as possible.

E. Fall Dig Hazard: Some species of trees and shrubs are considered “Fall Transplanting Hazards” by the nursery trade. The Contractor shall identify Fall Transplanting Hazards from the plant schedule, and factor the proper handling of these trees into the overall sequencing of construction and Project schedule. The Contractor shall notify the Landscape Architect of any conflicts arising from this analysis of the plant list and schedule.

F. Water:

1. Water shall be tested for presence of chloramine. If levels are determined to exceed acceptable levels, provide an alternate source for water.

2. Water connections may be available on site. The Contractor shall immediately notify the Construction Manager and Landscape Architect in writing if water is insufficient for work and maintenance operations.
3. Provide water as needed from sources free from impurities injurious to vegetation.
4. Provide all hoses and equipment as needed to distribute water to area of landscape work and areas needing watering. Provide water tank trucks if water service is interrupted. Prior to providing water tank trucks, submit to Landscape Architect for review and approval.
5. The Contractor shall employ conservation practices for all water use and shall instruct all of his/her installers to abide by this requirement.

G. Painting: Do not paint vegetation for any reason.

1.11 ACCEPTANCE AND MAINTENANCE

A. Request for Acceptance: In writing, request Landscape Architect’s inspection for acceptance at least 10 days in advance of preferred inspection date. Do not request inspection for acceptance until work is 100 percent complete (not including maintenance) and in compliance with the Contract requirements.

1. Final Acceptance is defined as the time at which 100 percent of the work has been performed and accepted by the Landscape Architect (excluding post project maintenance) including any work noted on the “Punch List.”
2. Partial Acceptance: Acceptance of partial areas or portions of the total work may be granted, at the Landscape Architect’s option, if the area to be inspected for acceptance is large, well defined, and easily described. The Landscape Architect is not obligated to provide partial acceptance of the work.

B. Maintenance Period: Completely maintain plants and trees from date of receipt from nursery until 60 days after Final Acceptance.

1. Plant and Tree Maintenance: Provide complete maintenance and service as required to promote and maintain healthy growth including, without limitation, watering, weeding, fallen leaf removal, treatment for insects and disease, resetting plants to proper grade and upright position, and other operations and maintenance work. Throughout the maintenance period, restore planting saucers. Tighten and adjust rootball fixing system to keep trees in vertical position.
   a. Watering: Flood all plants during the construction and maintenance periods at least twice each week. If present and operational, coordinate programming of irrigation system to meet watering needs. If irrigation system is not operational, provide hand watering as needed to maintain healthy growth. At each watering, thoroughly saturate the soil around each tree and shrub.
If sufficient moisture is retained in the soil as determined by the Landscape Architect, the required watering may be reduced. Trees will require a minimum of 20 gallons of water for each watering. Shrubs will require a minimum of ten gallons of water for each watering.

1) Lack of adequate soil moisture is often a major cause of winter damage. All plants, but especially narrow leaf and broadleaf evergreens, use water during winter. Moisture must be available below the frost line or frozen soil.
   a) Plants should be watered thoroughly in the fall to prepare them for the winter months.
   b) During dry winters, broadleaf evergreens should be watered about once each month.

b. Application of insecticides and herbicides is expressly prohibited. Confer with Landscape Architect for organic methods of controlling insect infestation or disease.

1.12 WARRANTY

A. Warranty: Provide written warranty agreeing to remove and replace work that exhibits defects in materials or workmanship for the specified periods. "Defects" is defined to include death, unsatisfactory growth, disease, insect infestation, abnormal foliage density, abnormal size, abnormal color, failure to thrive, and other unsatisfactory characteristics.

1. Warranty Period: Two years from date of Final Acceptance.
2. If the Contractor disagrees with the planting practices herein specified, he/she shall state them in writing at least 60 days before planting work commences. Failure to present this written notice shall be interpreted as acceptance of the planting practices specified herein.
3. Replacement: Replace defective work with new material of same species, size, character, and quality of originally accepted work. With each replacement material, provide a new 1-year warranty for the replacement work. If a replacement is unacceptable during this second 1-year warranty period, the Contractor shall provide another replacement or, when approved by the Owner, equivalent cash payment.
4. Replacement Planting Seasons: The replacement period for plant warranty work shall comply with the Planting Seasons specified herein. Electing to plant outside of the specified Planting Seasons shall not absolve the Contractor from providing the warranty.
5. Repair of Adjacent Work After Warranty Replacement: Contractor shall return all adjacent elements and systems modified during removal and replacement of plants to the condition in which they were found, including shrub and perennial planting, planting soils and drainage.
6. **Owner’s Responsibility and Warranty Exclusions:** The Contractor's warranty shall exclude problems due to improper or inadequate maintenance, vandalism or acts of nature.
   a. During the warranty period, the Contractor shall visit the site at least every other month to review the conditions of the accepted work. The Contractor shall submit in writing to the Owner regarding the Owner’s maintenance practices and/or any vandalism. The content of this notice shall include a list of specific plants involved, the presumed problem, and a method of remedy for the problem(s) cited. The Owner shall make reasonable efforts to correct the problems cited by the Contractor, but the Owner shall not be held responsible for the Contractor’s defects in materials or workmanship that result in decline or death to plants.
   b. Failure of the Contractor to make the required reviews of the site during the warranty period and to submit written notice to the Owner of maintenance defects shall negate the Contractor’s ability to make a claim against the Owner for negligence of maintenance.

**PART 2 PRODUCTS**

2.01 **PLANT MATERIALS - GENERAL**

A. **General:** Furnish specimen nursery-grown plants of genus, species, and cultivar specified complying with ANSI Z60.1, with healthy root systems well provided with fibrous roots developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects, such as knots, sun scald, injuries, abrasions, and disfigurement. All parts of the plant shall be moist and show active green cambium when cut. Plants will be densely foliated when in leaf.

B. **Grade:** Provide plants of specified height, caliper, sizes and grades complying with ANSI Z60.1 for type of plants required.
   1. **Larger Stock:** Plants larger than required may be used if approved by the Landscape Architect if rootball is proportionately larger, and if there is no change in Contract Price.
   2. **Undersize Stock:** If approved by the Landscape Architect, plants may be undersized as long as not more than 10 percent of plants smaller than required are used. If more than 10 percent undersized plants are used, then an 25 percent of the undersized plants shall be provided at no additional expense to the Owner.
C. Hardiness: Provide plant stock certified to have been grown within hardiness Zones 2 through 6 as established by the USDA’s Plant Hardiness Zone Map. Submit certification if so requested by the Landscape Architect.

D. Plant Character: All plants shall be typical of their species or variety and shall have a normal habit of growth and be legibly tagged with the proper name. Form and size shall comply with ANSI Z60.1.

1. Canopy Trees: Well-defined trunk flare, straight trunk, and single stem. Co-dominant leaders shall not be accepted. Evidence of equal increments of growth over the prior three seasons shall be discernible.

2. Multistem Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1.

3. Shrubs: Multi-stemmed plants complying with ANSI Z60.1 for the species indicated.

4. Groundcover: Provide groundcover of species indicated, established and well rooted in pots or similar containers, and complying with ANSI Z60.1.

5. Herbaceous Plants: Provide healthy plants from a commercial nursery, of species and variety shown or listed.

   a. Upon award of Bid, the Contractor shall arrange for all species or quantities of species require contract growing.

6. Herbaceous Plugs: All plants shall be typical of their species or variety and shall have a normal habit of growth.

   a. Provide fully rooted with a diameter of 1.5 inches, and a depth of 2.5 inches.

E. Trunk: The height of the trees shall be in accordance with ANSI Z60.1. No part of the trunk shall be conspicuously crooked as compared with normal trees of the same variety, for example ‘S’ curves shall not be allowed. The trunk shall be free from sunscald, frost cracks, or wounds resulting from abrasions, fire or other causes. No pruning wounds shall be present having a diameter exceeding 1 inch and such wounds must show vigorous bark on all edges.
F. Rootballs:

1. General:
   a. The diameter and depth of rootballs shall be sufficient to encompass the fibrous and root feeding system necessary for the healthy development of the plant in accordance with ANSI Z60.1, or the minimum rootball diameter shown, whichever is larger.
      1) If the root flare is buried 2 inches or more, provide a larger diameter or greater depth rootball to compensate for the buried root flare, as the soil overburden shall be removed prior to planting, which effectively reduces the size of the rootball.
         a) No plant will be accepted when the ball of earth surrounding its roots has been cracked or broken prior to or during the process of planting or after the burlap, staves, ropes or platform required in connection with its transplanting have been removed. The rootballs shall remain intact during all operations.
         b) Girdled Roots: Inspect root crown for girdling roots. Inspection for girdled roots shall be done at the nursery to the extent possible. If girdled roots are not visible at the nursery and are revealed before acceptance, any plant with a girdled root over 1/2-inch shall be rejected.

G. Balled and Burlapped: All plants to be moved balled and burlapped shall be moved with the root systems as solid units with balls of earth firmly wrapped with burlap, firmly held in place by a stout cord and drum lacing, or wire basket. Burlap for containing rootballs shall be untreated, made from biodegradable natural fibers.

H. Container Stock: Container stock shall have a full container with a well-developed root system. Plants loose in the container are not acceptable. The root zone shall be free of circling or kinked roots. Large matted roots at the sides or bottom of the container will not be accepted. Staked plants must be self-supporting when unfastened from the stake. Container grown plants may be substituted for balled and burlapped material if approved by the Landscape Architect.

2.02 PLANT SOURCES

A. The Contractor shall submit to the Landscape Architect any questions regarding the source of any plant.
B. Contract growing of some plants may be required. The Contractor shall identify plant species in need of contract growing within four weeks of beginning work.

2.03 DIGGING SEASON

A. Plants shall be delivered freshly dug from the nursery source. Plants that have been predug the previous season and held at the nursery or another off-site location shall not be accepted.

1. Spring Dig: Plants shall be dug as early as possible and as determined by the nursery owner, and no later than bud break.
   a. Do not transport plants within 14 days after bud break.

2. Fall Dig: Plants shall be dug while dormant, generally following leaf senescence.
   a. Fall Dig Hazard: Some species of trees or shrubs are considered “Fall Transplanting Hazards” by the nursery trade. The Contractor shall identify Fall Transplanting Hazards from the plant schedule, and factor the proper handling of these trees into the overall sequencing of construction and Project schedule. The Contractor shall notify the Landscape Architect of any conflicts arising from this analysis of the plant list and schedule.

2.04 SELECTION AND INSPECTION OF PLANTS

A. The Landscape Architect will review plant and select plant materials at the nursery source prior to digging. At the Landscape Architect’s discretion, plant material may be selected through photographs provided by the Contractor prior. All plants brought to the site will have been reviewed in this manner. Plants that do not have the Landscape Architect’s approval shall be removed from the site.

1. Tagging: At least 3 weeks prior to the expected digging date, request, in writing, the Landscape Architect’s inspection of plant material at the nursery. Provide photographs beforehand if requested by the Landscape Architect.
   a. The Landscape Architect will make his/her own travel arrangements to the nursery.
   b. Seals placed on the selected plants at the nursery shall remain on the plants until Final Acceptance of the work.

2. The Landscape Architect’s basis of plant selection will include:
   a. Conformance with specified genus, species, variety, size, form, rootball and quality.
   b. The visual characteristics of the plants.
c. Plant health.
d. Adherence of the nursery to cultural practices and maintenance procedures that are at or above industry standard.

3. On-Site Inspection:
a. The Contractor shall permit the Landscape Architect to inspect plants upon their arrival to the project site and at any time prior to planting. The Landscape Architect will inspect the plant materials for size and condition of rootballs and/or root systems, insects, injuries, defoliation, wind burn and latent defects. The Contractor shall remove plant material that is unsatisfactory or defective and replace the plants at no additional cost to the Owner.
b. The Landscape Architect may reject a specific nursery source and associated plants if he/she determines before, during or after receipt of plants, any of the following:
   1) The nursery stock does not meet health standards set forth herein, including disease and infestation.
   2) The nursery stock does not meet the requirements of the Landscape Architect’s basis of selection as stated herein.
   3) The nursery cannot supply the specified plant(s) or an acceptable substitute cultivar or species.

B. Substitutions: In the event that the Contractor is unable to obtain the plant material specified, either because of unavailability or the failure of the plant material to meet the quality requirements of this Section, the Contractor shall provide substitute plants of equal size, quality, character, overall form, branching habit, color, time of bloom and value to the plant originally specified. The substitute plants shall conform to all requirements of this Section and must be approved by the Landscape Architect.

2.05 PLANTING SOIL MIXTURE AND AMENDMENTS

A. See Section 32 91 13.19, Planting Soil System Procurement, and Section 32 91 19.13, Planting Soil System Installation, for planting soil mixture requirements. The Contractor shall strictly adhere to soil specification composition for each section of the Work.

B. Coordinate installation of soil mixes and plants to meet requirements of this Section and Section 32 91 19.13, Planting Soil System Installation.
2.06 TREE STAKING AND ANCHORING MATERIALS

A. Guying Straps: 3/4-inch-wide “ArborTie” flat polypropylene strap with break strength of 900 pounds minimum.

1. Color: Dark green or black.
   a. As manufactured by:
      1) DeepRoot Green Infrastructure, LLC, 101 Montgomery Street, Suite 2850, San Francisco, CA 94104, info@deeproot.com, Telephone: (415) 781-9700 / Toll Free: (800) 458-7668, Fax: (415) 781-0191.
      2) Platipus Anchors, Inc., 2008 Garner Station Boulevard, Raleigh, NC 27603, Telephone: (866) 752-8478, Fax: (919) 662-0998.
      3) “Or-equal.”

B. Bamboo Stakes: Provide 3/4-inch diameter Bamboo Stakes, 8-foot minimum in length.

C. Large Tree Anchoring System: Rootball anchoring system shall be as manufactured by Platipus Anchors, Inc., 2008 Garner Station Boulevard, Raleigh, NC 27603, Telephone: (866) 752-8478, “or-equal.” System shall be Platipus rootball fixing system, including Plati-Mat, Model No. RF2RP.

1. Work with manufacturer to confirm the correct size of anchoring system for specified trees.

D. Deadman Anchors: 9-inch by 5-3/4-inch by 4-foot length precast concrete, or approved equal. Provide three per tree as indicated on Drawings.

2.07 MISCELLANEOUS MATERIALS

A. Natural Burlap: Provide medium weight (7-ounce per square yard) natural burlap.

B. Anti-Erosion Mulch or Weed-free Straw Bales: Materials shall conform to Section 02220, Site Protection, Clearing, Salvage and Protections.

C. Siltation Fence: Materials shall conform to Section 02220, Site Protection, Clearing, Salvage and Protections.
D. Anti-Desiccant:

1. Provide emulsion type, film forming agent designed to permit vapor transmission but retard excessive moisture loss. Use anti-desiccant only with the approval of the Landscape Architect. Acceptable Manufacturers:
   b. Cloud Cover as manufactured by Easy Gardener, P.O. Box 21025, Waco, TX 76702-1025, Telephone: (254) 753-5353, www.easygardener.com.

E. Soil and Pavement Protection:

1. The driving of vehicles over planted areas is expressly prohibited. Protect subgrade, planting soils and pavements using one of the following:
   a. Plywood: Provide 3/4-inch Grade C or better plywood for use as planking when driving vehicles or moving equipment over areas to be planted.
   b. Oriented Strand Board (OSB): Two layers of 3/4-inch OSB on top of 6-inch mulch. Provide Filter Fabric under mulch layer.

PART 3 EXECUTION

3.01 PREPARATION AND EXAMINATION

A. Pre-Installation Examination Required: The Contractor shall examine previous work, related work, and conditions under which this work is to be performed and notify the Landscape Architect in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means Contractor accepts substrates, previous work, and conditions. The Contractor shall not place any plants or planting soil mixtures until all work in adjacent areas is complete and accepted by the Landscape Architect.

B. Concealed Conditions: Notify Landscape Architect before planting when below grade or on-structure conditions detrimental to proper plant growth are encountered. Do not proceed with planting without specific written instructions from the Landscape Architect. At the Landscape Architect’s direction and at no additional expense to the Owner, plants shall be relocated to avoid the obstruction.
C. Deliver materials and plants only after preparations for planting have been completed and accepted, including but not limited to: planting soil system, irrigation (minimum: Mainline), rough grading, utilities, decompaction or remediation of soils. The Landscape Architect will determine when the site is acceptable for planting.

3.02 HANDLING OF PLANTS

A. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape.

B. Provide a double tarp protective covering over exterior plants during transport.

C. Do not drop exterior plants during delivery.

D. Do not loosen drum-lacing nor remove container-grown stock from containers before time of planting.

E. Do not move trees if rootballs are saturated.

F. Handle planting stock by supporting the rootball or container.

3.03 TEMPORARY STORAGE OF PLANTS

A. Storage – General:

1. For plants stored on or off-site for more than 24 hours, the Contractor shall keep a log that records dates of watering.

2. The contractor shall fully inspect and maintain plants for the entire duration of the storage period.

3. All stored plants shall remain the property of the Contractor and shall be replaced in kind to meet the standards defined herein for healthy plants and the character and habit defined herein. The Landscape Architect shall be the sole evaluator of whether replacement plants match the originally stored plants.

4. No plant shall be stored more than 4 weeks without prior written acceptance by the Landscape Architect.
B. Storage of Plants Less than 1 week:

1. If planting is delayed more than 6 hours after delivery of plants to the site, the Contractor shall adhere to the following practices:
   a. Set plants in shade, protect from weather and mechanical damage, and keep roots moist.
   b. Store plants upright with room between rootballs.
   c. Closely monitor plants for sufficient root moisture.
   d. Store all plant materials in a secure and clean location, free from conditions that would be harmful and/or deleterious to the immediate or long-term health of the trees.

C. Storage of Plants More than 1 week:

1. The Contractor shall store plants at a location mutually agreed upon by the Contractor and Landscape Architect.
2. Space plants sufficiently apart to prevent damage or death to branches and leaves. During all seasons, set balled stock upright and plumb on firm ground and cover the ball with fully aged and decomposed wood mulch or other material acceptable to the Landscape Architect.
3. During the growing season, stored plant material shall be watered and the rootballs kept moist with an automatic drip irrigation system to prevent drying out. Mist plants several times a day as necessary to reduce transpiration in sunny or windy locations.
4. During the dormant season, rootballs shall be insulated against freezing and cold weather damage. Plants shall be protected from wind and ice damage.
   a. During winter months, stored plant material shall also be monitored for soil moisture and watered as needed to prevent desiccation. Plants shall generally be watered about once each month to keep the soil moist, but not wet.
5. During the storage period, inspect all plants for pests and diseases and, if found, have them evaluated by an arborist certified in the state where the project is located.
   a. Before proceeding, report on the presence of any diseases or pests.
   b. Before proceeding, report on issues and recommended treatment to the Landscape Architect for review and approval.
   c. Whenever possible, select and use organic treatments.
   d. Isolate trees with diseases or pests and remove and replace if the Landscape Architect determines that the plants are unusable.
3.04 PLANT LAYOUT

A. Horizontal Layout: The plant locations shown on Drawings are approximate. The Contractor shall layout the final location of individual plants by stake or flag and obtain the Landscape Architect’s approval of locations before starting installation. After staking is accepted, set plants in place for final review and acceptance by the Landscape Architect. The Contractor shall make revisions and adjustments as directed by the Landscape Architect.

1. Contractor shall not stake plant locations until proper subgrade, drainage, and subsoil layers are installed.
2. Contractor shall verify the locations of all unground utilities before staking plant locations.
3. Indicate the species and size of plant on the stake or flag.
4. Contractor shall make adjustments as determined by the Landscape Architect without additional cost to the Owner.

B. Vertical Layout: Set the elevation of trees through the use of string lines or by instrumentation. Demonstrate to the Landscape Architect through the use of stakes and string that trees have been set at the correct elevation prior to completing planting and installing the upper soil horizon, if requested.

3.05 PLANTING WOODY PLANTS

A. General:

1. Sequence of Planting: Plant trees and shrubs after the subgrade has been accepted and concurrently with the Horticultural Subsoil planting soil layer unless otherwise approved by the Landscape Architect. Complete landscaping work as quickly as possible on portions of the site as they become available for landscaping.
2. If plants are installed in planting pits, scarify sides of pits before placing trees.
3. Grade Stakes: If present, protect and maintain grade stakes and location stakes until removal is acceptable to the Landscape Architect and all parties involved in this Project. If grade stakes are not present, establish grade stakes to ensure that grades shown on Drawings are being met.
4. Painting: Do not paint vegetation for any reason.

B. Rootball and Rootflare:

1. Rootball Pedestals: Provide a rootball pedestal composed of subgrade fill immediately beneath the ball or root mass. Pedestal shall provide the relationship to finish grade described below and prevent settlement of the plant. Compact pedestal to 95 percent Standard Proctor.
2. Identifying and Exposing the Root Flare: Prior to setting the height of the rootball pedestal, the Contractor shall remove burlap and twine from the top of the rootball and inspect each plant to determine if the trunk flare is buried within the rootball. If buried, the Contractor shall expose the trunk flare by removing excess fill on top of rootball, taking care not to damage the bark or roots while removing the soil overburden. Adventitious roots and girdling roots shall be removed with sharp pruners. Adjust the rootball pedestal to position the trunk flare 2-inch to 3-inch higher than the proposed finished grade.

3. Wire Baskets: Once set, completely remove top one-third of wire basket. Cleanly cut each tier of all horizontal wires making one cut centered between each set of vertical wires.
   a. Burlap: Completely remove top one-third of burlap.

4. Drum lacing and Burlap: Once set, remove top one-third of lacing and burlap.

5. Containerized Plants: Completely remove container. Cut out container with a sharp blade if container does not readily separate from the rootball.

6. Scarification of Balled and Burlapped Plants: The Landscape Architect will examine the exposed rootball and determine if the Contractor shall scarify the sides of the rootball. Scarification shall result in no additional expense to the Owner.

7. Scarification of Containerized Plants: The Contractor shall scarify the rootballs of container plants with a sharp blade 2-inch in length. Rest the plant on its side and scarify an ‘X’ on the bottom of the root mass. Then make vertical cuts that are the full height of the rootball every 3 inches OC of the full circumference.

8. Rootballs shall be kept in a moist, but not wet, condition. Protect rootballs from damage due to sun and wind. Contractor shall strictly limit the time between exposing the rootball and backfilling. Protect exposed rootballs with burlap or other shading device until backfilled.

C. Placement of Planting Soil Mixture at Woody Plants: Place planting soil mix to levels shown on Drawings and described in Section 32 91 19.13, Planting Soil System Installation.

1. Maintain at all times during the planting operations at least one stockpile of each approved type of plant soil mixture.
2. Planting soil shall be in full contact with the rootball, with no voids or air pockets. Where burlap is present, burlap shall be tightly pressed between backfill and rootball. Folded or bunched burlap will create an obstruction to backfill and rootball contact and shall be removed.
3. Backfilling of Tree Pits in Existing Soil Areas (SC): Backfill with planting soil mix in 6-inch layers. Hand tamp each layer to eliminate voids and air pockets before placing subsequent layers. Continue until backfill has reached finish grade shown on Drawings.

4. Watering Dish and Mulch: Construct a watering dish as shown to promote water infiltration into the root zone. Hand tamp edges of watering dish to be firm and withstand hose pressure. Cover watering dish with mulch, leaving a 4-inch gap between mulch and the trunk.

D. Watering:

1. Flood all plants with water twice within the first 24 hours after planting. Take care to avoid saturating adjacent soils where planting operations are ongoing. Monitor water pressure. Displacement of soil materials including watering dish by watering shall not be acceptable.

2. Flood all plants during the construction and maintenance periods at least twice each week. If present and operational, coordinate programming of irrigation system to meet watering needs. If irrigation system is not operational, provide hand watering as needed to maintain healthy growth. At each watering, thoroughly saturate the soil around each tree and shrub. If sufficient moisture is retained in the soil as determined by the Landscape Architect, the required watering may be reduced. Trees will require a minimum of 20 gallons of water for each watering. Shrubs will require a minimum of 10 gallons of water for each watering.

   a. Winter Watering: Lack of adequate soil moisture is often a major cause of winter damage. All plants, but especially narrow leaf and broadleaf evergreens, use water during winter. Moisture must be available below the frost line or frozen soil.

      1) Plants should be watered thoroughly in the fall to prepare them for the winter months.

      2) During dry winters, broadleaf evergreens should be watered about once each month.

E. Plant Anchoring System: Install anchoring deadman and guy wires during subgrade construction. Adjust and reset guys during maintenance period as necessary.

1. Bamboo Staking: Wrap bamboo stake with a minimum of five layers of burlap where stake is in contact with tree trunk.
3.06 PLANTING POTTED HERBACEOUS PLANTS

A. The Contractor shall scarify the rootballs of container plants. Using a sharp knife, make vertical cuts the full height of the rootball at a depth of 2-inch and every 3 inches OC.

3.07 PLANTING HERBACEOUS PLUGS

A. Install the plug so the stem base is at or slightly above finish grade. Plant plugs fully into planting soil, not mulch.

B. Install plugs to their full depth. A “J-Root” installation shall not be acceptable.

C. Tamp each plug in place so that it is firmly seated in the soil, with no air pockets.

3.08 SOIL DIAGNOSTICS DURING THE MAINTENANCE PERIOD

A. If plants exhibit unsatisfactory growth during the maintenance period, perform soil testing for chemical properties, compaction and infiltration rates. See Section 32 91 19.13, Planting Soil System Installation, for testing definitions, sampling methods and procedures. Adhere to Landscape Architect’s recommend remediation. Remediation may include, but are not limited to, soil amendments, soil decompaction or fertilization.

3.09 TEMPORARY EROSION CONTROL

A. The construction of the site will initiate with the installation of measures sufficient to control sediment deposits and erosion. All sediment control measures will be maintained until all upstream ground within the construction area has been completely stabilized with permanent vegetation and all walks have been paved.

B. The Contractor shall remove accumulated sediments when they reach half the capacity of the erosion control devices. Sediment/erosion control devices must be checked after each storm event.

C. The Contractor is responsible for cleaning any and all sediment leaving the site. The Contractor shall be responsible for repairing all damages caused by the accumulation of sediment.

D. Failure to install, operate, or maintain all erosion control measures will result in the cessation of all construction until such measures are corrected to the local jurisdiction or city standards.
3.10 FINE GRADING

A. Prior to fine grading, Contractor shall verify that the rough grading, under drainage system, planting soil mixes, planting of woody plants and irrigation system have been accepted.

B. Fine Grading: Set finished grades by instrumentation. At minimum, set stakes at the bottom, middle, and top of slopes and at the edges and centers of plant beds. Connect contours and spot elevations with an even slope.

1. Fine grade planted areas shall have an even surface free from ridges, rills or depressions. Surface of planting soil shall be free draining have a fine texture.

2. All large stiff clods, lumps, brush, roots, litter and other foreign matter, and stones over one inch in diameter, shall be removed from the planting soil surface. Planting soil shall be free of smaller stones in excessive quantities as determined by the Landscape Architect.

3.11 PROTECTION, REPAIR AND CLEANUP

A. Protect new and existing site improvements from damage due to planting operations.

1. Underdrainage and Irrigation: Underdrainage and elements of the Irrigation System will be in place when planting activities begin. The contractor shall coordinate with the work of those Sections, and shall take all precautions to prevent damage to them. If damage occurs, the Contractor shall stop work and immediately report the damages to the Owner’s Representative and Landscape Architect. Work shall not resume until all work is repaired, inspected and accepted by the Landscape Architect.

B. The Contractor shall pay for all remediation to damages.

B. Limit all conditions that retard the growth of the plants, whether installed or when in storage.

C. The Contractor shall be strictly prohibited from tracking or driving over newly planted areas.

1. In areas where tracking or driving cannot be avoided, the Contractor shall install a protective barrier between the vehicle and the soil surface as approved by the Landscape Architect.
D. Restore areas disturbed by planting activities, or if otherwise eroded, settled, or disturbed after fine grading, and prior to groundcover or meadow installation.

E. Tags: Remove all identification labels, seals and tags at Final Acceptance of the Project.

END OF SECTION
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 301, Specifications for Structural Concrete.
2. American Water Works Association (AWWA):
   c. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm).
   d. C210 Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   e. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   g. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   h. C221, Fabricated Steel Mechanical Slip-Type Expansion Joints.
   i. C606, Grooved and Shouldered Joints.
3. ASTM International (ASTM):
   b. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
4. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
1.02 DESIGN REQUIREMENTS

A. Where pipe class or wall thickness is not indicated, design piping system for maximum stress based on the following [A: operating pressure and earth loads] [B: test pressure and earth loads] [C: earth and traffic loads]:

1. Operating Pressure: [D: ]
2. Field Hydrostatic Test Pressure: [E: ]
3. Earth Loads: [F: ]
4. Soil Density: [G: ]
5. Traffic Loads: [H: ]

1.03 SUBMITTALS

A. Action Submittals:

1. Detailed pipe fabrication drawings showing pipe details, special fittings and bends, dimensions, coatings, and other pertinent information.
2. Layout drawing showing location of each pipe section and each special length.
3. Pipe pressure class.
4. Wall thickness, reinforcing, and strength calculations.
5. Product Data: Manufacturer’s data for couplings, saddles, gaskets, and other pipe accessories. Indicate maximum rated working pressure and test pressure for each item.

B. Informational Submittals: Manufacturer’s Certificate of Compliance, in accordance with Section [A: 01 61 00, Common Product Requirements] [B: ].

1.04 DELIVERY, STORAGE, AND HANDLING

A. In accordance with manufacturer’s recommendations [A: and as specified in individual Specification(s) following this section].

B. Marking at Plant: Mark each pipe and fitting at plant. Include date of manufacture, manufacturer’s identification, specification standard, diameter of pipe [B: dimension ratio,] [C: pipe class,] [D: pipe number for laying purposes,] and other information required for type of pipe.

C. Pipe, specials, and fittings received at Project Site in damaged condition will not be accepted.

D. Gasket Storage: Store rubber gaskets in cool, well ventilated place, and do not expose to direct rays of sun. Do not allow contact with oils, fuels, petroleum, or solvents.
E. Store and support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.

F. Handling:

1. Pipe shall be handled with proper equipment in a manner to prevent distortion or damage. Use of hooks, chains, wire ropes, or clamps that could damage pipe, damage coating or lining, or kink and bend pipe ends is not permitted.

2. Use heavy canvas, or nylon slings of suitable strength for lifting and supporting materials.

3. Lifting pipe during unloading or lifting into trench shall be done using two slings placed at quarter point of pipe section. Pipe may be lifted using one sling near center of pipe, provided pipe is guided to prevent uncontrolled swinging and no damage will result to pipe or harm to workers. Slings shall bear uniformly against pipe.

4. Pipe and fittings shall not be stored on rocks or gravel, or other hard material that might damage pipe. This includes storage area and along pipe trench.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPE

A. As specified in the individual specification(s) following this section.

2.03 JOINTS

A. As specified in the individual specification(s) following this section.
2.04 COUPLINGS

A. General:

1. Coupling linings for use in potable water systems shall be in conformance with NSF/ANSI 61.
2. Couplings shall be rated for appropriate operating pressure and hydrostatic test pressure.
3. Exposed, bolted, sleeve-type couplings shall be [A: lined and coated with fusion bonded epoxy in accordance with AWWA C213] [B: lined and coated with liquid epoxy in accordance with AWWA C210] [C: ].
4. Buried, bolted, sleeve-type couplings shall be [D: lined and coated with fusion-bonded epoxy in accordance with AWWA C213] [E: lined and coated with liquid epoxy in accordance with AWWA C210] [F: and wrapped with petroleum wax tape in accordance with AWWA C217].

B. For Pipe with Plain-Ends:

1. Bolted, sleeve-type coupling, in accordance with AWWA C219.
   a. Manufacturer of couplings shall observe same quality control requirements as specified in AWWA C221 for fabrication of pipe expansion joints.
   b. Unless thrust restraint is provided by other means, bolted, sleeve-type couplings shall be harnessed. Harness details shall be in accordance with requirements of appropriate reference standard or as shown on Drawings.
   c. [A: Certified Welding Inspector at coupling fabrication facility shall verify welders and welding procedures are qualified, procedures are being followed, and quality assurance functions are being implemented.]
   d. Pipe Type to be Joined: [B: ]
   e. Standard to Which Pipe is Manufactured: [C: ]
   f. Pipe Ends Tolerance: [D: Conform to Table 4 of AWWA C219.] [E: ]
   g. Pipe Outside Diameter, Including Coating: [F: ]
   h. Service Type: [G: ]
   i. Rated Working Pressure: [H: ]
   j. Test Pressure: [I: ]
   k. Operating Temperature Range: [J: ]
   l. Anticipated Angular Deflection of Pipe: [K: ]
   m. Inner Sleeve:
      1) Length: [L: ]
      2) Thickness: [M: ]
n. Hydrostatic Test Requirements and Reporting: [N:  
]
o. Additional Nondestructive Weld Evaluation: [O:  
]
p. Marking Requirements: [P:  
]
q. [Q: Manufacturer’s Certificate of Compliance, in accordance with Section [R: 01 61 00, Common Product Requirements] [S:  
]

2. Fabricated steel, mechanical slip-type expansion joints, in accordance with AWWA C221.
a. Pipe Type Expansion Joint to Connect: [R:  
]
b. Standard to Which Pipe is Manufactured: [S:  
]
c. Pipe Ends Tolerance: [T: Conform to Table 2 of AWWA C221.]
   [U:  
]
d. Pipe Outside Diameter, Including Coating: [V:  
]
e. Wall Thickness, Schedule, or Pipe Class: [W:  
]
f. Rated Working Pressure: [X:  
]
g. Test Pressure: [Y:  
]
h. Operating Temperature Range: [Z:  
]
i. Pipe End Tolerance: [A:  
]
j. Anticipated Axial Movement: [B:  
]
k. Body and Slip Pipe: [C:  
]
l. Slip Pipe Length: [D:  
]
m. Slip Pipe Thickness: [E:  
]
n. Body Length: [F:  
]
o. Body Thickness: [G:  
]
p. Slip Pipe Material: [H: Chrome plated steel.] [I: Type 304 stainless steel.]
q. Coating Requirements: [J:  
]
r. Special Packing Requirements: [K:  
]
s. Special Bolting Requirements: [L:  
]
t. Hydrostatic Test Requirements and Reporting: [M:  
]
u. Additional Nondestructive Weld Evaluation: [N:  
]
v. Marking Requirements: [O:  
]
w. Limit Rods: [P:  
]
x. [Q: Manufacturer’s Certificate of Compliance, in accordance with Section [R: 01 61 00, Common Product Requirements] [S:  
]

C. For Pipe with Grooved Ends:
   1. Grooved couplings, in accordance with AWWA C606. System shall provide for [A: flexible joints] [B: rigid joints] [C: flexible or rigid joints as shown on Drawings].
   2. Exposed couplings shall be lined and coated with [D: liquid epoxy in accordance with AWWA C210] [E:  
]
3. Buried couplings shall be lined and coated with \( \text{coal tar epoxy in accordance with AWWA C210} \) [G: wrapped with petroleum wax tape in accordance with AWWA C217].

D. For Pipe with Flanged Ends:

1. Flanged coupling adapters, in accordance with AWWA C219.
   a. Pipe Type to be Joined: \( \text{[A: ]} \)
   b. Standard to Which Pipe is Manufactured: \( \text{[B: ]} \)
   c. Pipe Ends Tolerance: \( \text{[C: Conform to Table 4 of AWWA C219.]} \)
   d. Pipe Outside Diameter, Including Coating: \( \text{[D: ]} \)
   e. Service Type: \( \text{[F: ]} \)
   f. Rated Working Pressure: \( \text{[G: ]} \)
   g. Test Pressure: \( \text{[H: ]} \)
   h. Operating Temperature Range: \( \text{[I: ]} \)
   i. Anticipated Angular Deflection of Pipe: \( \text{[J: ]} \)
   j. Hydrostatic Test Requirements and Reporting: \( \text{[K: ]} \)
   k. Nondestructive Examination Requirements: \( \text{[L: ]} \)
   l. Marking Requirements: \( \text{[M: ]} \)
   m. \( \text{[N: Manufacturer’s Certificate of Compliance, in accordance with Section [O: 01 61 00, Common Product Requirements]} \)

2. Dismantling joints for connecting flanged pipe shall be AWWA C219 compliant. Provide studs and nuts to seal gasket separate and independent from tie-bar restraint system.

3. Rubber expansion joints shall allow compression, extension, and lateral deflection of the pipes being joined.
   a. Joints shall be suitable for use with \( \text{[O: potable water]} \)
   b. Materials of Construction: \( \text{[P: ]} \)
   c. Flange Drilling Pattern: \( \text{[Q: ]} \)
   d. Coating: \( \text{[R: ]} \)
   e. Maximum Movement: \( \text{[S: ]} \)
   f. Control Rods: \( \text{[T: ]} \)
   g. Working Pressure: \( \text{[U: ]} \)
   h. Test Pressure: \( \text{[V: ]} \)
   i. Manufacturers:
      1) Red Valve Company, Carnegie, PA.
      2) Mercer Rubber Company, Hauppauge, NY.

E. Bolting Materials for Couplings: \( \text{[A: In accordance with the applicable AWWA standard.]} \) \( \text{[B: As recommended by coupling manufacturer for specified conditions.]} \) \( \text{[C: Stainless steel in accordance with AWWA C219.]} \)
2.05 SERVICE SADDLES

A. Double strap design rated for [A: 150 psi minimum working pressure] [B: ].

2.06 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Modular Mechanical Seal:
   1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
   2. Assemble interconnected rubber links with Type 316 stainless steel bolts, nuts, and pressure plates.
   3. Size modular mechanical seals according to manufacturer’s instructions for the size of pipes shown to provide a watertight seal between pipe and wall sleeve opening.
   4. Manufacturers and Products:
      a. Thunderline/LinkSeal, Div. of PSI, Houston, TX; Link Seal.
      b. Calpico, Inc., South San Francisco, California; Sealing Linx.
      c. Advance Products and Systems, Lafayette, Louisiana; Innerlynx.

B. Wall Sleeves:
   1. Diameter, ends, and length shall be as shown on Drawings.
   2. Shall include integral seep ring to minimize seepage between metal sleeve and concrete.

C. Wall Couplings:
   1. Diameter, ends, and length shall be as shown on Drawings.
   2. Wall couplings shall provide flexible mechanical joint.
   3. Body and end rings shall be coated with fusion bonded epoxy.
   4. Body shall include integral seep ring.
   5. Shall comply with AWWA C219.

D. [A: If core drilling is required for penetrations of existing concrete walls or slabs, locations of drilling shall be determined by radiograph to avoid damage to reinforcing steel and conduits.]

2.07 FLANGES, FLANGE GASKETS, AND BOLTING MATERIALS

A. As specified in individual specifications following this section.

B. Flanges, bolting materials, and flange gaskets for steel flanges shall conform to AWWA C207.
C. Flanges, bolting materials, and flange gaskets for ductile iron flanges shall conform to AWWA C110 and AWWA C115.

D. [A: Stainless steel bolting material shall conform to ASTM F593, Type 304 stainless steel, Group 1, Condition SH1, 2, 3 or 4.]

E. [B: If the flanges are coated, provide two washers for each bolt on each side of the flange to minimize damage to the coating as the nuts are tightened. Provide bolts of the proper length to accommodate the washers.]

2.08 FLANGE INSULATION KITS AND INSULATING COUPLINGS

2.09 CONCRETE FOR THRUST BLOCKS

A. Thrust Block Concrete: As specified in Section [A: 03 30 00, Cast-in-Place Concrete] [B: ].

B. Reinforcing Steel: ASTM A615/A615M, Grade 60 deformed bars.

C. Welded Wire Fabric: ASTM A497/A497M.

D. Formwork: Plywood [A: ; earth cuts may be used as approved by Engineer].

E. Mix: ASTM C94/C94M, Option A.
   1. Cement: ASTM C150/C150M, Type [A: I] [B: II] [C: III].
   3. Design for Minimum Compressive Strength at 28 Days: [F: 2,500] [G: 3,000] [H: ] psi.

2.10 PIPE LOCATING TAPE

A. As specified in Section 31 23 23.15, Trench Backfill.

2.11 PIPE BEDDING AND PIPE ZONE MATERIAL

A. [A: Granular material] [B: or] [C: Controlled low strength material] as specified in Section 31 23 23.15, Trench Backfill.

2.12 TRENCH STABILIZATION MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.
PART 3  EXECUTION

3.01  GENERAL

A. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

B. Furnish feeler gauges of proper size, type, and shape for use during installation for each type of pipe furnished.

C. Distributing Materials: Place materials along trench only as will be used each day, unless otherwise approved by Engineer. Placement of materials shall not be hazardous to traffic or to general public, obstruct access to adjacent property, or obstruct others working in area.

3.02  EXAMINATION

A. Verify size, material, joint types, elevation, and horizontal location of existing pipeline to be connected to new pipeline or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

C. Damaged Coatings and Linings: Repair using coating and lining materials in accordance with manufacturer’s instructions.

3.03  PREPARATION OF TRENCH

A. Prepare trench as specified in Section 31 23 16, Excavation.

B. Unless otherwise permitted by Engineer, maximum length of open trench shall not exceed [A: 50] [B: 500] [C: ] feet.

3.04  INSTALLATION

A. General:

1. Join pipe and fittings in accordance with manufacturer’s instructions, unless otherwise shown or specified.

2. Install individual pipe lengths in accordance with approved lay diagram. Misplaced pipe shall be removed and replaced.

3. Inspect pipe and fittings before installation, clean ends thoroughly, remove foreign matter and dirt from inside.

4. Flanged Joints:
   a. Install perpendicular to pipe centerline.
   b. Bolt Holes: Straddle vertical centerline, aligned with connecting equipment flanges or as shown on Drawings.
c. Use torque-limiting wrenches to provide uniform bearing and proper bolt tightness.
d. Flange Type: Use flat-faced flange when joining with flat-faced ductile or cast iron flange.

5. Couplings:
a. Install in accordance with manufacturer’s written instructions.
b. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
c. [A: Remove pipe coating, if necessary, to obtain smooth surface.] [B: Do not remove pipe coating. If damaged, repair before joint is made.]
d. Clean gaskets before installation.
e. If necessary, lubricate with gasket lubricant for installation on pipe ends.
f. Tighten coupling bolts progressively, drawing up bolts on opposite sides gradually until bolts have uniform tightness.

B. Buried Pressure Pipe:

1. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown on Drawings.

2. Placement:
a. Keep trench dry until pipe laying and joining is completed.
b. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
c. Measure for grade at pipe invert, not at top of pipe.
d. Excavate trench bottom and sides of ample dimensions to permit proper joining, welding, visual inspection, and testing of entire joint.
e. Prevent foreign material from entering pipe during placement.
f. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day’s work.
g. In general, lay pipe upgrade with bell ends pointing in direction of laying.
h. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
   1) Shorter pipe lengths.
   2) Special mitered joints.
   3) Standard or special fabricated bends.
i. Check gasket position with feeler gauge to assure proper seating.
j. After joint has been made, check pipe alignment and grade.
k. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
1. Prevent uplift and floating of pipe prior to backfilling.

3. Tolerances:
   a. Deflection From Horizontal Line: Maximum [\( A: 2 \) inches].
   b. Deflection From Vertical Line: Maximum [\( C: 1 \) inch(es)].
   c. Joint Deflection: Maximum of 75 percent of manufacturer’s recommendation.
   d. Horizontal position of pipe centerline on alignment around curves maximum variation of [\( E: 1 \) foot].

4. Cover Over Top of Pipe: Minimum [\( G: 3 \) feet], unless otherwise shown.


3.05 THRUST RESTRAINT

A. Location: At pipeline tees, plugs, caps, bends, and locations where unbalanced forces exist.

B. Thrust Blocking:
   1. Place only where shown on Drawings.
   2. Quantity of Concrete: Sufficient to cover bearing area of pipe and provide required soil bearing area as shown on Drawings.
   3. Place blocking so pipe and fitting joints are accessible for repairs.
   4. Place concrete in accordance with [\( A: \text{Section 03 30 00, Cast-in-Place Concrete} \) \( B: \text{ACI 301} \)].

3.06 CORROSION PROTECTION

A. Buried Pipe: As specified in the individual specifications following this section.

B. Notify Engineer at least 3 days prior to start of surface preparation, coating application, and corrosion protection work.

3.07 PLACEMENT OF PIPE LOCATING TAPE

A. Place pipe locating tape in accordance with Section 31 23 23.15, Trench Backfill.

3.08 PIPE BEDDING AND ZONE MATERIAL

A. Place pipe bedding and pipe zone material in accordance with Section 31 23 23.15, Trench Backfill.
3.09 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in the individual specification(s) following this section.

3.10 CLEANING [A: AND DISINFECTION]

A. Following assembly and testing, and prior to [B: disinfection and] final acceptance, flush pipelines with water at 2.5 fps minimum flushing velocity until foreign matter is removed. Dispose of water and flushed foreign matter.

B. If impractical to flush large diameter pipe at 2.5 fps, [A: clean pipe in-place from inside by brushing and sweeping, then flush or blow line at lower velocity] [B: clean pipe by use of pipe pig as approved by Engineer. Multiple passes of pipe pig may be required to adequately clean line].

C. Remove accumulated debris through blowoffs 2 inches and larger or by removing spools and valves from piping.

D. Disinfection: [A: As specified in Section 33 13 00, Disinfection of Water Utility Distribution Facilities.] [B: ]

END OF SECTION
SECTION 33 13 00
DISINFECTION OF WATER UTILITY DISTRIBUTION FACILITIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. B300, Hypochlorites.
   b. B301, Liquid Chlorine.
   c. B302, Ammonium Sulfate.
   d. B303, Sodium Chlorite.
   e. C651, Disinfecting Water Mains.
   f. C652, Disinfection of Water Storage Facilities.
   g. C653, Disinfection of Water Treatment Plants.

2. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.


1.02 SUBMITTALS

A. Informational Submittals:

1. Plan describing and illustrating conformance to appropriate AWWA standards and this Specification.
2. Procedure and plan for cleaning system.
3. Procedures and plans for disinfection and testing.
4. Proposed locations within system where Samples will be taken.
5. Type of disinfecting solution and method of preparation.
6. Certification that employees working with concentrated chlorine solutions or gas have received appropriate safety training.
7. Method of disposal for highly chlorinated disinfecting water.
8. Independent Testing Agency: Certification that testing agency is qualified to perform chlorine concentration testing and bacteriological testing in accordance with AWWA standards, agency requirements, and this Specification.
9. Certified Bacteriological Test Results:
   a. Facility tested is free from coliform bacteria contamination.
   b. Forward results directly to Engineer.

1.03 QUALITY ASSURANCE

A. Independent Testing Agency: Certified in the State of Oklahoma with 10 years’ experience in field of water sampling and testing. Agency shall use calibrated testing instruments and equipment, and documented standard procedures for performing specified testing.

1.04 SEQUENCING

A. Commence disinfection after completion of following:
   1. Hydrostatic pressure testing, functional and performance testing and acceptance of pipelines and equipment.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

   1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 WATER FOR DISINFECTION AND TESTING

A. Clean, uncontaminated, and potable.

B. Owner will supply potable quality water. Contractor shall convey in disinfected pipelines or containers.

PART 3 EXECUTION

3.01 GENERAL

A. Conform to AWWA C651 for pipes and pipelines, except as modified in these Specifications.
B. Contractor’s Equipment:

1. Furnish chemicals and equipment, such as pumps and hoses, to accomplish disinfection.
2. Water used to fill pipeline may be supplied using a temporary connection to existing distribution system. Provide protection against cross-connections as required by AWWA C651.

C. Disinfect the following items installed or modified under this Project, intended to hold, transport, or otherwise contact potable water:

1. Pipelines: Disinfect new pipelines that connect to existing pipelines up to point of connection.
2. Disinfect surfaces of materials that will contact finished water, both during and following construction, using one of the methods described in AWWA C652 and AWWA C653. Disinfect prior to contact with finished water. Take care to avoid recontamination following disinfection.

D. Prior to application of disinfectants, clean pipelines of loose and suspended material.

E. Allow freshwater and disinfectant solution to flow into pipe or vessel at a measured rate so chlorine-water solution is at specified strength. Do not place concentrated liquid commercial disinfectant in pipeline or other facilities to be disinfected before it is filled with water.

3.02 TURBIDITY

A. Cleaning of equipment and facilities shall include removal of materials that result in a turbidity exceeding limits stated in Article Testing.

3.03 PIPING AND PIPELINES

A. Cleaning:

1. Before disinfecting, clean foreign matter from pipe in accordance with AWWA C651.
2. If continuous feed method or slug method of disinfection, as described in AWWA C651, are used flush pipelines with potable water until clear of suspended solids and color. Provide hoses, temporary pipes, ditches, and other conduits as needed to dispose of flushing water without damage to adjacent properties.
3. Flush service connections and hydrants. Flush distribution lines prior to flushing hydrants and service connections. Operate valves during flushing process at least twice during each flush.

B. Disinfecting Procedure: In accordance with AWWA C651, unless herein modified.

3.04 DISPOSAL OF CHLORINATED WATER

A. Do not allow flow into a waterway without neutralizing disinfectant residual.

B. See appendix of AWWA C651 for acceptable neutralization methods.

3.05 TESTING

A. Collection of Samples:
   1. Coordinate activities to allow Samples to be taken in accordance with this Specification.
   2. Provide valves at sampling points.
   3. Provide access to sampling points.

B. Chlorine Concentration Sampling and Analysis:
   1. Collect and analyze Samples in accordance with AWWA Standards.
   2. Analysis to be performed by an independent test laboratory. Samples will be analyzed using amperometric titration method for free chlorine as described in latest edition of Standard Methods for Examination of Water and Wastewater.

C. After pipelines have been cleaned, disinfected, and refilled with potable water, an independent laboratory will take water Samples and have them analyzed for conformance to bacterial limitations for public drinking water supplies.
   1. Collect Samples in accordance with applicable AWWA Standard.
   2. Analyze Samples for coliform concentrations in accordance with latest edition of Standard Methods for the Examination of Water and Wastewater.
   3. Obtain and analyze a minimum of two Samples on each of 2 consecutive days from every 1,000 feet of pipeline by standard procedures outlined by state and local regulatory agencies.
   4. Sampling points shall be representative and accepted by Engineer.
D. Turbidity Sampling and Analysis:

1. After pipelines have been cleaned, disinfected, and refilled with potable water, an independent laboratory will take water samples and have them analyzed for conformance to turbidity limitations for public drinking water supplies. Turbidity shall not exceed 0.3 NTU.

2. If turbidity is in excess of the limit, dispose of the water in accordance with this Specification and applicable regulations, take action to remove source of turbidity, refill system, and retest.

E. If minimum samples required above are bacterially positive, disinfecting procedures and bacteriological testing shall be repeated until bacterial limits are met.

END OF SECTION
SECTION 33 41 01
STORM DRAIN PIPING

PART 1   GENERAL

1.01   REFERENCES

A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:

1. American Association of State Highway and Transportation Officials (AASHTO):

2. American Water Works Association (AWWA):
   c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings, 3 in. Through 48 in. (75 mm Through 1200 mm) for Water and Other Liquids.
   e. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast, for Water.

3. ASTM International (ASTM):
   b. C14, Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
i. C497, Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.


l. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.


s. D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.


w. F794, Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.

x. F894, Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.

1.02 SUBMITTALS

A. Informational Submittals: Manufacturer’s Certification of Compliance.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

A. As specified in the Data Sheet following “End of Section.”
PART 3 EXECUTION

3.01 INSTALLATION OF PIPE, FITTINGS, AND APPURtenances

A. General:

1. Reinforced concrete pipe sections connected to a manhole or structure shall be no more than 4-feet in length, as measured from the inside face of the structure to the point of flexure of the joint.
2. Pipe shall be protected during handling against impact shocks and free fall.
3. Reinforced concrete pipe shall be installed with the mark “C-76” visible on the top of the pipe.
4. Pipe laying shall proceed upgrade with spigot ends pointing in direction of flow.
5. Excavate bell holes at each joint to permit correct assembly and inspection of entire joint.
6. Pipe invert may deviate from line or grade up to 1/2 inch for line and 1/4 inch for grade, provided that finished pipe line will present a uniform bore, and such variation does not result in a level or reverse sloping invert, or less than minimum slope shown.
7. Pipe bedding shall form continuous and uniform bearing and support for pipe barrel between joints. Pipe shall not rest directly on bell or pipe joint.
8. The ends of adjoining pipes shall butt against each other for their entire circumference in such a manner that there is no shoulder or unevenness of any kind.
9. If Contractor uses batterboards instead of laser level, a top line shall be maintained over a span of three grade stakes when laying pipe. As each batterboard is erected, the top line shall be sighted to assure the accuracy of the grade stakes and the batterboards’ settings. Any errors, discrepancies, or displacement of grade stakes shall be called to the attention of the Inspector for correction.
10. Prevent entry of foreign material into gasketed joints.
11. Reinforced concrete pipe ends and rubber gaskets to be jointed shall be cleaned immediately prior to joining. Extreme care shall be taken in moving the spigot end of the pipe into the bell end of the previously laid pipe. If the gasket is damaged or moved out of place, the new pipe shall be removed and a new gasket applied before rejoining.
12. After reinforced concrete pipe has been jointed, a band at least five-and-one-half inches wide shall be placed around the outside of the pipe at the joint. This band shall serve as a form for placing 1:1 cement mortar grout in the external recess formed by the face of the groove and the shoulder of the tongue. If a reinforced paper joint band is used, it shall
be drawn up tight around the pipe and the backfill tamped against it up to the spring line before pouring the grout. If a cloth band is used, it shall be wired around the outside of the pipe, and the grout poured before backfilling. On all pipes, the joint space remaining on the inside of the pipe shall be filled with a stiff mixture of 1:1 cement mortar which shall be troweled in place to produce a continuous, smooth, flush surface across the joint.

13. Plug or close off pipes that are stubbed off for manhole, concrete structure, or for connection by others, with temporary watertight plugs.

B. Concrete Closure Collars: Only use concrete closure collars where shown or authorized by Engineer.

3.02 SEWER CLEANING

A. Prior to final acceptance and final manhole-to-manhole inspection of the sewer system by Engineer, flush and clean all parts of the system. Remove all accumulated construction debris, rocks, gravel, sand, silt, and other foreign material from the sewer system at or near the closest downstream manhole. If necessary, use mechanical rodding or bucketing equipment.

B. Upon Engineer’s final manhole-to-manhole inspection of the sewer system, if any foreign matter is still present in the system, reflush and clean the sections and portions of the lines as required.

3.03 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>-.05</td>
<td>Reinforced Concrete Data Sheet</td>
</tr>
</tbody>
</table>

END OF SECTION
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe</td>
<td>ASTM C76, Wall B, Class III. Mark each joint with pipe class. Rotating packer or platform not allowed. Pipe length shall be no less than 6 feet, except for shorts and specials.</td>
</tr>
<tr>
<td>Cement</td>
<td>ASTM C150, Type II, or ASTMC150, Type I, with fly ash; maximum 12 percent Tricalcium Aluminate, or ASTM C595 Rev A, Type IP, with fly ash; Cement: ASTM C150. Minimum 564 pounds per cubic yard without fly ash. Minimum 479 pounds per cubic yard with fly ash.</td>
</tr>
<tr>
<td>Ratio: Water to Cementitious Materials</td>
<td>Not over 0.49.</td>
</tr>
<tr>
<td>Fly Ash</td>
<td>ASTM C618, Class C or Class F, Tables 1 and 2 modified as follows: Loss on Ignition: Maximum 3 percent Water Requirement: Maximum 100 percent of control Ratio Percent CaO/Fe₂O₃: Maximum 1.5 or test cement fly ash mix in accordance with ASTM C1012. Mix: Equal to or better than ASTM C150, Type II cement. 85 pounds per cubic yard minimum, 160 pounds per cubic yard maximum. Test: ASTM C311 and ASTM C618.</td>
</tr>
<tr>
<td>Joints</td>
<td>ASTM C361. Bell and spigot, employing a rubber gasket and cement mortar formed by a diaper. Rubber gaskets shall be either a standard O-ring gasket or a Forsheda prelubricated gasket, “or-equal.” For the O-ring gasket, the spigot end shall contain a groove to confine and compress the gasket on four surfaces when the joint is in final position. The Forsheda joint shall be designed and installed in accordance with the manufacturer’s recommendations.</td>
</tr>
</tbody>
</table>
## SECTION 33 41 01.05
### REINFORCED CONCRETE

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber Gaskets</td>
<td>ASTM C443.</td>
</tr>
<tr>
<td>Tees and Fittings</td>
<td>Reinforced concrete, rubber gasketed. Provide plug when service piping is not required.</td>
</tr>
<tr>
<td>Plugs</td>
<td>Removable. Removal shall provide a socket suitable for making a flexible jointed lateral connection or extension.</td>
</tr>
<tr>
<td>Circumferential Reinforcement</td>
<td>Not closer than 1 inch to inside surface of pipe. Area of outer circular reinforcing cage not less than 75 percent of inner cage. At least three circumferential reinforcing bars shall be provided in each pipe bell equal in area to an equivalent length of outside cage in the pipe barrel.</td>
</tr>
<tr>
<td>Elliptical Reinforcement</td>
<td>Not allowed.</td>
</tr>
<tr>
<td>Source Quality Control Testing</td>
<td>Testing shall be observed and reported by an independent testing laboratory approved by the Engineer.</td>
</tr>
<tr>
<td></td>
<td>Load Bearing 0.01-inch Crack, Compressive Strength and Absorption: ASTM C76. One Three-Edge Bearing Test in accordance with ASTM C497 shall be performed on a representative sample of each diameter and class of pipe to be furnished. One absorption test in accordance with ASTM C497 shall be performed for each 300 tons of pipe manufactured, not less than one test per days production. Absorption not to exceed 6 percent.</td>
</tr>
<tr>
<td></td>
<td>Load Bearing Ultimate: ASTM C76.</td>
</tr>
<tr>
<td></td>
<td>Permeability: ASTM C497.</td>
</tr>
<tr>
<td></td>
<td>Voids: Longitudinally sawcut one pipe from each 100 lengths of pipe manufactured in half with saw that will not damage the concrete or reinforcing steel. Inspect for voids adjacent to circumferential bars. Voids will be considered continuous if a 1/16-inch diameter pin can be inserted 1/4 inch deep. If voids exist adjacent to more than 10 percent of the circumferential bars, two additional pipes shall be tested. If either of the two pipes fail, the entire 100 lengths will be rejected.</td>
</tr>
</tbody>
</table>
Concrete shall have a minimum 28-day compressive strength of 6,000 psi. Four concrete cylinders or core samples shall be tested for compressive strength from each days production, two at 7 days and two at 28 days.

An in-plant hydrostatic test in accordance with ASTM C361 shall be performed on each section of pipe and each pipe joint at an internal hydrostatic head of 25 feet. The joints shall be tested for a minimum period of 1 hour under constant pressure as specified. Each pipe unit that satisfactorily passes all hydrostatic testing shall bear the seal of the testing laboratory. This seal does not constitute acceptance of the pipe installation, which will be subjected to further testing and inspection in the field.

In lieu of the in-plant hydrostatic testing of each joint, the Contractor may substitute the following procedure: (1) Perform one in-plant hydrostatic test per days production, in accordance with the previously specified criteria; and (2) Perform an air test on each joint in the field after assembly, in accordance with the City of Tulsa Water and Sewer Department Standard Air Test Procedure. The Contractor shall furnish all air test equipment. Testing and test conclusions shall be verified by the Engineer. The Engineer reserves the right to require additional in-plant hydrostatic testing.
PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:


2. ASTM International (ASTM):
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

PART 2 PRODUCTS

2.01 PRECAST UNITS

A. Conform to ASTM C478, except dimensions shall be as shown. Submit details of proposed units to Engineer for review.

B. Concrete Risers for Extensions: 6 inches high maximum and of same quality as sections.

   1. Confirm acceptability of risers with Engineer before installation.

2.02 MORTAR

A. Standard premixed mortar conforming to ASTM C387/C387M, Type S, or proportion one part portland cement to two parts clean, well-graded sand which will pass a 1/8-inch screen.

B. Admixtures may be used if not exceeding the following percentages of weight of cement:

   1. Hydrated Lime: 10 percent.
   2. Diatomaceous Earth or Other Inert Materials: 5 percent.
C. Consistency of Mortar: As required to readily adhere to concrete.

2.03 MANHOLE LIDS, FRAMES, AND GRATINGS

A. Lids, Frames, and Grates for Manholes, Catch Basins and Storm Drain Inlets: Cast iron conforming to ASTM A48/A48 and applicable sections of Drainage Structure Castings, AASHTO M 306, Class 35.

B. Bearing Surfaces: Clean and provide uniform contact.

C. Castings: Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.

D. Manhole adjusting ring shall be solid cast iron that fits in the standard City of Tulsa manhole frame and the standard manhole lid fits in the adjusting ring.

E. Adjusting rings shall conform to and be tested in accordance with the Standard Specification for Gray Iron Casings ASTM A48 and Drainage Structure Castings, AASHTO M306-89. Castings shall be Class 35-B iron and unpainted.

F. All bearing surfaces shall be machined smooth to prevent rocking and rattling.

G. The 2-inch manhole adjusting ring where specified shall have a minimum weight of 70 pounds and the 3-inch manhole adjusting ring where specified shall have a minimum weight of 100 pounds.

H. Markings on all gray iron castings shall conform to AASHTO M306-89. (AASHTO M306-89 states: Each casting shall be identified by the foundry showing): Name of Foundry, County of manufacturer, ASTM Designation Number, Class by a number followed by a letter indicating the minimum tensile strength and size of test bar (i.e., Class 35-B), Heat Number and Date. No other wording or marking of any kind other than those stated above or shown on the plan will be permitted on castings.

I. Casting shall be traffic load rated and must pass an AASHTO proof load test that can maintain a 40,000-pound proof load for 1 minute, applied on a 9-inch by 9-inch contact area in the center of the casting. The load shall be applied at a constant rate requiring a minimum of 30 seconds to reach the 40,000-pound level. Following this test the castings shall be visually inspected for cracks or permanent deformation which will be cause for rejection. Following this, the castings shall be loaded to failure. Cost for tensile and proof load testing shall be borne by manufacturer, and testing shall be performed at a testing facility acceptable to the Engineer. All tests shall be witnessed by the Engineer.

J. Casting dimensions shall vary by not more than plus 1/16 inch per foot.
PART 3 EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Excavate as required to accomplish construction. Backfill as specified for adjoining pipe trench.

3.02 PLACING PRECAST UNITS

A. Excavate and backfill trench bottom to required grade with 1-1/2-inch minus crushed rock uniformly graded from coarse to fine and with sufficient fines for proper compaction. Set units to grade at locations shown.

B. No more than 8 inches of concentric rings shall be used to bring manholes to finished grade.

3.03 EXTENSIONS

A. Install watertight extensions as shown. Lay risers in mortar with sides plumb and tops to grade. Seal joints with mortar, with interior and exterior troweled smooth. Prevent mortar from drying out and cure by applying a curing compound.

3.04 INSTALLATION OF FRAMES AND GRATES

A. Set frames and grates at elevations indicated or as determined in field and in conformance with Drawings.

B. Frames may be cast in, or set in mortar.

3.05 CLEANING

A. Upon completion, clean structure of silt, debris, and foreign matter.

END OF SECTION
PART 1 GENERAL

1.01 GENERAL

A. This section covers requirements for subsurface drainage piping, cleanouts, pump station sumps used to control shallow groundwater elevations within the Project area.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):

2. ASTM International (ASTM):
   e. D422, Standard Test Method for Particle-Size Analysis of Soils.
   h. F449, Standard Practice for Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control.
   i. F667, Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings.

1.03 DEFINITIONS

A. Cleanouts: Surface access ports used to access drain lines and constructed of solid corrugated piping.

B. Drain Lines: Buried perforated pipe providing collection and conveyance of drain water from saturated soils.

C. Granular Drain Material: Granular (sand or gravel) material used as an envelope around drain lines to provide pipe bedding, a permeable drainage zone, and stabilization of base soils to prevent migration of fines into drain lines.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data:
      1) Drain line pipe and fittings.
      2) Drain line installation equipment.
      3) High-pressure water jet cleaning equipment.
      4) Drain line sock; include manufacturer’s recommendation for length of time UV-resistant sock may be left exposed.
   b. Precast Base, Cone, and Top Slab Manhole Sections: Details of construction.

B. Informational Submittals:

1. Surveys:
   a. Field Survey: Information consisting of stationing and installed invert elevation of drain pipe for drain line grade QA/QC.
   2. Final drain line inspection and cleaning certification of compliance.

1.05 QUALITY ASSURANCE

A. Granular Drain Material Source:

1. Sampling:
   a. Conduct sampling of granular drain material source under supervision of Engineer in accordance with ASTM D75.
   b. Samples shall be representative and be clearly marked to show source of the material.
   c. Testing:
      1) In accordance with ASTM D1140 to determine percentage of fines.
2) In accordance with ASTM D422 to determine gradation of particles larger than No. 200 sieve.

d. Acceptance:
   1) Based on inspection of source by Engineer.
   2) Certified test results.

e. Provide additional sampling, testing, and certification for every 500 cubic yards of material and when there is a change in granular drain material.

f. Upon Engineer’s request, supply supplemental samples of granular drain material to a testing laboratory designated by Owner during installation of drain lines. Owner will bear costs of testing.

1.06 DOCUMENTATION

A. Surveying: Provide surveyed drain line grades to Engineer no more than 5 days following installation of drain line section.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Drain Sock:

1. Free of tears or other damage. Replace damaged sock.

2. Protect polyethylene drain lines with geotextile sock from UV light while stored onsite, unless geotextile sock is certified UV resistant.

3. UV-resistant Sock Stored Onsite Uncovered:
   a. Mark date of first sunlight exposure for each roll at factory.
   b. Do not allow UV-resistant sock to remain uncovered for more time than recommended by manufacturer.

PART 2 PRODUCTS

2.01 DRAIN LINES

A. Drain lines shall be perforated, unless otherwise noted on Drawings.

B. Perforated Drain Lines:

1. Heavy-duty corrugated polyethylene pipe meeting NRCS Conservation Practice Specification 606.

2. Conforming to ASTM F405 for 3-inch to 6-inch diameter pipe.

3. Conforming to ASTM F667 for 8-inch to 15-inch diameter pipe.
4. Water Inlet:
   a. Area of at least 1 square inch per foot of length.
   b. Dimensions of water inlet area shall be measured on a straight specimen with no external forces applied. Make measurements with instruments accurate to 0.01 inch.
   c. Perforations:
      1) Locate at least one perforation in the middle of corrugation so there is a shoulder on each side of perforation.
      2) Pipe 4 Inches to 12 Inches in Diameter:
         a) Slotted perforations shall be no wider than 1/8 inch or no longer than 1-1/4 inches.
         b) Slotted perforations equally spaced along length and circumference of tubing in not less than three rows.
      3) Pipe 15 inches in Diameter: Circular perforations will be accepted.

C. Nonperforated Drain Lines:
   1. Heavy-duty corrugated polyethylene pipe with smooth interior walls.
   2. Conforming to AASHTO M252 for 3-inch to 10-inch pipe.
   3. Conforming to AASHTO M294 for 12-inch to 15-inch pipe, Type S.

D. Drain Sock: Provide geotextile fabric material (sock) surrounding perforated drain lines.

E. Drain Line Fittings:
   1. Includes cleanouts, elbows, tees, branch connections, snap end caps, and reducing couplers.
   2. Conforming to ASTM F405 and ASTM F667 as appropriate.
   3. Cleanout snap end cap shall have a metal locating plate attached as shown in Drawings.
   4. Diameter of cleanout fittings shall be as shown on Drawings.
   5. Fittings installed as part of a continuous operation shall be clamp type rather than snap type. Fittings installed after pipe is in place may be either type.

2.02 GRANULAR DRAIN MATERIAL

A. In accordance with Section 31 23 23.15, Trench Backfill.

2.03 TRENCH BACKFILL

A. Above pipe zone shall be in accordance with Section 31 23 23.15, Trench Backfill.
B. Within pipe zone shall be in accordance with Section 31 23 23.15, Trench Backfill.

2.04 BASE ROCK

A. Base rock shall be clean 1-1/2-inch minus crushed granular or crushed rock uniformly graded from coarse to fine and with sufficient fines for proper compaction.

2.05 PUMP STATION SUMPS

A. Precast Manhole Sections:

1. Conform to ASTM C478 with minimum 48-inch inside diameter.
2. Tops and bottoms of sections shall be parallel.

B. Mortar:

1. Conform to ASTM C387/C387M or be proportioned one part portland cement to two parts clean, well-graded sand which will pass a 1/8-inch screen.
2. Admixtures shall not exceed the following percentages by weight of cement:
   a. Hydrated Lime: 10 percent.
   b. Diatomaceous Earth or Other Inert Materials: 5 percent.
3. Consistency of mortar shall be such that it will adhere readily to pipe.
4. Mortar mixed for longer than 30 minutes shall not be used.

C. Manhole Frames and Covers: Size and style indicated and shown on Drawings.

PART 3 EXECUTION

3.01 TRENCH EXCAVATION

A. Trenching Equipment:

1. Automatic laser-guided grade control.
2. Shoe (or boot) that allows granular fill to be placed uniformly around perforated drain lines in a continuous operation during installation.
3. Equipped with specially lengthened shield.
4. Capable of operating at sufficient speed to ensure drain lines can be laid and blinded with granular drain material before groundwater or soil-water slurry moves into trench and into direct contact with drain line geotextile sock.
B. In accordance with Section 31 23 16, Excavation.

C. Excavate to lines and grades shown on Drawings allowing required thickness of granular fill to be placed around drain lines as shown on Drawings.

D. Installation of Drain Lines below Water Table: Install with trenching machine specifically designed for fluid soil conditions.

3.02 DRAIN LINE INSTALLATION

A. General:

1. No portion of subsurface drainage system shall be installed until the permanent or temporary pump station is installed and operational.
2. Installation of drain lines shall proceed starting from the pump station.
3. Size temporary pumping and conveyance facilities to match rated pump flows and to convey water to approved discharge locations.

B. Pipe Installation:

1. Handle and install in conformance with ASTM F449.
2. Lay drain lines and appurtenances to lines and grades shown on Drawings.
3. Take special precautions on hot days to ensure stretch limit is not exceeded and excessive deflection is not caused by premature backfilling.

C. Fitting Installation:

1. Standard connections shall be in conformance with ASTM F449.
2. For nonstandard connections, join drain lines using manufacturer’s printed recommended methods to complete connection.
3. Drain lines that are exposed to make a connection after trench backfilling shall have 4 inches of granular drain material replaced around drain line and connection.
4. Wrap connections and fittings with geotextile sock.

3.03 GRANULAR DRAIN MATERIAL INSTALLATION

A. Place granular drain material around perforated drain lines as shown on Drawings.

B. Place granular drain material around perforated drain lines in a continuous operation during placement of drain lines.
C. Place granular drain material with spreader boxes or other equipment in a manner to minimize segregation.

3.04 TRENCH BACKFILL

A. Trench shall not be left open overnight; plug end of drain lines and backfill trench to prevent animals, sediment, or debris from entering pipe.

B. Perform in a manner that shall minimize settlement.

C. Backfill may be placed automatically by trencher.

D. Where backfill material is placed in drain line trenches mechanically, backfill material shall be pushed onto slope of backfill previously placed and allowed to slide down into trench. Backfill shall not be pushed into trench in such a way as to permit free fall of material until at least 2 feet of cover has been provided over the top of drain line.

E. Place in such a manner to prevent displacement of drain line and granular fill after backfilling.

F. Trench Compaction:

1. After initial backfilling to final grade, a rubber-tired tractor shall be driven a minimum of two passes with tires running parallel on top of trench to facilitate compaction.

2. Additional mechanical backfilling shall be done to leave trench with 4-inch to 6-inch elevated mound on trench.

G. Unless otherwise directed by Engineer, procedures for compaction of trench backfill material shall be accomplished by close of each day’s work.

3.05 CLEANING ACCESS INSTALLATION

A. Install inline cleanouts, end-of-line caps, and pump station sumps as shown on Drawings.

B. Install inline cleanout in drain lines longer than 1,000 feet and place cleanouts no further than 1,000 feet apart in drain lines longer than 2,000 feet.

C. Install end-of-line caps at upstream end of drain lines.
3.06 PUMP STATION SUMP INSTALLATION

A. Base Preparation:
   1. Remove loose material from excavation.
   2. Place base rock to a compacted depth of not less than 6 inches with top surface at proper elevation.
   3. Place precast base section on compacted imported base material.
   4. Properly locate, ensure firm bearing throughout, and plumb first section.

B. Placing Precast Manhole Sections:
   1. Make joints between precast manhole sections of cement mortar.
   2. Place mortar in groove of the lower section of pipe prior to placing next section.
   3. Set sections plumb.
   4. Fill joints between sections completely with mortar and trowel to a smooth finish.
   5. Joints between precast sections shall be watertight.
   6. Cut openings in precast manhole sections as required to accommodate inlet and discharge pipes.
   7. Cut holes with care and patch with nonshrinking mortar. Bend reinforcement out from the hole insofar as possible so as to reinforce patching.

C. Manhole Inverts: Construct of concrete in accordance with Drawings. Finished inverts shall be free from sharp edges or rough sections and shall provide a smooth flow.

D. Manhole Frame and Cover: Install in bed of mortar so as to provide a tight, secure joint. Elevation of finished cover shall be as shown on Drawings.

3.07 FIELD QUALITY CONTROL

A. Drain Line Grade:
   1. Measure by excavating down to drain every 250 feet and at the beginning and end of each line.
   2. Measure drain invert elevation with a survey method accurate to 0.01 foot vertical.
   3. Measure for grade at the top of pipe.
   4. Drain lines with grades less than 1 percent shall be placed to the design grade within a tolerance of plus or minus 0.1 foot of design invert elevation.
   5. Grades of 1 percent or steeper shall be placed to the design grade within a tolerance of plus or minus 0.2 foot of design invert elevation.
6. No reversal in grade of the drain lines shall be permitted.

B. Drain Line Stretching:

1. Drain lines shall not be stretched more than 5 percent during installation.
2. Measure stretch by measuring the distance across a minimum of 10 corrugations and comparing to manufacturer’s standard corrugation dimensions.

3.08 FINAL INSPECTION AND CLEANING

A. Preparation:

1. Do not begin jet washing until subsurface drainage work is complete.
2. Stage the Work to provide adequate supply of water for jet washing to allow inspection and cleaning of each section of drain line in one continuous operation.
3. Access to drain lines shall be through drain line cleanouts or the pump station sump.

B. High Pressure Jet Washing Equipment:

1. Suitable type and size to perform cleaning specified herein.
2. Cleaning nozzle capable of jet washing 6-inch diameter to 15-inch diameter drain lines in sections up to 1,000 feet long.
3. Capable of negotiating 4-inch diameter cleaning access point.
4. Jet mechanism shall have a forward-piercing jet with trailing side jets that propel mechanism forward.
5. Operating pressures at pump shall not exceed a maximum of 2,300 psi.
6. Operate in accordance with manufacturer’s printed instructions, recommendations, and best practice of the trade.

C. Pass high-pressure water jet cleaner through entire length of each drain line no sooner than 10 calendar days after installation of drain line.

D. When drain lines must be jet washed in sections, upstream sections shall be jet washed before connecting section downstream.

E. If tailwater produced is not clear, run jet cleaner through drain line section up to two more passes.

F. Obstructions within drain lines, collapsed drain line sections, or sections outside allowable tolerances for grade that are identified during final inspection and cleaning shall be repaired and corrected to meet Specification.
G. Complete final drain line inspection and cleaning certification of compliance addressing the following items:

1. Dates of work, equipment, and personnel performing work.
2. Locations and descriptions of obstructions, collapsed sections, out-of-grade sections, and actions taken to repair problems.
3. Locations of sections where tailwater did not run clear after three passes.

H. After completing jet washing for a drain line, restore area to a neat and finished appearance.

END OF SECTION
SECTION 35 20 25
PNEUMATIC GATE SYSTEMS

EQUIPMENT AND COMPONENT NUMBER(S)

Air Compressor 1.
Air Compressor 2.
Air Compressor 3.
Dryer 1.
Dryer 2.
Dryer 3.
Pneumatic Gate Control Panel.
Pneumatic Gate Valve Panel.

PART 1 GENERAL

1.01 SUMMARY

A. This Section covers the Work and materials necessary for the design, fabrication, delivery, installation, startup, and operation training for the pneumatic gate compressed air supply, hydraulic power supply, and control systems for operation of the pneumatic gates, and WaveShaper features as dimensioned on Drawings. The specific design and fabrication details for all materials and equipment shall be the responsibility of the Pneumatic Gate System Supplier. Drawings and Specifications are provided to clarify gate performance requirements contained in the Section. Shop Drawings shall be submitted as specified herein.

1.02 SCOPE OF SUPPLY

A. Items to be supplied by the pneumatic gate manufacturer include (but are not limited to) the following:

1. Control cabinets, per Article Instrumentation and Control, Paragraphs Crest Gate Valve Panel, and Crest Gate Control Panel, herein.
2. Field instruments and cable per Article Instrumentation and Control, Paragraph Field Instrumentation, herein.
3. Compressed air supply system.
4. Hydraulic power supply systems.
5. Anchor bolt setting template.
6. Installation supervision and training by Pneumatic Gate System Supplier’s technician.
7. Delivery FOB site, with freight prepaid.
8. Provide manufacturer’s extended guarantee or warranty with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall cover all aspects of the pneumatic gate system and shall provide for correction of items found defective during a period of 2 years after the date of Substantial Completion. This Special Guarantee includes all work (including parts, labor, equipment, shipping, testing) to remove, replace, and correct equipment furnished by responsible Pneumatic Gate System supplier. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

B. Items to be supplied and Work to be performed by the Installation Contractor include (but are not limited to) the following:

1. Verify conditions.
2. Provide concrete work as shown on Drawings.
3. Provide and install air supply pipe. This includes, but is not limited to:
   a. Encased AHP lines from Compressor Building to gates.
   b. AHP lines in gate structure which terminate as specified by the gate manufacturer for connection to the air bladders.
   c. AHP vent lines and purge valves as shown on Drawings.
4. Install anchor bolts.
5. Install the pneumatic gate system including air bladders, gate panels, and other related components.
6. Install abutment plates, including grouting.
7. Provide and install all electrical conduit.
8. Provide and install all control conduit and cable exterior to the building.
9. Coordinate routing of air supply piping between Compressor Building and the gates.
10. Commission, and test gates in conjunction with gate manufacturer.
11. Provide Neversieze or other approved lubricating compound for all stainless steel anchor bolts and fasteners.
12. Provide 100 percent silicone caulk for all interpanel seals, as needed.

1.03 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Maximum 104 degrees F; minimum minus 20 degrees F.

B. Humidity: Maximum 100 percent relative humidity; minimum 30 percent relative humidity.

C. Atmosphere: If located outdoors, equipment is subject to rain, ice, wind, and snow.
1.04 SUBMITTALS

A. Action Submittals:

1. Complete catalog information, descriptive literature, specifications, and identification of materials of construction for all equipment items provided.
2. Shop Drawings that include detailed structural, mechanical, and electrical drawings showing all equipment dimensions, size, tolerances, locations of connection, and weights of associated equipment.
3. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
4. Action submittals as required by Section 40 99 90, Package Control Systems.
5. Power and control wiring diagrams, including circuit breaker sizes, dimensions, and power distribution.
6. Factory finish systems.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Design calculations for compressed air system. Calculations shall establish sizes for all components in the system (equipment, piping, valves, etc.).
3. Informational submittals as required by Section 40 99 90, Package Control Systems.
4. Special shipping, storage and protection, and handling instructions.
5. Manufacturer’s printed installation instructions.
6. Suggested spare parts list to maintain equipment in service for period of 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
7. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
8. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
9. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services.

1.05 DELIVERY, STORAGE, AND HANDLING OF EQUIPMENT AND MATERIALS

A. Insofar as is practical, the equipment specified herein shall be factory assembled. The parts and assemblies that are, of necessity, shipped unassembled shall be packaged and tagged in a manner that will protect the
equipment from damage and facilitate the final assembly in the field. Generally, machined and unpainted parts shall be protected from damage by the elements of weather with the application of a strippable protective coating.

1.06 EXTRA MATERIALS

A. Three sets of air filter/dryer/separator cartridges.

B. One complete set of any special tools required to service the equipment.

PART 2 PRODUCTS

2.01 MATERIALS

A. Coordinate all penetrations for air piping, cable, and fiber.

B. Provide anchorage of equipment as required in Section 01 88 15, Anchorage and Bracing.

C. Support piping internal to the building in compliance with Section 40 05 15, Piping Support Systems, Anchorage and Bracing.

2.02 COMPRESSED AIR SUPPLY SYSTEM

A. General:

1. The compressed air system shall be complete and shall consist of air compressors with motor and motor starters, air receivers, heatless regenerative air dryers, coalescing prefilters, particulate afterfilters, control panels, piping, valving, wiring and associated accessories. All necessary piping, and wiring for all system components shall be Contractor-supplied.

2. The gate air supply system shall be capable of fully raise the gates within 60 minutes or fully lower the gates within 15 minutes without damage to either the dam structures or any of the gate system components.

B. Air Compressors:

1. High Capacity:
   a. Quantity: Two.
   b. Air-cooled, rotary screw-type, with base-mounted motors and V-belt drives with guards.
   c. Capacity: 196 scfm at 125 psig.
   d. Motor: Squirrel-cage type, with drip-proof enclosure. Rating shall be 40 hp minimum, 480 volts, three-phase, 60-Hz.
e. Manufacturer and Product: Ingersoll Rand; R30I-110.

2. Low Capacity:
   a. Quantity: One.
   b. Air-cooled, rotary screw-type, with base-mounted motors and V-belt drives with guards.
   c. Capacity: 19 scfm at 125 psig.
   d. Motor: Squirrel-cage type, with drip-proof enclosure. Rating shall be 10 hp minimum, 480 volts, three-phase, 60-Hz.
   e. Manufacturer and Product: Ingersoll Rand; R7.5I-110.

3. Equip compressor with full-discharge size flexible stainless steel hose (ASTM A276, Type 321; close pitch, annular corrugated with single braided jacket; U.S. Hose Corp.; Series 401M, “or-equal”) discharge connection, and isolation valve.

4. Provide combination circuit breaker style motor starter for motor control.

5. Controls: As described in Article Instrumentation and Control.

C. Air Dryers:

1. Type: Heatless Regenerative.

2. Power: 120V ac, single-phase, 60-Hz.

3. High Capacity:
   a. Quantity: Two.
   b. Maximum Operating Pressure: 200 psig.
   c. Capacity: 200 scfm.
   d. Manufacturer and Product: Ingersoll Rand; HLA200.

4. Low Capacity:
   a. Quantity: One.
   c. Capacity: 42 scfm at 232 psig.
   d. Manufacturer and Product: Ingersoll Rand; D71M.

D. Accessories:

1. Coalescing Prefilter:
   a. Provide to protect desiccant bed from oil or free water contamination in compressed air supply.
   b. Capable of removing 100 percent of aerosols 0.75 micron and larger, and 100 percent of 0.3-micron solid particles.
   c. Include automatic float drain.

2. Particulate Afterfilter:
   a. Protect air-lines from desiccant dust fines carried over from desiccant towers.
   b. Capable of removing 100 percent of 1 micron and larger particles.
E. Receiver:

1. Quantity: Two.
2. 400-gallon, minimum capacity, suitable for 125 psi working pressure and shall bear the ASME code stamp and plate for pressure vessels.
3. Furnish suitable safety valve, pressure gauge, and float-actuated snap action condensate purge valve (CPV) with isolation valve located at low point.

F. Condensate Treatment Unit:

1. Lubricant adsorbing media filtration.
2. Maximum Contaminant Concentration in Treated Condensate: 10 ppm.
4. Condensate Receptacle: Furnish container suitable for collecting condensate for period of 6 months. Container to be manually emptied to drain external to building.

G. Field Installed Piping: Furnish all piping not covered above and as shown on Drawings, in accordance with Section 40 27 00, Process Piping—General.

2.03 INSTRUMENTATION AND CONTROL

A. General:

1. The crest gate control system shall be in accordance with Section 40 99 90, Package Control Systems, including, but not limited to, instruments, panels, control equipment, application software development and control system testing.
2. All conduit, conductors, and terminations shall be in accordance with Drawings.

B. Gate Control Requirements:

1. Gate control shall include local, remote automatic, and remote manual operating modes.
2. Local-Off-Remote (LOR) switch for the crest gate shall be located in the Gate Control Panel or Valve Panel. It shall be monitored by the crest gate PLC to determine the gate operating mode. If a switch is placed in the OFF position, the gate will not move and will not respond to local or remote commands.
   a. Local Mode:
      1) This mode is intended to allow direct control for maintenance, for local operator intervention, and for backup operation if the PLC or HMI system is offline.
      2) The system shall be capable of incremental raising and lowering of each gate throughout its entire range when the local Up or Down pushbutton is pressed.
   b. Remote Automatic Mode:
      1) The PLC shall be capable of incremental raising and lowering of the gate throughout its entire range automatically to maintain the associated Level or Flow Setpoint as described in Paragraph Control Logic Descriptions.
      2) The duration of the valve operations will be calculated by a PID loop using the associated level or flow measurement signal and operator adjustable setpoint.
      3) The setpoints shall be adjustable from the Crest Gate Control Panel and the City Supervisory Control and Data Acquisition (SCADA) system. See coordination requirements in Section 40 99 90, Package Control Systems.
   c. Remote Manual Mode:
      1) Operators shall be able to override the automatic control of the gate from the Crest Gate Control Panel or the City SCADA system, and place the crest gate controls in Remote Manual mode.
      2) The PLC shall provide the capability for the operator to manually raise or lower gates.

C. Gate Valve Panel:

1. Panel shall be a NEMA 12 enclosure, located in the space shown on Drawings and shall receive power from a 120V ac, single-phase, 20-amp uninterruptible power circuit.
2. The Valve Panel shall include, but not be limited to, the following:
   a. Air pressure regulator.
   b. Pressure gauges.
   c. Pressure transmitters for the gate bladder.
   d. Supply pressure transmitter.
   e. Isolation valves.
f. Pressure relief valves.
g. Manual and automatic control valves.

3. External Interfaces:
a. Provide the following external interfaces:
   1) Discrete Inputs from Crest Gate Control Panel:
      a) Provide for the following contacts:
         (1) Gate RAISE command.
         (2) Gate LOWER command.
   2) One Analog Output to Crest Gate Control Panel:
      a) Provide for the following 4 mA dc to 20 mA dc outputs:
         (1) Crest Gate Bladder Pressure.

D. Crest Gate Control Panel:

1. Panel shall be a NEMA 12 enclosure, located in the space shown on Drawings and shall receive power from one 120V ac, single-phase, 20-amp power circuit and one 120V ac, single-phase, 20-amp uninterruptible power circuit. Critical control components shall be powered by the uninterruptible power circuit.

2. The Crest Gate Control Panel shall include, but not be limited to, the following:
   a. PLC for local and remote gate control as described herein.
   b. Human Machine Interface (HMI) touch panel.
   c. Ethernet network switch 10NS010.
   d. Control Selectors: ESTOP switch.
   e. External Interface:
      1) Crest Gate Control Panel:
         a) 120V ac Dry Contact Command Signals.
         b) LOCAL mode command.
         c) REMOTE mode command.
         d) OFF position status.
         e) Local RAISE command.
         f) Local LOWER command.
      2) Ethernet Communication to SCADA:
         a) All discrete PLC inputs shall be available to be monitored by the SCADA system.
         b) All analog PLC inputs shall be available as scaled values for monitoring by the SCADA system.
         c) All operator control functions, setpoints, and alarms that are available on the HMI shall be available from the SCADA system.
3) Ethernet Communication from SCADA:
   a) All operator control functions available from the HMI shall be available from SCADA.
   b) Forebay water level shall be read by the Crest Gate Control Panel from the SCADA system.

3. HMI:
   a. Indication shall include, but not be limited to, the following:
      1) Gate 0 percent to 100 percent position indicator.
      2) Gate pressure indicator.
      3) Supply pressure indicator.
      4) REMOTE mode indicator.
      5) LOCAL mode indicator.
      6) Air Compressor RUNNING indicator.
      7) Air Compressor RUNTIME hours.
      8) Air Compressor number of STARTS.
      9) Calculated flow.
     10) Forebay level.
     11) Gate Flow/Level control mode status.

   b. Control Functions:
      1) Gate 1 Remote Auto/Manual mode select.
      2) Gate 1 Flow Control Loop:
         a) Auto/Manual mode selection.
         b) Automatic flow setpoint.
         c) Manual gate position setpoint.
         d) Loop tuning PID entry.
      3) Gate 1 Level Control Loop:
         a) Auto/Manual mode selection.
         b) Automatic level setpoint.
         c) Manual gate position setpoint.
         d) Loop tuning PID entry.
      4) Supply Air Pressure High alarm setpoint.
      5) Supply Air Pressure Low alarm setpoint.
      6) Forebay High High Level alarm setpoint.
      7) Forebay High Level alarm setpoint.
      8) Forebay Low Level alarm setpoint.
      9) Forebay Low Low Level alarm setpoint.

   c. Alarms:
      1) E-Stop switch.
      2) LOW Supply Pressure.
      3) HIGH Supply Pressure.
      4) Forebay High High Level.
      5) Forebay High Level.
      6) Forebay Low Level.
      7) Forebay Low Low Level.
8) UPS on battery.
9) UPS low battery.
10) Utility power failure.
11) Analog input signal out of range alarm for each hardwired analog input.
12) HMI to PLC communication failure.

d. Security: HMI shall include three levels of security.
   1) View Only: No login required. Full navigation to all graphics available without login. No control function changes allowed.
   2) Operator: Username and Password required to adjust setpoints or to change control modes.
   3) Supervisor: Username and Password required to adjust PID tuning parameters.

e. History:
   1) All analog values including measured, calculated, setpoints, and tuning parameters shall be stored in history once per second.
   2) Provide minimum of 9 months of hard disk data storage. After 9 months, oldest data will be overwritten to ensure hard disk space is not completely filled.
   3) Provide written procedure for backing up historical data to USB drive for transfer to offsite storage.

f. Graphics:
   1) Menu navigation buttons shall be visible from all other graphics.
   2) Overview graphic shall provide status of entire system.
   3) Individual gate control popup graphics shall provide individual gate control interface.
   4) Alarm banner shall be visible from all other graphics.
   5) Alarm summary table graphic shall include the following:
      a) Alarm description and tag.
      b) Current active unacknowledged alarms.
      c) Current active acknowledged alarms.
      d) Time and date stamp of all alarms.
   6) Alarm history table graphic shall include the following:
      a) Alarm description and tag.
      b) Time and date stamp of alarm.
      c) Time and date stamp of alarm return to normal.
      d) Time and date stamp of operator acknowledgement of alarm.
      e) Provide a minimum of 500 historical alarm entries. Oldest alarm data will be overwritten to ensure hard disk space is not completely filled.
7) Trending graphic(s) shall include the following:
   a) Operator selection of historical tags to be displayed.
   b) Display up to 10 tags per trend graphic.
   c) Adjustable time and amplitude ranges.

E. Field Instrumentation:

   1. Inclinometers: Inclinometers will be provided on either end of each independently-operated gate section 30 feet or greater in width. Independently-operated gates less than 30 feet will have a single inclinometer installed at the gate edge. Inclinometer installation is as shown on approved gate manufacturer’s shop drawings. Inclinometer shall produce 4 mA dc to 20 mA dc signal in direct proportion to gate angle (from horizontal) for remote monitoring purposes. Angle shall be measured 0 degree to 90 degrees (from horizontal), with 20 mA signal equivalent to gate fully extended (90 degrees). Provide cable from each inclinometer to the terminal junction box as shown on approved gate manufacturer’s shop drawings.
      a. Resolution: 0.01 degree.
      b. Null Repeatability: Less than 0.04 degree.
      c. Repeatability: Less than 0.08 degree.
      e. Environmental: Minus 30 degrees C to 75 degrees C.

   2. Manufacturer and Product:
      a. Obermeyer; TSM-005.
      b. “Or-equal.”

F. Control Logic Descriptions:

   1. The Crest Gate PLC and HMI shall provide all of the automatic control functions as described.
      a. Group 1 Gates will be automatically controlled based on, forebay level control.

2.04 FACTORY FINISHING

A. Compressed air system components shall be coated with manufacturer’s standard coating.

PART 3 EXECUTION

3.01 INSTALLATION

A. The equipment specified herein shall be located as indicated and installed in conformance with the manufacturer’s suggested method as approved.
Contractor shall provide such additional incidental materials and labor as required for a complete and proper installation.

3.02 FIELD FINISHING

A. Factory-Finished Equipment: Repair damaged surfaces using manufacturer’s paint touchup kit.

3.03 FIELD QUALITY CONTROL

A. Prior to startup, all equipment shall be tested and inspected for proper alignment, quiet operation, proper connection, and satisfactory performance in conformance with Section 01 91 14, Equipment Testing and Facility Startup.

B. Functional Tests:

1. Each gate shall be fully raised and lowered three times using the control system. The gates shall operate smoothly with no binding.

2. Each gate system shall be inflated to one-half normal operating pressure. The gate system shall be isolated from the air supply system and held at pressure for 24 hours. Pressure and outside ambient temperature, and the position of the upper edge of each gate shall be recorded at the beginning and at 3-hour to 6-hour intervals during the test. Test data are considered satisfactory if the temperature-corrected bladder pressure is maintained, and gates do not drop more than 4 inches. Any bladders exhibiting leakage will be repaired by the manufacturer at no cost to the Owner. If the Contractor is responsible for the damage, the Contractor shall be responsible for making the necessary repairs that shall be acceptable to the Owner and the gate manufacturer at no cost to the Owner or gate manufacturer.

3. All Local control functions shall be fully tested prior to testing SCADA functions.

4. In coordination with Owner, the gate shall be fully tested including the following SCADA functions:
   b. Remote automatic control.
   c. Level and flow setpoint adjustment and PID control to maintain the associated control setpoint.
   d. Validate all remote monitoring status and alarm signals.

5. Documentation of the functional tests will be provided by the Contractor to the Owner’s representative for approval. If test results are unsatisfactory, the Contractor must remedy the cause of test failure, and retest.
C. Performance Tests:

1. In coordination with Owner, the gates shall be tested through the full operating range:
   a. Fully lowered.
   b. Partially raised in 10 degree increments with 0.5 feet overtopping at each increment. Hold gate position with 0.5 feet overtopping for 30 minutes at each increment.
   c. Fully raised with 0.5 feet overtopping.
   d. Validate gates were able to maintain position and meet all operational requirements specified.
   e. Validate all remote monitoring status and alarm signals.
   f. Documentation of the performance tests will be provided by the Contractor to the Owner’s representative for approval. If test results are unsatisfactory, the Contractor must remedy the cause of test failure, and retest.

3.04 MANUFACTURER'S SERVICES

A. Present at the Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 3 person-days for Software Development Workshop in conformance with Section 40 99 90, Package Control Systems.
3. 1 person-day for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation.
4. 1 person-day for prestartup classroom training.

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, General Requirements Specification Sections, apply to this Section.

1.02  WORK OF THIS SECTION

A. Work of this Section includes furnishing all labor, materials, equipment, and incidentals required and performing all operations in connection with the installation of commercially available Articulating Concrete Blocks (ACB) for revetments and ramps in accordance with the lines, grades, design and dimensions shown on Drawings and as specified herein.

B. In addition to the work indicated, work includes restoring all areas within the limit of work disturbed by work of the Contract and coordination of work with other subcontractors.

1.03  RELATED SECTIONS

A. The following items of related work are specified and included in other Sections of the Specifications:

1. Section 01 33 00, Submittal Procedures.
2. Section 01 50 00, Temporary Facilities and Controls.
3. Section 31 23 16, Excavation.
4. Section 31 23 23, Fill and Backfill.
5. Section 31 32 19.16, Geotextile.
6. Section 31 37 00, Riprap.
7. Section 32 15 00, Granular Paving.
8. Section 32 84 00, Landscape Irrigation.
10. Section 32 91 19.13, Planting Soil System Installation.
11. Section 32 92 01, Prairies, Meadows, and Wetlands.
1.04 DEFINITIONS

A. Precast Articulating Concrete Block System: A matrix of interconnected concrete block units for erosion protection. Units are connected by geometric interlock and/or cables, geotextiles, or geogrids, and include a geotextile underlayment for subsoil retention.

B. Blocks: ACB revetment units will be referred to as blocks.

C. Interlocking Blocks: Each pair of abutting blocks shall have interlocking keys that limit lateral expansion. The key and keyhole shall have an interference fit such that the joint movement has a minimum aperture at closure, and a maximum aperture when pulled apart. The joint “freeplay” shall allow articulation of each individual block.

D. Freeplay: The maximum lateral joint movement for interlocking blocks (difference between maximum and minimum aperture).

1.05 PERFORMANCE REQUIREMENTS

A. Certification (Open-Channel Flow): ACB mats will only be accepted when accompanied by documented hydraulic performance characteristics that are derived from tests under controlled flow conditions. Testing guidelines shall conform to FHWA-RD-89-199 and all hydraulic performance testing shall be performed in a on a 2H:1V soil slope in a flume.

B. Static Coefficient of Friction for Paving: Value for Level Surfaces shall be 0.6 minimum in accordance with ASTM C1028.

1.06 SUBMITTALS

A. General: Refer to and comply with Section 01 33 00, Submittal Procedures, for procedures and additional submittal criteria.

B. Product Data: Submit descriptive technical data including all material properties specified herein. Include catalogue cuts, technical data sheets, or test data showing that the products meet the specifications. The submittal shall also include a copy of any standard manufacturer's warranties for the products.

1. Submit for:
   a. Articulating concrete block.
   b. Geotextile.
C. Samples:
   1. Articulating Concrete Block: Submit one sample of each type of proposed block concurrent with the ACB and Geotextile Data product data submittal. The samples shall be typical of the size, texture, color, and finish.

D. Quality Control Submittals:
   1. Test reports.
   2. Geotextile Fabric: Submit manufacturer's certified test results showing actual test values obtained when the physical properties are tested for compliance with the requirements listed Error! Reference source not found herein. Include Gradient Ratio or the Hydraulic Conductivity Ratio tests as required for the geotextile selection in paragraph 2.3A.3.
   3. Manufacturer's Certificates of Compliance: Submit for ACB blocks/mats, revetment cable, and any revetment cable fittings and connectors.

1.07 REFERENCES AND STANDARDS

A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

2. ASTM International (ASTM):
   b. C140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   g. C1262, Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units.
   h. D4873, Identification, Storage, and Handling of Geosynthetic Rolls and Samples.
ZINK DAM IMPROVEMENTS


   a. FHWA-RD, Minimizing Embankment Damage during Overtopping.

1.08 DELIVERY, STORAGE AND HANDLING

A. Acceptance at Site: Check products upon delivery to ensure that the proper material has been received and is undamaged. For geosynthetics, the guidelines presented in ASTM D4873 shall be followed.

B. Blocks: Store blocks in a suitable location away from mud, paint, wet cement, and other contamination or disturbance.

C. Geotextiles:
   1. Labeling: Label each roll with the manufacturer's name, product identification, roll dimensions, lot number, and date manufactured.
   2. Handling: Handle geosynthetic and unload by hand, or with load carrying straps, a forklift with a stinger bar, or an axial bar assembly. Do not drag geosynthetic rolls, lift by one end, lift by cables or chains, or drop to the ground.
   3. Storage: Protect geotextiles from cement, paint, excessive mud, chemicals, sparks and flames, temperatures in excess of 140 degrees F, and any other environmental condition that may degrade the physical properties. If stored outdoors, the rolls shall be elevated from the ground surface and protected with an opaque waterproof cover. Deliver geotextiles to the site in a dry and undamaged condition. To the extent possible, keep the fabric wrapped in its protective covering. Do not expose geotextile to sunlight, ultraviolet rays until the installation process begins.

1.09 SCHEDULING

A. To limit ultraviolet light exposure of the geotextile, place the ACB blocks within 7 days after placing the geotextile, and the void filler within 14 days after placing the geotextile.
PART 2  PRODUCTS

2.01  MATERIALS

A.  Cementitious Materials:

1. Portland Cement: ASTM C150, Type II.
4. Pozzolans (Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete): ASTM C618.

B.  Aggregates: Normal Weight, ASTM C33, except that grading requirements shall not necessarily apply.

2.02  ARTICULATING CONCRETE BLOCK (ACB)

A.  General:

1.  Fabricate ACB mats as an assembly of concrete blocks, with specific hydraulic capacities, laced with revetment cables where indicated or required. ACB mats may be assembled on-site by hand-placing the individual units either with or without subsequent insertion of cables as indicated or noted on Drawings.
2.  Individual units in the system shall be staggered and interlocked for enhanced stability. Construct the mats with open and/or closed cell units as indicated. The open cell units have two vertical openings of rectangular cross section with sufficient wall thickness to withstand loads applied during shipping and installation. Parallel strands of cable shall extend through two cable ducts in each block allowing for longitudinal binding of the units within a mat. Each row of units shall be laterally offset by one-half of a block width from the adjacent row so that any given block is cabled to four other blocks (two in the row above and two in the row below).
3.  Each block shall incorporate interlocking surfaces that minimize lateral displacement of the blocks within the mats when they are lifted by the longitudinal revetment cables. The interlocking surfaces must not protrude beyond the perimeter of the blocks to such an extent that they reduce the flexibility or articulation capability of the cellular mats or become damaged or broken when the mats are lifted during shipment or placement. Once the mats are in place, the interlocking surfaces shall minimize the lateral displacement of the blocks even if the cables should become damaged or removed. The mats must be able to flex a minimum of 18 degrees between any given row or column of blocks in the uplift direction and a minimum of 45 degrees in the downward direction.
4. The cables inserted into the mats shall form lifting loops at one end of the mat with the corresponding cable ends spliced together to form a lifting loop at the other end of the mat. Insert the cables only after sufficient time has been allowed for the concrete to complete the curing process.

5. The cellular concrete mats shall be placed on a filter fabric as specified herein. Under no circumstances shall the geotextile be affixed (i.e. chemically bonded to the blocks) to the mattress in a manner in which would jeopardize the functionality of the filter fabric. Specifically, the filter fabric shall be independent of the block system.

B. Concrete Unit Requirements:

1. Blocks:
   a. ASTM D6684, sound and free of defects that would interfere with proper placement or that would impair the strength or longevity of the installation. Minor surface cracks, incidental to the usual method of manufacture, or chipping that result from customary methods of handling in shipping, delivery and placement will not be deemed grounds for rejection. Discard blocks with the following defects:
      1) Broken appendages.
      2) Chips larger than 2 inches in any dimension or resulting in a weight loss exceeding 10 percent of the average weight of a concrete unit.
      3) Cracks wider than 0.02 inches in width, longer than 33 percent of the nominal height, and/or 1.0 inch in depth.

2. The concrete units shall be produced by a dry cast method. The dry cast units obtain strength in a shorter duration as well as an increase in the durability and overall quality of product.

3. The minimum compressive strength shall be 4,000 psi for an average of three units, and 3,500 psi for an individual unit. Compressive strength shall be determined by ASTM C140.

4. The maximum water absorption for dry cast units shall be 9 pcf for an average of three units, and 12 pcf for an individual unit. Water absorption shall be determined by ASTM C140.

5. The minimum saturated surface-dry density shall be 140 for average of three units, and 140 for an individual unit.

6. For freeze-thaw durability tested in accordance with ASTM C1262, specimens shall comply with either of the following:
   a. The weight loss of each of five specimens after 100 cycles shall not exceed 1 percent; or
   b. The weight loss of each of five specimens after 150 cycles shall not exceed 1.5 percent.
C. The ACB Matrix Assembly shall meet the following criteria in Table 1 below:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Required Value</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Shear Stress, Minimum</td>
<td>3.5 psf</td>
<td>FHWA RD-89-199</td>
</tr>
<tr>
<td>Critical Velocity, Minimum</td>
<td>15 ft/sec</td>
<td>FHWA RD-89-199</td>
</tr>
<tr>
<td>Curvature Radius, Maximum</td>
<td>3 feet</td>
<td>Note b.</td>
</tr>
<tr>
<td>Surface Void Area Ratio</td>
<td>25 to 40 percent</td>
<td>Note c.</td>
</tr>
<tr>
<td>Drainage Correction Factor (dcf)</td>
<td>20 to 35 percent</td>
<td>Note d.</td>
</tr>
<tr>
<td>Block/Geotextile Interface Friction Angle</td>
<td>35 degrees</td>
<td>Note e.</td>
</tr>
</tbody>
</table>

Notes:

a. Determine the weight of the mattress per unit area with the nominal joint spacing, in a nonsubmerged condition.

b. The curvature radius shall be indicative of the ability of the assembled mattress to conform to one-dimensional subgrade curves without binding, such as for anchor trenches and swales. The curvature radius shall be demonstrated, if requested by the Construction Manager.

c. The surface void area ratio shall be determined at the visible (with filled voids) surface of the blocks, with the joints spaced in a neutral position (50%), and shall be expressed as a percentage of the gross mat area. The void area shall include area between the blocks and open cells within the block.

d. The drainage correction factor shall be the minimum void area ratio (usually taken at the base of the blocks), with the joints spaced in a neutral position (50% freeplay in each direction), and shall be expressed as a percentage of the gross mat area.

e. The concrete surface shall be sufficiently rough to prevent sliding of the blocks on the geotextile. The interface friction must be matched with the selected block and geotextile combination, and shall be included with the ACB and geotextile data submittal. The block/geotextile interface friction angle shall be demonstrated, if requested by the Landscape Architect.
D. Matrix Assembly - Interlocking Blocks: Interlocking blocks are assumed to function without the use of cables or similar restraints. Place void filler to inhibit lateral movement and block pullout, cover the geotextile, and increase hydraulic stability.

E. Matrix Assembly - Cabled Systems: Interlock cable tied concrete block by flexible cables running through the blocks. Each block shall be penetrated by a cable that allows articulation of the blocks, but restrains removal of individual blocks. Place void filler to inhibit lateral movement, cover the geotextile, and increase hydraulic stability.

F. Available Manufacturers:

4. “Or-equal.”

2.03 GEOTEXTILE

A. Geotextile used as filters below the ACB shall be a woven fabric. The geotextile shall meet the material properties specified in AASHTO M288 for Class 1 strength property requirements and for permanent erosion control. Filter requirements in AASHTO M288 shall be based on in-situ soil with greater than 50 percent passing the 0.075 mm sieve opening.

1. The geotextile must be permitted to function properly by allowing relief of hydrostatic pressure; therefore fine soil particles shall not be allowed to clog the fabric.
2. The geotextile fiber shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of propylene, ethylene, ester, or amide, and shall contain stabilizers and/or inhibitors added to the base plastic, if necessary, to make the filaments resistant to deterioration due to ultraviolet and heat exposure. The edges of the geotextile shall be finished to prevent the outer fiber from pulling away from the geotextile.
3. Final acceptance of the filtration geotextile by the Landscape Architect will be dependent upon the geotextile performance when tested in accordance with ASTM D5101. Soil characteristics such as grain size distribution and plasticity shall be determined for each source of borrow material used during construction. Significant differences in soil characteristics shall require further performance testing by either the Gradient Ratio or the Hydraulic Conductivity Ratio tests of ASTM D5101 at the discretion of the Landscape Architect. The locations for which the material to be tested is extracted shall be approved by the Landscape Architect. The Contractor shall provide the site-specific soil and modified Proctor curves for the site-soil, at his own expense, to the manufacturer. Also, the Contractor shall be responsible for the performance of the test by a certified independent laboratory experienced in performing such test. The test shall be performed under the actual field soil conditions or as otherwise required by the Landscape Architect.

4. In the event pre-assembled panels of fabric are required, the panels of geotextile fabric shall be sewn together at the manufacturer or another approved location.

2.04 CABLE

A. Installation Requirements for Cable: Size and fasten cable used for preassembled mattresses sufficient for the size/weight of the assembled mattresses such that the assembled mattresses can be placed in compliance with OSHA standards. The manufacturer shall be responsible for determining the minimum cable strength compatible with the mattress size for safe handling. Base cable strength on a minimum factor of safety of five, and include appropriate reduction factors for mechanically crimped cable, and other fasteners. If applicable, loading conditions shall include the use of a spreader bar for placing the mattresses.

B. Design Requirements for Cable: Use ropes manufactured from polyester, stainless steel wire, or galvanized steel wire for ACB's that rely on cables to maintain block to block interconnection. Select cable and fittings in a manner that ensures a safe design factor for mats being lifted from both ends, thereby forming a catenary. Consider the bending of the cables around hooks or pins during lifting. Select revetment cable splicing fittings so that the resultant splice provides a minimum of 60 percent of the minimum rated cable strength. Fittings such as sleeves and stops shall be aluminum and washers shall be galvanized steel unless otherwise shown on Drawings. The revetment cable shall exhibit resistance to most concentrated acids, alkalis and solvents. Cable shall be impervious to rot, mildew and degradation associated with marine conditions.
organisms. The materials used in the construction of the cable shall not be affected by continuous immersion in fresh or salt water.

1. Polyester Revetment Cable and Fittings:
   a. High tenacity, low elongating, continuous filament polyester fibers; and consisting of a core construction comprised of parallel fibers contained within an outer jacket or cover. The weight of the parallel core shall be between 65 percent to 70 percent of the total weight of the cable. The revetment cable shall have the following physical properties:

<table>
<thead>
<tr>
<th>Nominal Cable Dia. (D), inches</th>
<th>Approx. Avg. Strength (lbs)</th>
<th>Weight per Length (lbs/100 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>3,000</td>
<td>2.2</td>
</tr>
<tr>
<td>5/16</td>
<td>7,000</td>
<td>4.4</td>
</tr>
<tr>
<td>3/8</td>
<td>10,000</td>
<td>5.5</td>
</tr>
<tr>
<td>1/2</td>
<td>15,000</td>
<td>9.7</td>
</tr>
</tbody>
</table>

1) Elongation requirements specified below are based upon stabilized new, dry cable. Stabilization refers to a process in which the cable is cycled 50 times between a load corresponding to 200D2 and a load equal to 10 percent, 20 percent or 30 percent of the cable's approximate average breaking strength. Relevant elongation values are as shown in Table 2 below. The tolerance on these values is plus 5 percent.

<table>
<thead>
<tr>
<th>Percentage of Break Strength</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastic Elongation</td>
<td>0.6</td>
<td>1.4</td>
<td>2.2</td>
</tr>
</tbody>
</table>
2. Galvanized Steel Revetment Cable and Fittings: Preformed galvanized aircraft cable made from individual wires and strands that have been formed during the manufacture into the shape they have in finished cable.
   
a. Cable shall consist of a core construction comprised of seven wires wrapped within seven- or 19-wire strands with the physical properties in Table 3:

<table>
<thead>
<tr>
<th>Nominal Cable Dia. (D), inches</th>
<th>Type</th>
<th>Approx. Avg. Strength (lbs)</th>
<th>Weight per Length (lbs/100 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8 7x7</td>
<td></td>
<td>1,700</td>
<td>2.8</td>
</tr>
<tr>
<td>3/16 7x7</td>
<td></td>
<td>3,700</td>
<td>6.2</td>
</tr>
<tr>
<td>1/4 7x7</td>
<td></td>
<td>6,100</td>
<td>10.6</td>
</tr>
<tr>
<td>5/16 7x19</td>
<td></td>
<td>9,800</td>
<td>17.3</td>
</tr>
<tr>
<td>3/8 7x19</td>
<td></td>
<td>14,400</td>
<td>24.3</td>
</tr>
</tbody>
</table>

2.05 VOID FILLER

A. Aggregate: Aggregate for filling the voids in the block shall meet the requirements of ASTM D1241, Gradation D.

2.06 FABRICATION

A. ACB, cables, and fittings may be fabricated into mattresses at the manufacturer's plant or another approved location into mats with a width of up to 8 feet and a length up to 40 feet, as approved by the Landscape Architect.

B. Mat Length: The ACB mats shall have the ability for fabrication in various lengths, widths, and in combinations of length and/or widths. Special mats are a combination of two opposing dimensions either in the longitudinal or transverse direction of the mats. The special mats are available in various dimensions that allow for a custom fit to a site-specific project.
2.07 SOURCE QUALITY CONTROL

A. The purchaser or their authorized representative shall be accorded proper access to facilities to inspect and sample the units at the place of manufacture from lots ready for delivery.

PART 3 EXECUTION

3.01 PREPARATION

A. Clearing: Completely remove all vegetation as specified in Section 02 41 13, Site Preparation, Clearing and Protection. Remove remaining roots from trees and brush to a depth of 1 foot below the subgrade surface. Loose roots and twigs, turf clods, grade stakes, stones larger than 1/2-inch diameter, and other debris shall be raked and removed from the final surface. Rills and gullies from erosion shall be corrected.

B. General: Perform all subgrade preparation as per ASTM D6884. Place the ACB revetment on undisturbed native soils, or acceptably placed and compacted fill. Do not place the ACB on surfaces that contain mud, frost, organic soils, embankment that has not met compaction requirements, or where the Construction Manager determines that unsatisfactory material remains in or under the subgrade.

C. Bank Grading: Rough grade to a smooth surface, typical of that obtainable with a dozer and blade. A rough surface typically obtained with a backhoe or dragline will not be acceptable, except when ACB placement in water is shown on Drawings or approved by the Construction Manager. When natural shorelines require grading in preparation for ACB installation, observe and document the bank stratification in daily Contractor Quality Control reports. Avoid grading practices of spreading fine grained soils over more pervious soils, particularly near practices of spreading fine grained soils over more pervious soils, particularly near.
D. Compaction and Subgrade Finishing: Compact fill soils to the specified density in **Section 31 20 00, Earthwork**. Compact incidental grading (where embankment is not otherwise specified) by heavy equipment or by tamping with a bucket to a density characteristic of the surrounding soils. Compact the final surfaces accessible by compaction equipment with a smooth drum roller or vibratory plate tamper until there is no further evidence of consolidation. Where slopes limit operation of compaction equipment, back-drag the final surface to a dense smooth surface with bladed equipment. Correct localized loose or soft zones.

1. Fine grade the slope to a smooth plane surface to ensure that intimate contact is achieved between the slope face and the geotextile (filter fabric), and between the geotextile and the entire bottom surface of the cellular concrete blocks. No holes, "pockmarks", slope board teeth marks, footprints, or other voids greater than 0.5 inch in depth normal to the local slope face shall be permitted. No grooves or depressions greater than 0.5 inches in depth normal to the local slope face with a dimension exceeding 1 foot in any direction shall be permitted. Where such areas are evident, bring to grade by placing compacted homogeneous material. Uniformly compact the slope and slope face; the depth of layers, homogeneity of soil, and amount of compaction shall be as required by the Landscape Architect.

2. If and where indicated, excavate and prepare anchor trenches, flanking trenches, and toe trenches or aprons in accordance to the lines, grades and dimensions shown on Drawings. Uniformly grade the anchor trench hinge-point at the top of the slope so that no dips or bumps greater than 0.5 inch over or under the local grade occur. The width of the anchor trench hinge-point shall also be graded uniformly to assure intimate contact between all cellular concrete blocks and the underlying grade at the hinge-point.

3. Grade Tolerances: Within 2 inches from the prescribed elevations, with no abrupt variations that would cause unacceptable projections of individual blocks.

4. Subgrade Surface Tolerances: Maintained in a smooth condition between installation of the geotextile and the blocks. Windrows, stones, clods of cohesive soil, and irregularities shall be raked smooth. Correct ruts, rills and gullies resulting from traffic, precipitation runoff, groundwater seepage, etc. prior to installation of blocks.
3.02 GEOTEXTILE INSTALLATION

A. Inspection: Immediately prior to placing the fabric and ACB blocks, the prepared subgrade will be inspected by the Construction Manager and Landscape Architect. Do not place fabric or blocks thereon until that area has been approved by each of these parties.

1. At the time of installation, the geotextile will be rejected if it has been removed from its protective cover for over 72 hours or has defects, tears, punctures, flow deterioration, or damage incurred during manufacture, transportation or storage. With the acceptance of the Landscape Architect, place a geotextile fabric patch over the damaged area prior to placing the mats to repair a torn or punctured section of fabric. The patch shall be large enough to overlap a minimum of 3 feet in all directions.

B. General: Place geotextile within the limits of ACBs shown on Drawings and in accordance with as per ASTM D6884. Lay the geotextile flat and smooth so that it is in direct intimate contact with the subgrade. The geotextile shall be free of tension, folds, and wrinkles. Minimize the number of seams and overlaps by selective orientation of geotextile panels, within the limitations of maintaining a consistent pattern. Do not walk on or disturb the geotextile when the result is a loss of intimate contact between the cellular concrete block and the geotextile or between the geotextile and the subgrade. Place geotextile immediately prior to block installation, if necessary to limit damage to the geotextile from equipment or repeated pedestrian traffic and limit disturbance of the subgrade from precipitation or runoff.

C. Seams: Shingle seams on slopes and butt end seams so that runoff and channel flow passes over the fabric. Overlap the longitudinal and transverse joints at least 2 feet. Extend the geotextile at least 1 foot beyond the top and bottom revetment termination points, or as indicated or required by the Landscape Architect. If ACBs are assembled and placed as large mattresses, the top lap edge of the geotextile should not occur in the same location as a space between cellular concrete mats unless the space is concrete filled. Secure geotextile panels before block placement by adequate sandbags, spare blocks, or pins/staples.

3.03 ACB INSTALLATION

A. Place ACB in accordance with as per ASTM D6884, the manufacturer's recommendations and approved Shop Drawings.
B. Placement of Pre-Assembled Mattresses: Place with mattresses attached to a spreader bar or other approved device to aid in lifting, aligning and placing the mattresses by the use of a crane or other approved equipment. The equipment used shall have adequate capacity to place the mats without bumping, dragging, tearing or otherwise damaging the underlying fabric. Place the mattresses directly into position, side-by-side and/or end-to-end, so that the mats abut each other with a maximum space or gap between mattresses of 3 inches in excess of the nominal joint spacing of blocks within the mattress. Backfill mat seams or openings between mats greater than 2 inches with 4,000 psi nonshrink grout, concrete or other material approved by the Landscape Architect. Lift and reset mattresses out of alignment. Do not push or pull mattresses laterally after they are in contact with the geotextile. No overlapping of mats will be accepted and no blocks shall project vertically more than 1 inch beyond the adjacent blocks. As adjacent mats are placed, secure them to each other by fastening the protruding horizontal and vertical cable connections and end cable loops together along each side of the mats.

C. Whether placed by hand or in large mattresses, distinct changes in grade that results in a discontinuous revetment surface in the direction of flow will require backfill at the grade change location so as to produce a continuous surface.

D. Hand Placement of Interlocking Blocks: Space hand placed blocks to maximize the ACB ability to articulate. Use adequate alignment control, such as string lines, to keep the block pattern in alignment and the joint spacing consistent and uniform. Initially, no more than two working block rows shall progress simultaneously in the direction of placement. Add additional working rows only after experience shows that true lines are maintained. The starting position for ACB placement shall be a convenient location for control of the block pattern alignment. The Construction Manager shall approve of the starting position for placement of the ACB.

1. Target Joint Spacing: install interlocking blocks with a uniform aperture in the interlocking connections. The target joint spacing shall be neutrally spaced with equal free-play for the joint to open and close.

2. Correction of Joint Spacing: If the block pattern becomes skewed to an extent that blocks bind, joints close, or blocks stickup, then remove and replace ACB determined to be out of tolerance. Where the nonconformance of the joint spacing is due to project features, such as warped slopes or anchor trenches, then field locate cast-in-place concrete joints in concurrence with the Landscape Architect.
3. Maintenance of Joint Spacing: If the block pattern becomes skewed to an extent that the joint freeplay is not acceptable to the Landscape Architect, then cast-in-place concrete joints field located as directed by the Landscape Architect.

4. Block Layout Pattern Dependent on Project Features: If the block pattern is shown to be maintained parallel and perpendicular to selected project features, such as the crest/toe of levee/channel slopes, then implement field location of cast-in-place concrete joints as needed, and as directed by the Landscape Architect.

E. Tolerances: Maximum acceptable block projections (vertical offset from adjacent blocks) for "installation in the dry" shall not exceed 0.5 inch for interlocking blocks and 1 inch for cabled systems. Typical block projections shall be less than half the maximum projections.

F. Termination trenches and side trenches will be backfilled and compacted flush with the top of the blocks. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the cellular concrete blocks for its entire service life. Toe trenches will be backfilled as shown on Drawings.

G. Finishing: Backfill and compact the cells or openings in the cellular concrete blocks with suitable material, as specified by the Landscape Architect. Complete backfilling and compaction in a timely manner.

H. Finishing requirements are explicitly at the discretion of the Landscape Architect.

3.04 CONCRETE JOINTS

A. General Requirements:

1. Minimize the use of cast-in-place concrete joints to the extent practicable. Inform the Construction Manager of all concrete joints not shown on Shop Drawings prior to field placement. Joints that shall require concrete include:
   a. Joints between cable-tied ACB mattresses where the joint is 3 inches wider than the nominal joint.
   b. Joints where block interlock is discontinuous.
   c. Abutments where the ACB meets headwalls, pipe penetrations, or sidewalks.
   d. Any areas where there are partial blocks (to avoid small blocks with reduced hydraulic stability).
B. Abutments: The ACB shall abut pathways in a neat appearance. Unless a specific detail is indicated on Drawings, fill voids with partial blocks and fill the gap with cast-in-place concrete. Install the concrete flush with the surface of the blocks, and float finished.

3.05 VOID FILLER

A. The voids of the articulating concrete block mats shall be filled with aggregate void filler. All cable ties shall be completed prior to filling voids.

3.06 FIELD QUALITY CONTROL

A. Field installation procedures shall comply with the procedures utilized during the hydraulic testing procedures of the recommended system. All system restraints and ancillary components (such as synthetic drainage mediums) shall be employed as they were during testing. For example, if the hydraulic testing installations utilize a drainage layer then the field installation must utilize a drainage layer; an installation without the drainage layer would not be permitted.

B. Tests: The Contractor’s Testing Laboratory shall perform the following testing independent of the manufacturing process, by an agency other than the manufacturer. The ACB blocks shall be sampled and tested for compressive strength, water absorption and unit weight. The sample frequency shall be three specimens for each type of ACB.

1. Test methods shall be consistent with those specified in Part 2 of this section.

C. Manufacturer’s Field Service: The manufacturer of the ACB shall provide design and construction advice during the design and initial installation phases of the project as necessary, by the discretion of the Construction Manager.

3.07 PROTECTION

A. Protect work against damage from subsequent operations. Remove and replace displaced or broken blocks to conform to all requirements of this section. Do not incorporate damaged material into the work. Do not allow equipment on the ACB that could crack, cause abrasion, or otherwise damage the blocks. Do not operate vehicles directly on geotextile, except that rubber tired vehicles may operate directly on short reaches of geotextile that meets or exceeds AASHTO M288 survivability requirements for Class 1 geotextile, if there is no rutting, if the vehicle access is necessary to accomplish the work, and if the Construction Manager observes the operation and approves. Do not operate vehicles on the ACB until (during or after) placement of void filler.
Restrict vehicle traffic on the ACB to light weight rubber tired vehicles, and where intermittent access is necessary to accomplish the work. Routine haul routes will not be allowed. These allowances shall not waive the Contractor's obligation to maintain shall not waive the Contractor's obligation to maintain.

END OF SECTION
SECTION 40 05 15
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

3. ASTM International (ASTM):
   b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
4. International Code Council (ICC):
   b. International Mechanical Code (IMC).
5. Manufacturers’ Standardization Society (MSS):
   a. SP 58, Pipe Hangers and Supports—Materials, Design and Manufacture.
   b. SP 127, Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, and Application.

1.02 DEFINITIONS

A. Wetted or Submerged: Submerged, less than 3 foot above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp locations.

1.03 SUBMITTALS

A. Action Submittals:

1. Catalog information and drawings of piping support system, locating each support, sway brace, seismic brace, hanger, guide, component, and anchor for piping 4 inches and smaller. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.
2. Calculations for each type of pipe support, attachment and anchor.
3. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
4. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
3. Maintenance information on piping support system.

1.04 QUALIFICATIONS

A. Piping support systems shall be designed and Shop Drawings prepared and sealed by a registered professional engineer in the state where the Work is to be installed.

1.05 DESIGN REQUIREMENTS

A. General:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. Piping Smaller than 30 Inches: Supports are shown only where specific types and locations are required; additional pipe supports may be required.
3. Meet requirements of MSS SP 58 and ASME B31.1 or as modified by this section.

B. Pipe Support Systems:

1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes or internal pressures, including insulation and weight of fluid in pipes.
2. Seismic loads in accordance with governing codes.
3. Maximum Support Spacing and Minimum Rod Size: In accordance MSS SP 58 Table 3 and Table 4.
4. Electrical Conduit Support: Include in design of framing support system.
C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.

D. Vertical Sway Bracing: 10-foot maximum centers or as shown.

PART 2 PRODUCTS

2.01 GENERAL

A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.

B. Special support and hanger details may be required for cases where standard catalog supports are not applicable.

C. Materials: In accordance with Table 1, attached as Supplement at end of section.

2.02 HANGERS

A. Clevis: MSS SP 58, Type 1:

1. Anvil; Figure 260 for steel pipe and Figure 590 for ductile-iron pipe, sizes 1/2 inch through 30 inches.
2. Insulated Steel Pipe: Anvil; Figure 260 with insulated saddle system (ISS), sizes 1/2 inch through 16 inches.
3. B-Line; Figure B3100, sizes 1/2 inch through 30 inches.

B. Adjustable Swivel Split-Ring Pipe Clamp: MSS SP 58, Type 6:

1. Anvil; Figure 104, sizes 3/4 inch through 8 inches.
2. B-Line; Figure B3171, sizes 3/4 inch through 8 inches.

C. Steel Yoke Pipe Rolls and Roller Supports: MSS SP 58, Type 41 or Type 43:

1. Anvil; Figure 181 for sizes 2-1/2 inches through 24 inches, and Figure 171 for sizes 1 inch through 30 inches.
2. B-Line; Figure B3110 for sizes 2 inches through 24 inches and Figure B3114 for 30 inches.

D. Pipe Rollers and Supports: MSS SP 58, Type 44:

1. Anvil; Figure 175, sizes 2 inches through 30 inches.
2. B-Line; Figure B3120, sizes 2 inches through 24 inches.
2.03 WALL BRACKETS, SUPPORTS, AND GUIDES

A. Welded Steel Wall Bracket: MSS SP 58, Type 33 (heavy-duty):
   1. Anvil; Figure 199, 3,000-pound rating.
   2. B-Line; Figure B3067, 3,000-pound rating.

B. Adjustable “J” hanger MSS SP 58, Type 5:
   1. Anvil; Figure 67, sizes 1/2 inch through 8 inches.
   2. B-Line; Figure B3690, sizes 1/2 inch through 8 inches.

C. Offset Pipe Clamp: Anvil; Figure 103, sizes 3/4 inch through 8 inches.

D. Channel Type:
   1. Unistrut.
   2. Anvil; Power-Strut.
   3. B-Line; Strut System.
   4. Aickinstrut (FRP).

2.04 PIPE SADDLES

A. Saddle Supports, Pedestal Type:
   1. Minimum standard weight pipe stanchion, saddle, and anchoring flange.
   2. Nonadjustable Saddle: MSS SP 58, Type 37 with U-bolt.
      a. Anvil; Figure 259, sizes 4 inches through 36 inches with Figure 63C base.
      b. B-Line; Figure B3095, sizes 1 inch through 36 inches with B3088S base.
   3. Adjustable Saddle: MSS SP 58, Type 38 without clamp.
      a. Anvil; Figure 264, sizes 2-1/2 inches through 36 inches with Figure 62C base.
      b. B-Line; Figure B3092, sizes 3/4 inch through 36 inches with Figure B3088S base.

2.05 CHANNEL TYPE SUPPORT SYSTEMS

A. Channel Size: 12-gauge, 1-5/8-inch wide minimum steel, or 1-1/2-inch wide, minimum FRP.

B. Members and Connections: Design for loads using one-half of manufacturer’s allowable loads.
C. Fasteners: Vinyl ester fiber, polyurethane base composite nuts and bolts, or encapsulated steel fasteners.

D. Manufacturers and Products:
   1. B-Line; Strut System.
   2. Unistrut.
   3. Anvil; Power-Strut.
   4. Aickinstrut (FRP System).
   5. Enduro-Durostrut (FRP Systems).

2.06 PIPE CLAMPS

A. Riser Clamp: MSS SP 58, Type 8.
   1. Anvil; Figure 261, sizes 3/4 inch through 24 inches.
   2. B-Line; Figure B3373, sizes 1/2 inch through 30 inches.

2.07 ELBOW AND FLANGE SUPPORTS

A. Elbow with Adjustable Stanchion: Sizes 2 inches through 18 inches, Anvil; Figure 62C base.

B. Elbow with Nonadjustable Stanchion: Sizes 2-1/2 inches through 42 inches, Anvil; Figure 63A or Figure 63B base.

C. Flange Support with Adjustable Base: Sizes 2 inches through 24 inches, Standon; Model S89.

2.08 INTERMEDIATE PIPE GUIDES

A. Type: Hold down pipe guide.
   1. Manufacturer and Product: B-Line; Figure B3552, 1-1/2 inches through 30 inches.

B. Type: U-bolts with double nuts to provide nominal 1/8-inch to 1/4-inch clearance around pipe; MSS SP 58, Type 24.
   1. Anvil; Figure 137 and Figure 137S.
   2. B-Line; Figure B3188 and Figure B3188NS.
2.09 PIPE ALIGNMENT GUIDES

A. Type: Spider.

B. Manufacturers and Products:

1. Anvil; Figure 255, sizes 1/2 inch through 24 inches.
2. B-Line; Figure B3281 through Figure B3287, sizes 1/2 inch through 24 inches.

2.10 PIPE ANCHORS

A. Type: Anchor chair with U-bolt strap.

B. Manufacturer and Product: B-Line; Figure B3147A or Figure B3147B.

2.11 SEISMIC RESTRAINTS

A. Solid pipe bracing attachment to pipe clevis with clevis cross brace and angle rod reinforcement.

B. Manufacturers:

1. Mason Industries.
2. B-Line.
3. Anvil.

2.12 ACCESSORIES

A. Anchor Bolts:

1. Size and Material: Sized by Contractor for required loads, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.
2. Bolt Length (Extension Above Top of Nut):
   a. Minimum Length: Flush with top of nut preferred. If not flush, shall be no more than one thread recessed below top of nut.
   b. Maximum Length: No more than a full nut depth above top of nut.

B. Dielectric Barriers:

1. Plastic coated hangers, isolation cushion, or tape.
2. Manufacturer and Products:
   a. B-Line; B1999 Vibra Cushion.
   b. B-Line; Iso Pipe, Isolation Tape.
C. Insulation Shields:
   1. Type: Galvanized steel or stainless steel, MSS SP 58, Type 40.
   2. Manufacturers and Products:
      a. Anvil; Figure 167, sizes 1/2 inch through 24 inches.
      b. B-Line; Figure B3151, sizes 1/2 inch through 24 inches.

D. Welding Insulation Saddles:
   1. Type: MSS SP 58, Type 39.
   2. Manufacturers and Products:
      a. Anvil; Figure Series 160, sizes 1 inch through 36 inches.
      b. B-Line; Figure Series B3160, sizes 1/2 inch through 24 inches.

E. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.

F. Attachments:
   1. I-Beam Clamp: Concentric loading type, MSS SP 58, Type 21, Type 28, Type 29, or Type 30, which engage both sides of flange.
   2. Concrete Insert: MSS SP 58, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.
   3. Welded Beam Attachment: MSS SP 58, Type 22.
      a. Anvil; Figure 66.
      b. B-Line; Figure B3083.
   4. U-Channel Concrete Inserts: As specified in Section 05 50 00, Metal Fabrications.
   5. Concrete Attachment Plates:
      a. Anvil; Figure 47, Figure 49, or Figure 52.
      b. B-Line; Figure B3084, Figure B3085, or Figure B3086.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install support systems in accordance with MSS SP 58, unless shown otherwise.
   2. Install pipe hanger rods plumb, within 4 degrees of vertical during shut down, start up or operations.
   3. Support piping connections to equipment by pipe support and not by equipment.
4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
5. Support no pipe from pipe above it.
6. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
7. Do not use adhesive anchors for attachment of supports to ceiling or walls.
8. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
9. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
10. Install lateral supports for seismic loads at changes in direction.
11. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
12. Repair mounting surfaces to original condition after attachments are completed.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
   a. Single Pipes: Clevis hangers or adjustable swivel split-ring.
   b. Grouped Pipes: Trapeze hanger system.

2. Horizontal Piping Supported from Walls:
   a. Single Pipes: Wall brackets, or attached to wall, or to wall mounted framing with anchors.
   b. Stacked Piping: Wall mounted framing system and “J” hangers acceptable for pipe smaller than 3-inch.
   c. Pipe clamp that resists axial movement of pipe through support is not acceptable. Use pipe rollers supported from wall bracket.

3. Horizontal Piping Supported from Floors:
   a. Saddle Supports:
      1) Pedestal Type, elbow and flange.
      2) Provide minimum 1-1/2-inch grout beneath baseplate.
   b. Floor Mounted Channel Supports:
      1) Use for pipe smaller than 3-inch running along floors and in trenches at pipe elevations lower than can be accommodated using pedestal pipe supports.
      2) Attach channel framing to floors with baseplate on minimum 1-1/2-inch nonshrink grout and with anchor bolts.
      3) Attach pipe to channel with clips or pipe clamps.
   c. Concrete Cradles: Use for pipe larger than 3 inches along floor and in trenches at pipe elevations lower than can be accommodated using stanchion type.
4. Vertical Pipe: Support with wall bracket and elbow support, or riser clamp on floor penetration.

C. Intermediate and Pipe Alignment Guides:
   1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.
   2. Guide pipe on each side of expansion joint or loop at 4 pipe and 14 pipe diameters from each joint or loop.
   3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

D. Accessories:
   1. Dielectric Barrier:
      a. Provide between painted or galvanized carbon steel members and copper or stainless steel pipe or between stainless steel supports and nonstainless steel ferrous metal piping.
      b. Install rubber wrap between submerged metal pipe and oversized clamps.

3.02 FIELD FINISHING

A. Paint atmospheric exposed surfaces hot-dip galvanized steel components as specified in Section 09 90 00, Painting and Coating.

3.03 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:
   1. Table 1: Nonchemical Areas.

END OF SECTION
<table>
<thead>
<tr>
<th>Exposure Conditions</th>
<th>Support Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor Building</td>
<td>Galvanized steel or precoated steel, plastic coated hangers for uninsulated stainless steel piping</td>
</tr>
<tr>
<td>Process Areas: Wetted or Submerged</td>
<td>Stainless steel or FRP</td>
</tr>
</tbody>
</table>

Notes:
1. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
2. Stainless steel to be Type 316.
3. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M.
SECTION 40 27 00
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 DEFINITIONS

A. Submerged or Wetted: Zone below elevation of liquid surface or within 3 feet above top of liquid surface.

1.02 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

2. Allowable Soil Pressure 1,000 pounds per square foot.
   a. Low Pressure Pipelines:
      1) When bearing surface of the fitting against soil provides an area equal to or greater than area required for thrust restraint, concrete thrust blocks will not be required.
      2) Determine bearing area for fittings without thrust blocks by projected area of 70 percent of internal diameter multiplied by chord length for fitting centerline curve.

1.03 SUBMITTALS

A. Action Submittals: Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Manufacturer’s Certification of Compliance, in accordance with Section 1 61 00, Common Product Requirements.
   a. Pipe and fittings.
2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
3. [F: Flanged Pipe and Fittings: Manufacturer’s product data sheets for gaskets including torqueing requirements and bolt tightening procedures.]
4. Qualifications:
b. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.

c. Welders:
   1) Continuity log for welders and welding operators.
   2) Welder qualification test records conducted by Contractor or manufacturer.

5. Welding Procedures: Qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).

6. Nondestructive inspection and testing procedures.

7. Test logs.

8. CWI inspection records and NDE test records.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
   a. 10 years’ experience in field of welding and welded pipe and fittings’ testing required for this Project.
   b. Calibrated instruments and equipment, and documented standard procedures for performing specified testing.
   c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
   d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
   e. Verification Welding Inspector: AWS QC1 Certified.

2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D1.1/D1.1M (Annex N Forms).

3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).

4. Contractor’s CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

B. Quality Assurance: Provide services of independent inspection and testing agency for welding operations.

1. Note, the presence of Owner’s Special Inspector or Verification CWI does not relieve Contractor from performing own quality control, including 100 percent visual inspection of welds.
1.05 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 PRODUCTS

2.01 PIPING

A. As specified on Piping Data Sheet and Piping Schedule located at the end of this section as Supplements.

B. Diameters Shown:


2.02 JOINTS

A. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

B. Flexible Mechanical Compression Joint Coupling:

1. Stainless steel, ASTM A276, Type 305 bands.
2. Manufacturers:
   a. Pipeline Products Corp.
   b. Fernco Joint Sealer Co.

2.03 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe manufacturer and no substitute or “or-equal” will be allowed.

2.04 PIPE CORROSION PROTECTION

A. Coatings: See Section 09 90 00, Painting and Coating, for details of coating requirements.
B. Heat Shrink Wrap:
   1. Type: Cross-linked polyolefin wrap or sleeve with mastic sealant.
   2. Manufacturer and Product: Raychem; WPC or TPS.

C. Polyethylene Encasement (Bagging):
   1. Encasement Tube: Black polyethylene encasement tube, 8 mils minimum thickness, conforming to AWWA C105/A21.5, free of gels, streaks, pinholes, foreign matter, undispersed raw materials, and visible defects such as tears, blisters, and thinning at folds.
   2. Securing Tape: Thermoplastic tape, 8 mils minimum thickness, 1 inch wide, pressure sensitive adhesive face capable of bonding to metal, bituminous coating, and polyethylene encasement tube.

D. Insulating Flanges, Couplings, and Unions:
   1. Materials:
      a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME [A: B31.9] [B: B31.3] [C: ] working pressure rating equal to or higher than that of joint and pipeline.
      b. Galvanically compatible with piping.
      c. Resistant for intended exposure, operating temperatures, and products in pipeline.
   2. Union Type, 2 Inches and Smaller:
      a. Screwed or solder-joint.
      b. O-ring sealed with molded and bonded insulation to body.
   3. Flange Type, 2-1/2 Inches and Larger:
      a. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
      b. Bolt insulating sleeves shall be provided full length between insulating washers.
      c. Ensure fit-up of components of insulated flange assembly to provide a complete functioning installation.
      d. AWWA C207 steel flanges may be drilled oversize up to 1/8-inch to accommodate insulating sleeves.
      e. No less than minimum thread engagement in accordance with specified bolting standards will be permitted to accommodate thicknesses of required washers, flanges, and gasket.
   4. Flange Insulating Kits:
      a. Gaskets: Full-face, Type E with elastomeric sealing element. Sealing element shall be retained in a groove within retainer portion of gasket.
b. Insulating Sleeves: Full-length [D: mylar] [E: fiberglass reinforced epoxy (NEMA LI-1, G-10 grade)].

5. Manufacturers and Products:
a. Dielectric Flanges and Unions:
   1) PSI, Houston, TX.
   2) Advance Products and Systems, Lafayette, LA.
b. Insulating Couplings:
   1) Dresser; [J: STAB-39] [K: ].
   2) Baker Coupling Company, Inc.; [L: Series 216] [M: ].

2.05 VENT AND DRAIN VALVES

A. Pipeline 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain unless shown otherwise.

B. Pipelines 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain unless shown otherwise.

2.06 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Piping Schedule.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.02 PREPARATION

A. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

B. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

3.03 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting manufacturer.
B. Weld Identification: Keep paper record of which welder welded each joint.

C. Pipe End Preparation:
   2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.

D. Surfaces:
   1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
   2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
   3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:
   1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
   2. Root Opening of Joint: As stated in qualified welding procedure.
   3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1 inch, whichever is greater.

F. Climatic Conditions: Do not perform welding if there is impingement of any rain, snow, sleet, or wind exceeding 5 mph on the weld area, or if ambient temperature is below 32 degrees F.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Quality: Meet requirements of governing welding codes.

3.04 INSTALLATION—GENERAL

A. Join pipe and fittings in accordance with manufacturer’s instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.
C. Flanged Joints:
1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Grooved Joint Flange Adapters: Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.
6. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.
7. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
8. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
9. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
10. Manufacturer: Same as pipe manufacturer [A: or grooved joint flange adapter manufacturer].

D. Threaded and Coupled Joints:
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

E. Soldered Joints:
1. Use only solder specified for particular service.
2. Cut pipe ends square and remove fins and burrs.
3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply noncorrosive flux to the male end only.
4. Wipe excess solder from exterior of joint before hardened.
5. Before soldering, remove stems and washers from solder joint valves.

F. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 40 27 01, Process Piping Specialties.
3.05 INSTALLATION—EXPOSED PIPING

A. Piping Runs:
   1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
   2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 40 05 15, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:
   1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
   2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
   3. From Adjacent Work: Minimum 1 inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
   4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
   5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.
   6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
   7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.
3.06 INSTALLATION—BURIED PIPE

A. Joints:
   1. Dissimilar Buried Pipes:
      a. Provide flexible mechanical compression joints for pressure pipe.
      b. Provide concrete closure collar for [A: gravity] [B: and] [C: low pressure (maximum 10 psi)] piping or as shown.
   2. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown.

B. Placement:
   1. Keep trench dry until pipe laying and joining are completed.
   2. Pipe Base and Pipe Zone: As specified in Section 31 23 23.15, Trench Backfill.
   3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
   4. Measure for grade at pipe invert, not at top of pipe.
   5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
   6. Prevent foreign material from entering pipe during placement.
   7. Prevent foreign material from entering pipe during placement.
   8. Lay pipe upgrade with bell ends pointing in direction of laying.
   9. [A: Install closure sections and adapters for gravity piping at locations where pipe laying changes direction.]
   10. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
       a. Shorter pipe lengths.
       b. Special mitered joints.
       c. Standard or special fabricated bends.
   11. After joint has been made, check pipe alignment and grade.
   12. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
   13. Prevent uplift and floating of pipe prior to backfilling.

C. PVC Pipe Placement:
   1. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and during operation.
   2. Do not lay pipe when temperature is below 40 degrees F, or above 90 degrees F when exposed to direct sunlight.
3. Shield ends to be joined from direct sunlight prior to and during the laying operation.

D. Tolerances:

1. Deflection from Horizontal Line \([A:, \text{ Except PVC, CPVC, or HDPE}]:\)
   Maximum 2 inches.
2. Deflection from Vertical Grade: Maximum 1/4 inch.
3. Joint Deflection: Maximum of 75 percent of manufacturer’s recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75 feet from position shown.
5. Pipe Cover: Minimum 3 feet, unless otherwise shown.

3.07 PIPE CORROSION PROTECTION

A. PVC Exposed: As specified in Section 09 90 00, Painting and Coating.

B. Piping Accessories:

1. Exposed:
   a. Field paint black and galvanized steel, brass, copper, and bronze piping components as specified in Section 09 90 00, Painting and Coating, as applicable to base metal material.
   b. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners.

2. Buried:
   a. Ferrous Metal and Stainless Steel Components: Coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating.
   b. Bolts, Nuts, and Similar Items: Coat with bituminous paint.
   c. Flexible Couplings \([A:, \text{ Grooved Couplings,}]\) and Similar Items: Wrap with heat shrink wrap \([B:\text{ or coat with cement}]\).
   d. Buried Valves and Similar Elements on Wrapped Pipelines: Coat with bituminous paint and wrap entire valve in polyethylene encasement.
   e. Cement-Coated Pipelines: Cement coat appurtenances same as pipe.

C. Polyethylene Encasement: Install in accordance with AWWA C105/A21.5 and manufacturer’s instructions.

D. Tape Coating System: As specified in Section 09 90 00, Painting and Coating.

E. Heat Shrink Wrap: Apply in accordance with manufacturer’s instructions to surfaces that are cleaned, prepared, and primed.
F. Insulating Flanges, Couplings, and Unions:

1. Applications:
   a. Dissimilar metal piping connections.
   b. Where required for electrically insulated connection.

2. Pipe Installation:
   a. Insulating joints connecting immersed piping to nonimmersed piping shall be installed above maximum water surface elevation.
   b. Align and install insulating joints as shown on the Drawings and according to manufacturer’s recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.

3.08 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 40 27 01, Process Piping Specialties.

3.09 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first block valve in the line carrying the lower pressure, unless otherwise shown.

3.10 VENTS AND DRAINS

A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install vents on high points and drains on low points of pipelines.

3.11 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in Section 40 80 01, Process Piping Leakage Testing.

B. Minimum Duties of Welding Inspector:
   1. Job material verification and storage.
   2. Qualification of welders.
   3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:

1. Perform examinations in accordance with Piping Code ASME B31.3.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welding operator.
4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.12 CLEANING

A. Blow clean of loose debris process air lines with compressed air at 4,000 fpm; do not flush with water.

B. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

C. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.13 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this Specification:

1. Piping Schedule.
2. Data Sheets.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 27 00.08</td>
<td>Stainless Steel Pipe and Fittings—General Service</td>
</tr>
<tr>
<td>40 27 00.10</td>
<td>Polyvinyl Chloride (PVC) Pipe and Fittings</td>
</tr>
</tbody>
</table>

END OF SECTION
### Piping Schedule

<table>
<thead>
<tr>
<th>Service</th>
<th>Legend</th>
<th>Size(s) (In.)</th>
<th>Exposure</th>
<th>Piping Material</th>
<th>Specification</th>
<th>Joint Type</th>
<th>Lining/Coating</th>
<th>Test Pressure and Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air, High Pressure</td>
<td>AHP</td>
<td>&lt;= 3</td>
<td>ENC</td>
<td>Stainless Steel</td>
<td>40 27 00.08</td>
<td>W</td>
<td>None/None</td>
<td>50 psig, Pneumatic</td>
<td>Test pipe prior to encasement in accordance with Section 40 80 01, Process Piping Leakage Testing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EXP</td>
<td></td>
<td></td>
<td>FL, S, W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Fluid</td>
<td>HF</td>
<td>&lt;= 1</td>
<td>ENC and EXP</td>
<td>Stainless Steel Tubing or Hydraulic Fluid Hose or approved equal(s) as shown on Drawings</td>
<td>40 27 00.08 40 27 01</td>
<td>W or compression fittings</td>
<td>None/None</td>
<td>3000 psig, Hydrostatic (See Remarks)</td>
<td>Test prior to encasement. Contractor shall have spill containment materials and kits available during the test. Refer to Section 40 80 01, Process Piping Leakage Testing, for hydrostatic test requirements except that the test fluid shall be the system working fluid instead of water.</td>
</tr>
</tbody>
</table>

1 "\(>\)" Greater Than
2 "\(<\)" Less Than
3 "\(\leq\)" Less Than or Equal To
4 "\(>\)" Greater Than or Equal To
5 "All" All Sizes

2 ENC = Concrete encased
EXP = exposed
3 FL = flanged
S = threaded/screwed
W = Welded
HU = Hub and Spigot
## SECTION 40 27 00.08
STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe</td>
<td>2-1/2&quot; &amp; smaller</td>
<td>Schedule 10S: ASTM A312/A312M, Type 316L, pickled and passivated.</td>
</tr>
<tr>
<td>Tubing</td>
<td>Hydraulic Fluid</td>
<td>ASTM A269, Type 316 stainless steel, seamless, fully annealed hydraulic tubing, 0.065-inch wall thickness minimum.</td>
</tr>
<tr>
<td>Joints</td>
<td>1-1/2&quot; &amp; smaller</td>
<td>Threaded or flanged at equipment as required or shown.</td>
</tr>
<tr>
<td></td>
<td>2&quot; &amp; larger</td>
<td>Butt-welded or flanged at valves and equipment.</td>
</tr>
<tr>
<td>Tubing Joints</td>
<td>All</td>
<td>Flareless compression fitting.</td>
</tr>
<tr>
<td>Fittings</td>
<td>1-1/2&quot; &amp; smaller</td>
<td>Threaded: Forged 1,000 CWP minimum, ASTM A182/A182M, Grade F316 or cast Class 150, ASTM A351/A351M, Grade CF8M/316.</td>
</tr>
<tr>
<td></td>
<td>2&quot; &amp; 2-1/2&quot;</td>
<td>Butt Welded: ASTM A403/A403M, Type 316L pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.</td>
</tr>
<tr>
<td>Tubing Fittings</td>
<td>All</td>
<td>Flareless Compression Type Forged: ASTM A182/A182M, Grade F316, Parker-Hannifin Ferulok, Flodar BA Series.</td>
</tr>
<tr>
<td>Branch Connections</td>
<td>2&quot; &amp; smaller</td>
<td>Butt-welding tee or reducing tee in accordance with fittings above.</td>
</tr>
<tr>
<td>Tubing Branch Connections</td>
<td>All</td>
<td>Compression type tees or reducing tees in accordance with Tubing Fittings above.</td>
</tr>
<tr>
<td>Flanges</td>
<td>All</td>
<td>Forged Stainless Steel: ASTM A182/A182M, Grade: F316L, ASME B16.5 Class 150 or Class 300, slip-on weld neck or raised face. Weld slip-on flanges inside and outside.</td>
</tr>
</tbody>
</table>
## SECTION 40 27 00.08
**STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE**

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Cast Carbon Steel: ASTM A216/A216M Grade WCA, drilled, ASME B16.5 Class 150 or Class 300 Van Stone Type with stainless steel stub ends,</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>ASTM A240/A240M Type 316L “as-welded grade”, conforming to MSS SP 43, wall thickness same as pipe.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Blind Flanges, exposed to the atmosphere and not buried nor immersed in liquid, may be either stainless steel or Class 125 ductile iron or</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Class 150 carbon steel with gaskets as specified herein.</strong></td>
</tr>
<tr>
<td>Unions</td>
<td>2&quot; &amp; smaller</td>
<td><strong>Threaded Forged: ASTM A182/A182M, Grade F316, 2,000-pound or 3,000-pound WOG, integral ground seats, AAR design meeting the requirements of</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>ASME B16.11, bore to match pipe.</strong></td>
</tr>
<tr>
<td>Bolting</td>
<td>All</td>
<td><strong>Forged Flanges: Type 316 stainless steel, ASTM A320/A320M Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436 Type</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Van Stone Flanges and anywhere mating flange on equipment is cast iron and gasket is flat ring: Carbon steel ASTM A307 Grade B hex head</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>bolts, ASTM A563 Grade A hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>bolt minimum yield stress.</strong></td>
</tr>
</tbody>
</table>
### SECTIONS 40 27 00.08
STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanged Joints</td>
<td></td>
<td>in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts and ASTA M A194/A194M, Grade 8M hex nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.</td>
</tr>
<tr>
<td>Gaskets</td>
<td>All Flanges</td>
<td>Flanged, Water, Hot Air, Fuel Gas and Sewage Services: 1/8 inch thick, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 250 degrees F. continuous and conforming to ASME B16.21 and ASTM D1330, Steam Grade. Blind Flanges: Gasketed covering entire inside face with gasket cemented to blind flange.</td>
</tr>
</tbody>
</table>

END OF SECTION
<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>All</td>
<td>Materials in contact with potable water shall conform to NSF 61 acceptance.</td>
</tr>
<tr>
<td>Pipe</td>
<td>All</td>
<td>Schedule 80 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D1784 and ASTM D1785. If exposed, pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded Nipples: Schedule 80 PVC.</td>
</tr>
<tr>
<td>Fittings</td>
<td>All</td>
<td>Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.</td>
</tr>
<tr>
<td>Joints</td>
<td>All</td>
<td>Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.</td>
</tr>
<tr>
<td>Flanges</td>
<td>All</td>
<td>One-piece, molded hub type PVC flat face flange in accordance with Fittings above, ASME B16.1, Class 125 drilling</td>
</tr>
<tr>
<td>Bolting</td>
<td>All</td>
<td>Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. With Raised Face Mating Flange: Carbon steel ASTM A307 Grade B square head bolts, ASTM A563 Grade A heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.</td>
</tr>
</tbody>
</table>
## SECTION 40 27 00.10
POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

<table>
<thead>
<tr>
<th>Item</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaskets</td>
<td>All</td>
<td>Flat Face Mating Flange: Full faced 1/8-inch-thick ethylene propylene (EPR) rubber. Raised Face Mating Flange: Flat ring 1/8-inch ethylene propylene (EPR) rubber, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.</td>
</tr>
<tr>
<td>Solvent Cement</td>
<td>All</td>
<td>Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656, chemically resistant to the fluid service, and as recommended by pipe and fitting manufacturer</td>
</tr>
<tr>
<td>Thread Lubricant</td>
<td>All</td>
<td>Teflon Tape.</td>
</tr>
</tbody>
</table>

**END OF SECTION**
PART 1  GENERAL

1.01  REFERENCES

A.  The following is a list of standards which may be referenced in this section:

1.  American Society of Mechanical Engineers (ASME):

2.  American Water Works Association (AWWA):
   c.  C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   d.  C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   e.  C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.

3.  ASTM International (ASTM):


5. NSF International (NSF):
   a.  NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b.  NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02  SUBMITTALS

A.  Action Submittals: Manufacturer’s data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).

B.  Informational Submittals: Operation and Maintenance Data as specified in Section [A 01 78 23, Operation and Maintenance Data] [B: ].
PART 2 PRODUCTS

2.01 GENERAL

A. Provide required piping specialty items, whether shown or not shown on Drawings, as required by applicable codes and standard industry practice.

B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.

2.02 CONNECTORS

A. Teflon Bellows Connector:

1. Type: Two convolutions, unless otherwise shown, with metal reinforcing bands.
2. Flanges: Ductile iron, drilled 150 psi ASME B16.5 standard.
3. Working Pressure Rating: 140 psi, minimum, at 120 degrees F.
4. Thrust Restraint: Limit bolts to restrain force developed by specified test pressure.
5. Manufacturers and Products:
   a. Garlock; Style [A: 214] [B: ].
   b. Resistoflex; No. [C: R6904] [D: ].
   c. Unisource Manufacturing, Inc.; Style 112.
   d. Proco Products, Inc.; Series 442.

B. Flexible Metal Hose Connector:

1. Type: Close pitch, annular corrugated with single braided jacket.
3. End Connections:
   a. 3 Inches and Larger: Shop fabricated flanged ends to match mating flanges.
   b. 2-1/2 Inches and Smaller: Screwed ends with one union end.
4. Minimum Burst Pressure: 600 psig at 70 degrees F for 12 inches and smaller.
5. Length: Provide hose live-length equal to lengths shown on Drawings.
6. Manufacturers:
   a. U.S. Hose Corp.; Series 401M.
   b. Anamet Industrial, Inc.; BWC21-1.
2.03 EXPANSION JOINTS

A. Flexible Metal Hose:

1. Type: Close pitch, annular corrugated with single braided jacket.
3. End Connections:
   a. 3 Inches and Larger: Shop fabricated flanged ends to match mating flanges.
   b. 2-1/2 Inches and Smaller: Screwed ends with one union end.
4. Minimum Burst Pressure: 600 psig at 70 degrees F for 12 inches and smaller.
5. Length: Provide hose live-length equal to lengths shown on Drawings.
6. Manufacturers:
   a. U.S. Hose Corp.; Series 401M.
   b. Anamet Industrial, Inc.; BWC21-1.

2.04 PIPE SLEEVES

A. Steel Pipe Sleeve:

1. Minimum Thickness: 3/16 inch.
2. Seep Ring:
   a. Center steel flange for water stoppage on sleeves in exterior or water-bearing walls, 3/16-inch minimum thickness.
   b. Outside Diameter: Unless otherwise shown, 3 inches greater than pipe sleeve outside diameter.
   c. Continuously fillet weld on each side all around.
3. Factory Finish:
   a. Galvanizing:
      1) Hot-dip applied, meeting requirements of ASTM A153/A153M.
      2) Electroplated zinc or cadmium plating is unacceptable.
   b. Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.

B. Molded Polyethylene Pipe Sleeve:

1. Molded HDPE with integral water stop ring not less than 3 inches larger than sleeve.
2. Provided with end caps for support during concrete placement.
3. Manufacturer and Product: Century-Line, Model CS sleeves as manufactured by PSI-Thunderline/Link-Seal.
C. Insulated and Encased Pipe Sleeve:
   1. Manufacturer and Product: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.

D. Modular Mechanical Seal:
   1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
   2. Fabrication:
      a. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts and nuts.
      b. Pressure plates shall be reinforced nylon polymer.
   3. Size: According to manufacturer’s instructions for size of pipes shown to provide a watertight seal between pipe and wall sleeve opening.

2.05 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Steel or Stainless Steel Wall Pipe:
   1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
   2. Lining: Same as connecting pipe.
   3. Thrust Collar:
      a. Outside Diameter: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe.
      b. Continuously fillet welded on each side all around.

2.06 HYDRAULIC FLUID HOSE

1. Pressure Rating: 3,000 psig.
2. Connectors: Stainless steel quick connects and fittings.
3. Hose and fittings shall be approved for Marine Applications (SAEJ1942).

PART 3 EXECUTION

3.01 GENERAL

A. Provide accessibility to piping specialties for control and maintenance.
3.02 PIPING EXPANSION

A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.

B. Expansion Joints:
   3. Air and Water Service Above 120 Degrees F: Metal bellows expansion joint.

C. Anchors: Install as specified in Section 40 05 15, Piping Support Systems, to withstand expansion joint thrust loads and to direct and control thermal expansion.

3.03 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

A. Install to prevent piping from being supported by equipment, for vibration isolation, and where shown.

B. Product Applications Unless Shown Otherwise:
   2. Compressor Discharge: Flexible metal hose connector.
   3. All Other Piping: Elastomer bellows connector.

C. Limit Bolts and Control Rods: Tighten snug prior to applying pressure to system.

3.04 PIPE SLEEVES

A. Application:
   1. As specified in Section 40 27 00, Process Piping—General.
   3. Belowgrade or in Submerged or Damp Environments: Shop-lined and coated.
   4. Alternatively, molded polyethylene pipe sleeve as specified may be applied.
B. Installation:

1. Support noninsulating type securely in formwork to prevent contact with reinforcing steel and tie-wires.
2. Caulk joint with specified sealant in non-submerged applications and seal below grade and submerged applications with wall penetration seal.

3.05 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Applications:

1. Watertight and Below Ground Penetrations:
   a. Wall pipes with thrust collars.
   b. Provide taps for stud bolts in flanges to be set flush with wall face.
3. Existing Walls: Rotary drilled holes.
4. Fire-Rated or Smoke-Rated Walls, Floors or Ceilings: Insulated and encased pipe sleeves.

B. Wall Pipe Installation:

1. Isolate embedded metallic piping from concrete reinforcement.
2. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

END OF SECTION
PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Testing Plan:
   a. Submit prior to testing and include at least the information that follows.
      1) Testing dates.
      2) Piping systems and section(s) to be tested.
      3) Test type.
      4) Method of isolation.
      5) Calculation of maximum allowable leakage for piping section(s) to be tested.


PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.

B. Pressure Piping:

1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.

2. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.

3. New Piping Connected to Existing Piping: Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.

4. Test Pressure: As indicated on Piping Schedule in Section 40 27 00, Process Piping—General.
ZINK DAM IMPROVEMENTS

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING

A. Fluid: Clean river water or potable water.

B. Exposed Piping:
   1. Perform testing on installed piping prior to application of insulation.
   2. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
   3. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
   4. Maintain hydrostatic test pressure continuously for 60 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
   5. Examine joints and connections for leakage.
   6. Correct visible leakage and retest as specified.

C. Buried Piping:
   1. Test after backfilling has been completed.
   2. Expel air from piping system during filling.
   3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
   4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
   5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
   6. Maximum Allowable Leakage:

   \[ L = \frac{SD(P)^{1/2}}{148,000} \]

   where:

   \[ L = \text{Allowable leakage, in gallons per hour.} \]
   \[ S = \text{Length of pipe tested, in feet.} \]
   \[ D = \text{Nominal diameter of pipe, in inches.} \]
P = Test pressure during leakage test, in pounds per square inch.

7. Correct leakage greater than allowable, and retest as specified.

3.03 PNEUMATIC TEST FOR PRESSURE PIPING

A. Do not perform on:
   1. PVC or CPVC pipe.
   2. Piping larger than 18 inches.
   3. Buried and other non-exposed piping.

B. Fluid: Oil-free, dry air.

C. Procedure:
   1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections; examine for leakage.
   2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
   3. Gradually increase pressure in system to half of specified test pressure. Thereafter, increase pressure in steps of approximately one-tenth of specified test pressure until required test pressure is reached.
   4. Maintain pneumatic test pressure continuously for minimum of 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
   5. Correct visible leakage and retest as specified.

D. Allowable Leakage: Piping system shall show no visual evidence of leakage.

3.04 HYDROSTATIC TEST FOR GRAVITY PIPING

A. Testing Equipment Accuracy: Plus or minus 1/2-gallon water leakage under specified conditions.

B. Maximum Allowable Leakage: 0.16 gallon(s) per hour per inch diameter per 100 feet. Include service connection footage in test section, subjected to minimum head specified.

C. [A: Gravity Sanitary and Roof Drain Piping: Test with 15 feet of water to include highest horizontal vent in filled piping. Where vertical drain and vent systems exceed 15 feet in height, test systems in 15-foot vertical sections as piping is installed.]
D. Exfiltration Test:

1. Hydrostatic Head:
   a. At least 6 feet above maximum estimated groundwater level in section being tested.
   b. No less than 6 feet above inside top of highest section of pipe in test section, including service connections.

2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.

E. Infiltration Test:

1. Groundwater Level: At least 6 feet above inside top of highest section of pipe in test section, including service connections.

F. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if pipe previously passed a pressure test.

G. Defective Piping Sections: Replace and retest as specified.

3.05 FIELD QUALITY CONTROL

A. Test Report Documentation:

1. Test date.
2. Description and identification of piping tested.
3. Test fluid.
4. Test pressure.
5. Remarks, including:
   a. Leaks (type, location).
   b. Repair/replacement performed to remedy excessive leakage.
6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION
SECTION 40 90 01
INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):

2. International Society of Automation (ISA):
   a. S5.1, Instrumentation Symbols and Identification (NRC ADOPTED).
   b. PR12.6, Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations.
   d. S20, Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
   e. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.

3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ICS 1, General Standards for Industrial Control and Systems.


5. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 SUMMARY

A. Work Includes:

1. Engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and Owner training for complete Process Instrumentation and Control (PIC) for plant.

2. Major parts are:
   a. Primary elements, transmitters, and control devices.
   b. Control panel.
   c. Programmable logic controller.
   d. Operator interface.
   e. Interfaces with existing control systems.

B. Detailed Design: PIC as shown and specified includes functional and performance requirements and component specifications. Complete detailed PIC design.

1.03 DEFINITIONS

A. Abbreviations:

1. LCP: Local Control Panel.
2. MCC: Motor Control Center.
3. PAT: Performance Acceptance Test.
5. PLC: Programmable Logic Controller.

B. Rising/Falling: Terms used to define actions of discrete devices about their setpoints.

1. Rising: Contacts close when an increasing process variable rises through setpoint.
2. Falling: Contacts close when a decreasing process variable falls through setpoint.

C. Signal Types:

1. Analog Signals, Current Type:
   a. 4 mA to 20 mA dc signals conforming to ISA S50.1.
   b. Unless otherwise indicated for specific PIC Subsystem components, use the following ISA 50.1 options:
      1) Transmitter Type: Number 2, two-wire.
      2) Transmitter Load Resistance Capacity: Class L.
      3) Fully isolated transmitters and receivers.
2. Discrete signals, two-state logic signals using dc or 120V ac sources as indicated.

3. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.

1.04 SUBMITTALS

A. Action Submittals:

1. General:
   a. Shop Drawings, full-scaled details, wiring diagrams, catalog cuts, and descriptive literature.
   b. Identify proposed items and options. Identify installed spares and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).
   c. Legends and Abbreviation Lists: Complete definition of symbols and abbreviations used on this Project (for example, engineering units, flow streams, instruments, structures, and other process items used in nameplates, legends, and data sheets).

   a. Group equipment items by enclosure and field, and within an enclosure, as follows:
      1) I&C Components: By component identification code.
      2) Other Equipment: By equipment type.
   b. Data Included:
      1) Equipment tag number.
      2) Description.
      3) Manufacturer, complete model number, and all options not defined by model number.
      4) Quantity supplied.
      5) Component identification code where applicable.

3. Catalog Cuts: I&C Components, Electrical Devices, and Mechanical Devices:
   a. Catalog information, mark to identify proposed items and options.
   b. Descriptive literature.
   c. External power and signal connections.
   d. Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.

4. Component Data Sheets: Data sheets for I&C components.
   a. Format and Level of Detail: In accordance with ISA-S20.
   b. Include component type identification code and tag number on data sheet.
c. Specific features and configuration data for each component:
   1) Location or service.
   2) Manufacturer and complete model number.
   3) Size and scale range.
   4) Setpoints.
   5) Materials of construction.
   6) Options included.

d. Name, address, and telephone number of manufacturer’s local office, representative, distributor, or service facility.

5. Panel Construction Drawings:
   a. Scale Drawings: Show dimensions and location of panel mounted devices, doors, louvers, and subpanels, internal and external.
   b. Panel Legend: List front of panel devices by tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.
   c. Bill of Materials: List devices mounted within panel that are not listed in panel legend. Include tag number, description, manufacturer, and model number.
   d. Construction Details: NEMA rating, materials, material thickness, structural stiffeners and brackets, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other connection callouts and details.
   e. Construction Notes: Finishes, wire color schemes, wire ratings, wire and terminal block, numbering and labeling scheme.

   a. Diagram Type: Ladder diagrams. Include devices, related to discrete functions, that are mounted in or on the panel and that require electrical connections. Show unique rung numbers on left side of each rung.
   b. Item Identification: Identify each item with attributes listed.
      1) Wires: Wire number and color. Cable number if part of multiconductor cable.
      2) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.
   c. Discrete Components:
      a) Tag number, terminal numbers, and location (“FIELD”, enclosure number, or MCC number).
      b) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description (for example, Sump Level High).
4) Relay Coils:
   a) Tag number and its function.
   b) On right side of run where coil is located, list contact location by ladder number and sheet number.
      Underline normally closed contacts.

5) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).
   c) Show each circuit individually. No “typical” diagrams or “typical” wire lists will be permitted.
   d) Ground wires, surge protectors, and connections.

   a) Components: Valves, regulators, and filters.
   b) Connections to panel mounted devices.
   c) Panel interface connections.

8. Loop Diagrams: Individual wiring diagram for each analog or pulse frequency loop.
   a) Divide each loop diagram into areas for panel face, back-of-panel, and field.
   b) Show:
      1) Terminal numbers, location of dc power supply, and location of common dropping resistors.
      2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.

9. Interconnecting Wiring Diagrams:
   a) Diagrams, device designations, and symbols in accordance with NEMA ICS 1.
   b) Show:
      1) Electrical connections between equipment, consoles, panels, terminal junction boxes, and field mounted components.
      2) Component and panel terminal board identification numbers, and external wire and cable numbers.
      3) Circuit numbers.
      4) Intermediate terminations between field elements and panels (for example, to terminal junction boxes and pull boxes).
      5) Pull boxes.

10. Installation Details: Include modifications or further details required to adequately define installation of I&C components.

11. List of spares, expendables, test equipment and tools.
B. Informational Submittals: For PIC equipment, provide Manufacturer’s Certificate of Proper Installation and readiness for operation.

1. Owner Training Plan. Reference Section 01 43 33, Manufacturers’ Field Services.
2. Operation and Maintenance (O&M) Manuals: In accordance with Section 01 78 23, Operation and Maintenance Data, unless otherwise specified in this section.
   a. Content and Format:
      1) Complete sets O&M manuals.
      2) Sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for each PIC component.
      3) Final versions of Legend and Abbreviation Lists.
      4) Manual format in accordance with Section 01 78 23, Operation and Maintenance Data.
   b. Include:
      1) Process and Instrumentation Diagrams: One reproducible copy of revised P&ID to reflect as-built PIC design.
      2) Refer to Paragraph Shop Drawings for the following items:
         a) Bill of Materials.
         b) Catalog Cuts.
         c) Component Data Sheets.
         d) Panel Control Diagrams.
         e) Panel Plumbing Diagrams.
         f) Loop Diagrams.
         g) Interconnecting Wiring Diagrams.
         h) Application Software Documentation.
      3) Device O&M manuals for components, electrical devices, and mechanical devices include:
         a) Operations procedures.
         b) Installation requirements and procedures.
         c) Maintenance requirements and procedures.
         d) Troubleshooting procedures.
         e) Calibration procedures.
         f) Internal schematic and wiring diagrams.
         g) Component Calibration Sheets from field quality control calibrations.
      4) List of spares, expendables, test equipment and tools provided.
      5) List of additional spares, expendables, test equipment and tools recommended.
3. Performance Acceptance Tests (PAT) Submittals:
   a. Preliminary Test Procedures: Outlines of proposed tests, forms, and checklists.
   b. Final Test Procedures: Proposed test procedures, forms, and checklists.
   c. Test Documentation: Copy of signed off test procedures when tests are completed.

1.05 QUALITY ASSURANCE

A. Calibration Instruments: Each instrument used for calibrating PIC equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous 12 months to a standard endorsed by the NIST.

B. Coordination Meetings:
   1. In accordance with Section 01 31 13, Project Coordination.
   2. Location: Project site.
   3. Attended By: Engineer, Owner, and Contractor.
   4. Minimum of four are required. Specific dates will be established in Progress Schedule.
   5. First Meeting: Within 60 days after Notice to Proceed.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Provide Site and warehouse storage facilities for PIC equipment.

B. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers, and related equipment as recommended by the capsule manufacturer.

C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.

D. Cover panels and other elements that are exposed to dusty construction environments.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Standard Environmental Requirements: Unless otherwise noted, design equipment for continuous operation in these environments:
   1. Freestanding Panel and Consoles:
      b. Inside: NEMA 12.
2. Smaller Panels and Assemblies (that are not Freestanding):
   a. Inside, Air Conditioned: NEMA 12.
   b. All Other Locations: NEMA 4X.
3. Field Elements: Outside.

B. Environmental Design Requirements: Following defines the types of environments referred to in the above.

1. Inside, Air Conditioned:
   a. Temperature:
      1) Normal: 60 degrees F to 80 degrees F.
      2) With Up to 4-Hour HVAC System Interruptions: 40 degrees F to 105 degrees F.
   b. Relative Humidity:
      1) Normal: 10 percent (winter) to 70 percent (summer).
      2) With Up to 4-Hour HVAC System Interruption: 10 degrees F to 100 percent.
   c. NEC Classification: Nonhazardous.
2. Inside:
   a. Temperature: 40 degrees F to 104 degrees F.
   b. Relative Humidity: 10 percent to 95 percent noncondensing.
   c. NEC Classification: Nonhazardous.
3. Outside:
   a. Temperature: 10 degrees F to 113 degrees F.
   b. Relative Humidity: 10 percent to 100 percent.
   c. NEC Classification: Nonhazardous.

1.08 SEQUENCING AND SCHEDULING

A. Activity Completion:

1. The following is a list of key activities and their completion criteria:
   a. Shop Drawings: Reviewed and approved.
   b. Quality Control Submittals: Reviewed and accepted.
   c. Hardware Delivery: Hardware delivered to Site and inventoried by Owner.
   d. PAT: Completed and required test documentation accepted.

B. PIC Substantial Completion: When Engineer issues Certificate of Substantial Completion.

1. Prerequisites:
   a. All PIC Submittals have been completed.
   b. PIC has successfully completed PAT.
   c. Owner training plan is on schedule.
d. All spares, expendables, and test equipment have been delivered to Owner.

C. PIC Acceptance: When Engineer issues a written notice of Final Payment and Acceptance.

   1. Prerequisites:
      a. Certificate of Substantial Completion issued for PIC.
      b. Punch-list items completed.
      c. Final revisions to O&M manuals accepted.
      d. Maintenance service agreements for PIC accepted by Owner.

D. Prerequisite Activities and Lead Times: Do not start the following key Project activities until the prerequisite activities and lead times listed below have been completed and satisfied:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Prerequisites and Lead Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submittal reviews by Engineer</td>
<td>Engineer acceptance of Submittal breakdown and schedule.</td>
</tr>
<tr>
<td>Hardware purchasing, fabrication, and assembly</td>
<td>Associated shop drawing Submittals completed.</td>
</tr>
<tr>
<td>Shipment</td>
<td>Completion of PIC Shop Drawing Submittals and preliminary O&amp;M manuals.</td>
</tr>
<tr>
<td>Owner Training</td>
<td>Owner training plan completed.</td>
</tr>
<tr>
<td>PAT</td>
<td>Startup, Owner training, and PAT procedures completed; notice 4 weeks prior to start.</td>
</tr>
</tbody>
</table>

PART 2 PRODUCTS

2.01 GENERAL

A. PIC functions as shown on Drawings and as required for each loop. Furnish equipment items as required. Furnish all materials, equipment, and software, necessary to effect required system and loop performance.

B. First Named Manufacturer: PIC design is based on first named manufacturers of equipment and materials.

   1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes in accordance with Article Submittals.
2. If using proposed item requires other changes, provide work and equipment to implement these changes. Changes that may be required include, but are not limited to: different installation, wiring, raceway, enclosures, connections, isolators, intrinsically safe barriers, software, and accessories.

C. Like Equipment Items:

1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer’s services.
2. Implement all same or similar functions in same or similar manner. For example, control logic, sequence controls, and display layouts.

2.02 LOOP SPECIFICATIONS

A. Location: Article Supplements.

B. Organization: By unit process and loop number.

C. Functional Requirements for Control Loops:

1. Shown on Drawings, in Panel Control Diagrams, and Process and Instrumentation Diagrams (P&ID). P&ID format and symbols are in accordance with ISA S5.1, except as specified or shown on Drawings.
2. Supplemented by Loop Specifications.

2.03 I&C COMPONENTS

A. Components for Each Loop: Major components for each loop are listed in Instrument List referenced in Article Supplements. Furnish all equipment that is necessary to achieve required loop performance.

B. Component Specifications: Generalized specifications for each type of component are located in Article Supplements.

2.04 NAMEPLATES AND TAGS

A. Panel Nameplates: Enclosure identification located on the enclosure face.

1. Location and Inscription: As shown.
2. Materials: Laminated plastic attached to panel with stainless steel screws.
3. Letters: 1/2-inch white on black background, unless otherwise noted.
B. Component Nameplates—Panel Face: Component identification located on panel face under or near component.

1. Location and Inscription: As shown.
2. Materials: Laminated plastic attached to panel with stainless steel screws.
3. Letters: 3/16-inch white on black background, unless otherwise noted.

C. Component Nameplates—Back of Panel: Component identification located on or near component inside of enclosure.

1. Inscription: Component tag number.
3. Letters: 3/16-inch white on black background, unless otherwise noted.

D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.

1. Inscription:
   a. Refer to:
      1) Table under paragraph Standard Pushbutton Colors and Inscriptions.
      2) Table under paragraph Standard Light Colors and Inscriptions.
      3) P&IDs on Drawings.
2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
3. Letters: Black on gray or white background.

E. Service Legends: Component identification nameplate located on face of component.

1. Inscription: As shown.
3. Letters: 3/16-inch white on black background, unless otherwise noted.

F. Nametags: Component identification for field devices.

1. Inscription: Component tag number.
4. Mounting: Affix to component with 16-gauge or 18-gauge stainless steel wire or stainless steel screws.
2.05 ELECTRICAL REQUIREMENTS

A. In accordance with Division 26, Electrical.

B. I&C and Electrical Components, Terminals, Wires, and Enclosures: UL recognized or UL listed.

C. Wires within Enclosures:
   1. ac Circuits:
      a. Type: 600-volt, Type MTW stranded copper.
      b. Size: For current to be carried, but not less than 16 AWG.
   2. Analog Signal Circuits:
      a. Type: 300-volt stranded copper, twisted shielded pairs.
      b. Size: 18 AWG, minimum.
   3. Other dc Circuits:
      a. Type: 300-volt, Type MTW stranded copper.
      b. Size: For current carried, but not less than 18 AWG.
   4. Special Signal Circuits: Use manufacturer’s standard cables.
   5. Wire Identification: Numbered and tagged at each termination.
      a. Wire Tags: Machine printed, heat shrink.
      b. Manufacturers:
         1) Brady PermaSleeve.
         2) Tyco Electronics.

D. Wires entering or leaving enclosures, terminate and identify as follows:
   1. Analog and discrete signal, terminate at numbered terminal blocks.
   2. Special signals, terminated using manufacturer’s standard connectors.
   3. Identify wiring in accordance with Section 26 05 05, Conductors.

E. Terminal Blocks for Enclosures:
   1. Quantity:
      a. Accommodate present and spare indicated needs.
      b. Wire spare PLC I/O points to terminal blocks.
      c. One wire per terminal for field wires entering enclosures.
      d. Maximum of two wires per terminal for internal enclosure wiring.
      e. Spare Terminals: 20 percent of all connected terminals, but not less than 10 per terminal block.
   2. General:
      a. Connection Type: Screw compression clamp.
b. Compression Clamp:
   1) Complies with DIN-VDE 0611.
   2) Hardened steel clamp with transversal groves that penetrate wire strands providing a vibration-proof connection.
   3) Guides strands of wire into terminal.


d. Current Bar: Copper or treated brass.

e. Insulation:
   1) Thermoplastic rated for minus 55 degrees F to plus 110 degree C.
   2) Two funneled shaped inputs to facilitate wire entry.

f. Mounting:
   1) Standard DIN rail.
   2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
   3) End Stops: Minimum of one at each end of rail.

g. Wire Preparation: Stripping only permitted.

h. Jumpers: Allow jumper installation without loss of space on terminal or rail.

i. Features:
   1) Color: Gray or beige body, or as noted.
   2) Spacing: 0.25 inch, or as noted.
   3) Rated Wire Size: 10 AWG.

j. Marking System:
   1) Terminal number shown on both sides of terminal block.
   2) Allow use of preprinted and field marked tags.
   3) Terminal strip numbers shown on end stops.
   4) Mark terminal block and terminal strip numbers as shown on Panel Control Diagrams and Loop Diagrams.
   5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

k. Manufacturers:
   1) Entrelec.
   2) Phoenix Contact.

3. Terminal Block, General-Purpose:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 30 amp.
   c. Wire Size: 22 AWG to 10 AWG.

4. Terminal Block, Ground:
   a. Wire Size: 22 AWG to 12 AWG.
   b. Color: Green and yellow body.
   c. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
5. Terminal Block, Blade Disconnect Switch:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 10-amp.
   c. Wire Size: 22 AWG to 12 AWG.
   d. Color: Grey body, orange switch.

6. Terminal Block, Fused, 24V dc:
   a. Rated Voltage: 600V dc.
   b. Rated Current: 16-amp.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Fuse: 0.25 inch by 1.25 inches.
   e. Indication: LED diode 24V dc.
   f. Spacing: 0.512 inch, maximum.

7. Terminal Block, Fused, 120V ac:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 16-amp.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Fuse: 0.25 inch by 1.25 inches.
   e. Indication: Neon Lamp 110V ac.
   f. Leakage Current: 1.8 mA, maximum.
   g. Spacing: 0.512 inch, maximum

8. Terminal Block, Fused, 120V ac, High Current:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 35 amps.
   c. Wire Size: 18 AWG to 8 AWG.
   d. Rated Wire Size: 8 AWG.
   e. Fuse: 13/32 inch by 1.5 inches.
   f. Spacing: 0.95 inch, maximum.

F. Grounding of Enclosures:
   1. Ground enclosure back panel and metal enclosure.
   2. Ground power circuits at a common ground point in accordance with National Electrical Code requirements.
   3. Single Point Ground for Each Analog Loop:
      a. Use to ground wire shields for loop.
      b. Provide dedicated grounded terminal block for each loop.
   4. Ground terminal block rails.

G. Analog Signal Isolators: Furnish signal isolation for analog signals that are transmitted from one enclosure to another.
H. Power Distribution within Panels:

1. Feeder Circuits:
   a. One or more 120V ac, 60-Hz feeder circuits.
   b. Make provisions for feeder circuit conduit entry.
   c. Furnish terminal board for termination of wires.

2. Power Distribution: Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
   a. Locate to provide clear view of and access to breakers when door is open.
   b. Breaker sizes: Coordinate such that fault in branch circuit will trip only branch breaker but not trip the main breaker.
      1) Branch Circuit Breaker: 15 amps at 250V ac.
   c. Breaker Manufacturers and Products: Refer to Division 26, Electrical.

3. Circuit Wiring: P&IDs and Control Diagrams on Drawings show function only. Use following rules for actual circuit wiring:
   a. Devices on Single Circuit: 20, maximum.
   b. Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.
   c. Branch Circuit Loading: 12 amperes continuous, maximum.
   d. Panel Lighting and Service Outlets: Put on separate 15-amp, 120V ac branch circuit.
   e. Provide 120V ac plug mold for panel components with line cords.

I. Signal Distribution:

1. Within Panels: 4 mA dc to 20 mA dc signals may be distributed as 1V dc to 5V dc.
2. Outside Panels: Isolated 4 mA dc to 20 mA dc only.
3. All signal wiring twisted in shielded pairs.

J. Relays:

1. General:
   b. Relay Enclosure: Furnish dust cover.
   c. Socket Type: Screw terminal interface with wiring.
   d. Socket Mounting: Rail.
   e. Provide holddown clips.
2. PLC Interface Relay:
   a. Type: Narrow design for high density and direct connection of field wiring to relay terminals.
   b. Function: Convert PLC output to dry contact for isolated discrete signal interface.
   c. Relay Mounting: Plug into terminal block style socket.
   e. Socket Width: 0.25-inch nominal.
   f. Coil Voltage: 120V ac.
   g. Coil Power: 0.5 VA.
   h. Expected Mechanical Life: 10,000,000 operations.
   i. Operating Indicator: LED lights when coil is energized.
   j. Contact Arrangement: One Form C, SPDT contact.
   k. Contact Rating: 5A, at 24V dc and 250V ac.
   l. Connection Type: Screw compression clamp.
   m. Terminal Marking: Numbered with preprinted or field-marked tags.
   n. Manufacturers and Products:
      1) Phoenix Contact; PLC-RSC-120UC.
      2) Allen-Bradley; Bulletin 700-HL Terminal Block Relays.
      3) Idec; RV8H series.

3. Control Circuit Switching Relay, Nonlatching:
   a. Type: Compact general-purpose plug-in.
   b. Contact Arrangement: 3 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.
   h. Expected Electrical Life at Rated Load: 100,000 operations.
   i. Indication Type: Neon or LED indicator lamp.
   j. Push to test button.
   k. Manufacturer and Product: Potter and Brumfield; Series KUP.

4. Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
   g. Expected Mechanical Life: 500,000 operations.
   h. Expected Electrical Life at Rated Load: 50,000 operations.
   i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.
5. Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 240V ac.
      1) Contact Material: Silver cadmium oxide alloy.
   d. Coil Voltage: As noted or shown.
   e. Operating Temperature: Minus 10 degrees C to 55 degrees C.
   f. Repeatability: Plus or minus 2 percent.
   g. Delay Time Range: Select range such that time delay setpoint fall between 20 percent to 80 percent of range.
   h. Time Delay Setpoint: As noted or shown.
   i. Mode of Operation: As noted or shown.
   j. Adjustment Type: Integral potentiometer with knob external to dust cover.
   k. Manufacturer and Products:
      1) Potter and Brumfield:
         a) Series CB for 0.1 second to 100 minute delay time ranges.
         b) Series CK for 0.1 to 120 second delay time ranges.

K. Power Supplies:

1. Furnish to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
   a. Protect instruments from damage due to power supply failure.
   b. Protect power supply from damage due to external failure.
4. Enclosures: NEMA 1 in accordance with NEMA 250.
5. Mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
   a. Type: Indicating.
   b. Mount so fuses can be easily seen and replaced.

L. Internal Panel Lights for Freestanding Panels:

1. Type: Switched 15-watt LED back-of-panel lights.
2. Quantity: One light for every 4 feet of panel width.
3. Mounting: Inside and in the top of back-of-panel area.
5. Protective metal shield for lights.
M. Service Outlets for Freestanding Panels:

1. Type: Three-wire, 120-volt, 15-ampere, GFCI duplex receptacles.
2. Quantity:
   a. For Panels 4 Feet Wide and Smaller: One.
   b. For Panels Wider than 4 Feet: One for every 4 feet of panel width, two minimum per panel.

N. Standard Light Colors and Inscriptions: Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted in Instrument List, Article Supplements.

<table>
<thead>
<tr>
<th>Tag Function</th>
<th>Inscription(s)</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>ON</td>
<td>Red</td>
</tr>
<tr>
<td>OFF</td>
<td>OFF</td>
<td>Green</td>
</tr>
<tr>
<td>OPEN</td>
<td>OPEN</td>
<td>Red</td>
</tr>
<tr>
<td>CLOSED</td>
<td>CLOSED</td>
<td>Green</td>
</tr>
<tr>
<td>LOW</td>
<td>LOW</td>
<td>Amber</td>
</tr>
<tr>
<td>FAIL</td>
<td>FAIL</td>
<td>Amber</td>
</tr>
<tr>
<td>HIGH</td>
<td>HIGH</td>
<td>Amber</td>
</tr>
<tr>
<td>AUTO</td>
<td>AUTO</td>
<td>White</td>
</tr>
<tr>
<td>MANUAL</td>
<td>MANUAL</td>
<td>Yellow</td>
</tr>
<tr>
<td>LOCAL</td>
<td>LOCAL</td>
<td>Yellow</td>
</tr>
<tr>
<td>REMOTE</td>
<td>REMOTE</td>
<td>White</td>
</tr>
</tbody>
</table>

2.06 SPARE PARTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Percent of Each Type and Size Used</th>
<th>No Less Than</th>
</tr>
</thead>
<tbody>
<tr>
<td>dc power supplies</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Fuses</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Indicating light bulb</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Relays</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Terminal Blocks</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
2.07 EXPENDABLES

A. Corrosion-Inhibiting Vapor Capsules: Manufacturer’s recommended 2-year supply.

2.08 FABRICATION

A. General:

1. Panels with external dimensions and instruments arrangement as shown on Drawings.
2. Panel Construction and Interior Wiring: In accordance with the National Electrical Code, state and local codes, NEMA, ANSI, UL, and ICECA.
3. Fabricate panels, install instruments, wire, and plumb, at the PIC factory.
4. Electrical Work: In accordance with Division 26, Electrical.

B. Factory Assembly: Assemble panels at the manufacturer’s factory. No fabrication other than correction of minor defects or minor transit damage shall be done on panels at Site.

C. UL Listing Mark for Enclosures: Mark stating “Listed Enclosed Industrial Control Panel” per UL 508A.

D. Wiring Within PIC Panels:

1. Restrain by plastic ties or ducts or metal raceways.
2. Hinge Wiring: Secure at each end so that bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
3. Arrange wiring neatly, cut to proper length, and remove surplus wire.
4. Abrasion protection for wire bundles which pass through holes or across edges of sheet metal.
5. Connections to Screw Type Terminals:
   a. Locking-fork-tongue or ring-tongue lugs.
   b. Use manufacturer’s recommended tool with required sized anvil to make crimp lug terminations.
   c. Wires terminated in a crimp lug, maximum of one.
   d. Lugs installed on a screw terminal, maximum of two.
6. Connections to Compression Clamp Type Terminals:
   a. Strip, prepare, and install wires in accordance with terminal manufacturer’s recommendations.
   b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.
7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V dc and analog signal circuits on separate terminal block from ac circuit terminal blocks.
9. Separate analog and dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
10. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.

E. Temperature Control:

1. Freestanding Panels:
   a. Nonventilated Panels: Size to adequately dissipate heat from equipment mounted inside panel or on panel.
   b. Ventilated Panels:
      1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel or on panel.
      2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.
      3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
      4) Louver Construction: Stamped sheet metal.
      5) Ventilation Fans:
         a) Furnish where required to provide adequate cooling.
         b) Create positive internal pressure within panel.
         c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
      6) Air Filters: Washable aluminum, Hoffman Series A-FLT.
   c. Refrigerated System: Furnish where heat dissipation cannot be adequately accomplished with natural convection or forced ventilation.

2. Smaller Panels (that are not freestanding): Size to adequately dissipate heat from equipment mounted inside panel or in panel face.
3. Space Heaters: Thermostatically controlled to maintain internal panel temperatures above dew point.

F. Freestanding Panel Construction:

1. Materials: Sheet steel, unless otherwise shown on Drawings with minimum thickness of 10-gauge, unless otherwise noted.
2. Panel Fronts:
   a. Fabricated from a single piece of sheet steel, unless otherwise shown on Drawings.
   b. No seams or bolt heads visible when viewed from front.
   c. Panel Cutouts: Smoothly finished with rounded edges.
   d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.

3. Internal Framework:
   a. Structural steel for instrument support and panel bracing.
   b. Permit panel lifting without racking or distortion.

4. Lifting rings to allow simple, safe rigging and lifting of panel during installation.

5. Adjacent Panels: Securely bolted together so front faces are parallel.

6. Doors: Full height, fully gasketed access doors where shown on Drawings.
   a. Latches: Three-point, Southco Type 44.
   c. Hinges: Full length, continuous, piano type, steel hinges with stainless steel pins.
   d. Access Doors: Extend no further than 36 inches beyond panel when opened to 90-degree position.

G. Nonfreestanding Panel Construction:

1. Based on environmental design requirements required and referenced in Article Environmental Requirements, provide the following:
   a. For panels listed as inside, air conditioned:
      1) Enclosure Type: NEMA 12 in accordance with NEMA 250.
      2) Materials: Steel.
   b. For all other panels:
      1) Enclosure Type: NEMA 4X in accordance with NEMA 250.
      2) Materials: Type 316 stainless steel.


3. Doors:
   a. Rubber-gasketed with continuous hinge.
   b. Stainless steel lockable quick-release clamps.

4. Manufacturers:
   b. Rittal.
H. Factory Finishing:

1. Enclosures:
   a. Stainless Steel and Aluminum: Not painted.
   c. Steel Panels:
      1) Sand panel and remove mill scale, rust, grease, and oil.
      2) Fill imperfections and sand smooth.
      3) Paint panel interior and exterior with one coat of epoxy coating metal primer, two finish coats of two-component type epoxy enamel.
      4) Sand surfaces lightly between coats.
      5) Dry Film Thickness: 3 mils, minimum.

2. Manufacturer’s standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment with light gray color.

2.09 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers:
   1. Northern Instruments; Model Zerust VC.
   2. Hoffmann Engineering Co; Model A-HCI.

2.10 SOURCE QUALITY CONTROL

A. Scope: Inspect and test entire PIC to ensure it is ready for shipment, installation, and operation.

B. Location: Manufacturer’s factory or Engineer approved staging Site.

C. Test: Exercise and test all functions.

D. Temporary PLC software configuring to allow PLC testing.

PART 3 EXECUTION

3.01 EXAMINATION

A. For equipment not provided by PIC, but that directly interfaces with the PIC, verify the following conditions:

   1. Proper installation.
   2. Calibration and adjustment of positioners and I/P transducers.
   3. Correct control action.
   4. Switch settings and dead bands.
5. Opening and closing speeds and travel stops.
6. Input and output signals.

3.02 INSTALLATION

A. Material and Equipment Installation: Retain a copy of manufacturers’ instructions at Site, available for review at all times.

B. Electrical Wiring: As specified in Division 26, Electrical.

C. Mechanical Systems:

1. Drawings for PIC Mechanical Systems are diagrammatic and not intended to specifically define element locations or piping and tubing run lengths. Base materials and installations on field measurements.

2. Copper and Stainless Steel Tubing Support: Continuously supported by an aluminum tubing raceway system.

3. Plastic Tubing Supports: Except as shown on Drawings, provide continuous support in conduits or by aluminum tubing raceway system.

4. Install tubing conduit for plastic tubing and tubing raceways parallel with, or at right angles to, structural members of buildings. Make vertical runs straight and plumb.

5. Tubing and Conduit Bends:
   a. Tool-formed without flattening, and all of same radius.
   b. Bend Radius: Equal to or larger than conduit and tubing manufacturer’s recommended minimum bend radius.
   c. Slope instrument connection tubing in accordance with installation details.
   d. Do not run liquid filled instrument tubing immediately over or within a 3-foot plan view clearance of electrical panels, motor starters, or mechanical mounting panel without additional protection. Where tubing must be located in these zones, shield electrical device to prevent water access to electrical equipment.
   e. Straighten coiled tubing by unrolling on flat surface. Do not pull to straighten.
   f. Cut tubing square with sharp tubing cutter. Deburr cuts and remove chips. Do not gouge or scratch surface of tubing.
   g. Blow debris from inside of tubing.
   h. Make up and install fittings in accordance with manufacturer’s recommendations. Verify makeup of tube fittings with manufacturer’s inspection gauge.
   i. Use lubricating compound or TFE tape on stainless steel threads to prevent seizing or galling.
   j. Run tubing to allow, for example, clear access to doors, controls, and control panels; and to allow for easy removal of equipment.
k. Provide separate support for components in tubing runs.
l. Supply expansion loops and use adapters at pipe, valve, or component connections for proper orientation of fitting.
m. Keep tubing and conduit runs at least 12 inches from hot pipes.
n. Locate and install tubing raceways in accordance with manufacturer’s recommendations. Locate tubing to prevent spillage, overflow, or dirt from above.
o. Securely attach tubing raceways to building structural members.

6. Enclosure Lifting Rings: Remove rings following installation and plug holes.

D. Removal or Relocation of Materials and Equipment:

1. Remove from Site materials that were part of the existing facility but are no longer used, unless otherwise directed by Engineer to deliver to Owner.
2. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.

3.03 FIELD FINISHING

A. Refer to Section 09 90 00, Painting and Coating.

3.04 FIELD QUALITY CONTROL

A. Startup and Testing Team:

1. Thoroughly inspect installation, termination, and adjustment for components and systems.
2. Complete onsite tests.
3. Complete onsite training.
4. Provide startup assistance.

B. Operational Readiness Inspections and Calibrations: Prior to startup, inspect and test to ensure that entire PIC is ready for operation.

1. Loop/Component Inspections and Calibrations:
   a. Check PIC for proper installation, calibration, and adjustment on a loop-by-loop and component-by-component basis.
   b. Prepare component calibration sheet for each active component (except simple hand switches, lights, gauges, and similar items).
      1) Project name.
      2) Loop number.
      3) Component tag number.
      4) Component code number.
5) Manufacturer for elements.
6) Model number/serial number.
7) Summary of functional requirements, for example:
   a) Indicators and recorders, scale and chart ranges.
   b) Transmitters/converters, input and output ranges.
   c) Computing elements’ function.
   d) Controllers, action (direct/reverse) and control modes (PID).
   e) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
8) Calibrations, for example:
   a) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
   b) Discrete Devices: Actual trip points and reset points.
   c) Controllers: Mode settings (PID).
9) Space for comments.

2. Leak Test: In accordance with Section 40 80 01, Process Piping Leakage Testing.

C. Performance Acceptance Tests (PAT): These are the activities that Section 01 91 14, Equipment Testing and Facility Startup, refers to as Performance Testing.

1. General:
   a. Test all PIC elements to demonstrate that PIC satisfies all requirements.
   b. Test Format: Cause and effect.
      1) Person conducting test initiates an input (cause).
      2) Specific test requirement is satisfied if correct result (effect) occurs.
   c. Procedures, Forms, and Checklists:
      1) Conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
      2) Describe each test item to be performed.
      3) Have space after each test item description for sign off by appropriate party after satisfactory completion.
   d. Required Test Documentation: Test procedures, forms, and checklists. All signed by Engineer and Contractor.
   e. Conducting Tests:
      1) Provide special testing materials, equipment, and software.
      2) Wherever possible, perform tests using actual process variables, equipment, and data.
      3) If it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation.
Define simulation techniques in test procedures.

f. Coordinate PIC testing with Owner and affected Subcontractors.

1) Excessive Test Witnessing: Refer to Supplementary Conditions.

2. Test Requirements:
   a. Once facility has been started up and is operating, perform a witnessed PAT on complete PIC to demonstrate that it is operating as required. Demonstrate each required function on a paragraph-by-paragraph and loop-by-loop basis.
   b. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
   c. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
   d. Make updated versions of documentation required for PAT available to Engineer at Site, both before and during tests.
   e. Make one copy of O&M manuals available to Engineer at the Site both before and during testing.
   f. Refer to referenced examples of PAT procedures and forms in Article Supplements.

3.05 MANUFACTURER’S SERVICES

A. Specialty Equipment: For following equipment, provide the services of a qualified manufacturer’s representative during installation, startup, and demonstration testing and Owner training. Provide original equipment manufacturer’s services for:

3.06 TRAINING

A. General:

1. Provide an integrated training program to meet specific needs of Owner’s personnel.
2. Include training sessions, classroom and field, for managers, engineers, operators, and maintenance personnel.
3. Provide instruction on one working shift(s) as needed to accommodate the Owner’s personnel schedule.
4. Owner reserves the right to make and reuse video tapes of training sessions.
B. Operations and Maintenance Training:

1. Include a review of O&M manuals and survey of spares, expendables, and test equipment.
2. Use equipment similar to that provided or currently owned by Owner.
3. Provide training suitable for instrument technicians with at least a 2-year associate engineering or technical degree, or equivalent education and experience in electronics or instrumentation.

C. Operations Training:

1. Training Session Duration: Five 8-hour instructor days.
2. Number of Training Sessions: One.
3. Location: Project Site.
4. Content: Conduct training on loop-by-loop basis.
   a. Loop Functions: Understanding of loop functions, including interlocks for each loop.
   b. Loop Operation: For example, adjusting process variable setpoints, AUTO/MANUAL control transfer, AUTO and MANUAL control, annunciator acknowledgement and resetting.
   c. Interfaces with other control systems.

D. Maintenance Training:

1. Training Session Duration: Five 8-hour instructor days.
2. Number of Training Sessions: One.
3. Location: Project Site.
4. Content: Provide training for each type of component and function provided.
   a. Loop Functions: Understanding details of each loop and how they function.
   b. Component calibration.
   c. Adjustments: For example, controller tuning constants, current switch trip points, and similar items.
   d. Troubleshooting and diagnosis for components.
   e. Replacing lamps, chart paper, fuses.
   f. Component removal and replacement.
   g. Periodic maintenance.
   h. PLC program file storage and loading, online troubleshooting.

3.07 CLEANING/ADJUSTING

A. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.
B. Cleaning:

1. Prior to closing system using tubing, clear tubing of interior moisture and debris.
2. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.08 PROTECTION

A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.

B. Periodically replace capsules in accordance with capsule manufacturer’s recommendations. Replace capsules just prior to Final Payment and Acceptance.

3.09 SUPPLEMENTS

A. Supplements listed below, following “End of Section,” are part of this Specification.

1. Instrument List.
2. Loop Specifications.
3. **PLC Input and Output List.**
4. Instrument Calibration Sheet: Provides detailed information on each instrument (except simple hand switches, lights, and similar items).
5. Performance Acceptance Test Sheet: Describes the PAT for a given loop. The format is mostly free form.
   a. Lists the requirements of the loop.
   b. Briefly describes the test.
   c. Cites expected results.
   d. Provides space for check off by witness.

**END OF SECTION**
<table>
<thead>
<tr>
<th>Tag Number</th>
<th>Comp Code</th>
<th>Component Title</th>
<th>Options</th>
<th>P&amp;ID</th>
<th>Inst. Detail</th>
<th>Mech/Elec</th>
<th>Panel Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LOOP SPECIFICATIONS

LOOP xx

Functions:
## Instrument Calibration Sheet

### Component Information

<table>
<thead>
<tr>
<th>Code:</th>
<th>Name:</th>
<th>Serial #:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Project Information

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Functions

<table>
<thead>
<tr>
<th>Range</th>
<th>Value</th>
<th>Units</th>
<th>Computing Functions? Y/N</th>
<th>Control? Y/N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Indicate? Y/N: Chart: Describe:
- Record? Y/N: Scale:
- Transmit/ Convert? Y/N: Input: Output:

### Analog Calibrations

#### Required

<table>
<thead>
<tr>
<th>Input</th>
<th>Indicated Output</th>
<th>Increasing Input</th>
<th>Decreasing Input</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indicated Output</td>
<td>Indicated Output</td>
<td>Indicated Output</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Trip Point</th>
<th>Reset Pt.</th>
<th>Trip Point</th>
<th>Reset Pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(note rising or falling)</td>
<td>(note rising or falling)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. 
2. 
3. 
4. 
5. 
6.

### Discrete Calibrations

<table>
<thead>
<tr>
<th>Note</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Control Mode Settings

<table>
<thead>
<tr>
<th>P:</th>
<th>I:</th>
<th>D:</th>
</tr>
</thead>
</table>

### Notes

Component Calibrated and Ready for Startup

By:  
Date:  
Tag No.:
**INSTRUMENT CALIBRATION SHEET**

**EXAMPLE - ANALYZER/TRANSMITTER**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>MANUFACTURER</th>
<th>PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: pH Element &amp; Analyzer/Transmitter</td>
<td>Model: 12429-3-2-1-7</td>
<td>Name: UOSA AWT PHASE 3</td>
</tr>
<tr>
<td>Serial #: 11553322</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### FUNCTIONS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmit/</td>
<td>Convert? Y</td>
<td>Input:</td>
<td>1-14</td>
<td>pH units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convert? Y</td>
<td></td>
<td>Output:</td>
<td>4-20</td>
<td>mA dc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ANALOG CALIBRATIONS

<table>
<thead>
<tr>
<th>REQUIRED</th>
<th>AS CALIBRATED</th>
<th>DISCRETE CALIBRATIONS</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>Indicated</td>
<td>Output</td>
<td>Increasing Input</td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>4.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2.3</td>
<td>2.3</td>
<td>5.6</td>
<td>2.2</td>
</tr>
<tr>
<td>7.5</td>
<td>7.5</td>
<td>12.0</td>
<td>7.5</td>
</tr>
<tr>
<td>12.7</td>
<td>12.7</td>
<td>18.4</td>
<td>12.7</td>
</tr>
<tr>
<td>14.0</td>
<td>14.0</td>
<td>20.0</td>
<td>14.0</td>
</tr>
</tbody>
</table>

### CONTROL MODE SETTINGS:

<table>
<thead>
<tr>
<th>P: N.A.</th>
<th>I:</th>
<th>D:</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# NOTES:

1. Need to recheck low pH calibration solutions.

**Component Calibrated and Ready for Startup**

By: J.D. Sewell

Date: Jun-6-92

Tag No.: AIT-12-6[pH]
### Demonstration Test(s): For each functional requirement of the loop:

(a) List and number the requirement. (b) Briefly describe the demonstration test.

(c) Cite the results that will verify the required performance. (d) Provide space for signoff.

<table>
<thead>
<tr>
<th>Forms/Sheets Verified</th>
<th>By</th>
<th>Date</th>
<th>Loop Accepted By Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop Status Report</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrument Calibration Sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I&amp;C Valve Calibration Sheet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance Acceptance Test</td>
<td>By</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Performed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Witnessed</td>
<td></td>
<td></td>
<td>Loop No.:</td>
</tr>
</tbody>
</table>
### Demonstration Test(s): For each functional requirement of the loop:

- **List and number the requirement.**
- **Briefly describe the demonstration test.**
- **Cite the results that will verify the required performance.**
- **Provide space for signoff.**

#### 1. MEASURE EFFLUENT FLOW

1.a With no flow, water level over weir should be zero and 

   FIT indicator should read zero.

   **Jun-20-92 BDG**

#### 2. FLOW INDICATION AND TRANSMISSION TO LP & CCS

With flow, water level and FIT indicator should be related by expression

\[ Q(\text{MGD}) = 429 \times H^{(2/3)} \]  

\( H = \) height in inches of water over weir.

Vary \( H \) and observe that following.

2.a Reading of FIT indicator.

2.b Reading is transmitted to FI on LP-521-1.

2.c Reading is transmitted and displayed to CCS.

**Jun-6-92 BDG**

<table>
<thead>
<tr>
<th>( H(\text{measured}) )</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q(\text{computed}) )</td>
<td>0</td>
<td>47.96</td>
<td>135.7</td>
<td>251.7</td>
</tr>
<tr>
<td>( Q(\text{FIT indicator}) )</td>
<td>0</td>
<td>48.1</td>
<td>137</td>
<td>253</td>
</tr>
<tr>
<td>( Q(\text{FI on LP-521-1}) )</td>
<td>0</td>
<td>48.2</td>
<td>138</td>
<td>254</td>
</tr>
<tr>
<td>( Q(\text{display by CCS}) )</td>
<td>0</td>
<td>48.1</td>
<td>136.2</td>
<td>252.4</td>
</tr>
</tbody>
</table>

### Forms/Sheets Verified

<table>
<thead>
<tr>
<th>Forms/Sheets Verified</th>
<th>By</th>
<th>Date</th>
<th>Loop Accepted By Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop Status Report</td>
<td>J.D. Sewell</td>
<td>May-18-92</td>
<td>By: J.D. Smith</td>
</tr>
<tr>
<td>Instrument Calibration Sheet</td>
<td>J.D. Sewell</td>
<td>May-18-92</td>
<td>Date: Jun-6-92</td>
</tr>
<tr>
<td>I&amp;C Valve Calibration Sheet</td>
<td>N.A.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance Acceptance Test</td>
<td>By</td>
<td>Date</td>
<td>Loop No.: 30-12</td>
</tr>
<tr>
<td>Performed</td>
<td>J. Blow MPSDC Co.</td>
<td>Jun-6-92</td>
<td></td>
</tr>
<tr>
<td>Witnessed</td>
<td>B.deGlanville</td>
<td>Jun-6-92</td>
<td></td>
</tr>
</tbody>
</table>
SECTION 40 91 00
INSTRUMENTATION AND CONTROL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. This section gives general requirements for instrumentation and control components.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

PART 2 PRODUCTS

2.01 GENERAL

A. Article Mechanical Systems Components covers requirements of mechanical PIC components that are not specifically referenced elsewhere.

B. Article Electrical Components covers requirements for electrical PIC components that are not specifically referenced elsewhere.

2.02 MECHANICAL SYSTEMS COMPONENTS

A. Flow Element, Rotameter, Purge:

   1. For air or water service, unless otherwise noted.
   3. Direct-Reading Scale Length: 2-1/2 inches, minimum.
   4. Scale Ranges: 0 scfh to 2.5 scfh for air service or 0 gph to 10 gph for water service.
   5. Integral inlet needle valves.
   6. Integral Differential Pressure Regulators:
      a. For water service.
      b. For air service for level ranges greater than 10 feet of water.
   7. Rotameters for water service.
8. Manufacturers and Products:
   a. Fischer & Porter; Series 10A3130.
   b. Brooks; Series DS-1350.

B. Manifold, Three-Valve Equalizing:
   1. Type: For isolation and equalization of differential pressure transducers.
   3. Manufacturers and Products:
      b. Evans.

C. Pressure Gauge: For other than process variable measurement.
   1. Dial Size: Nominal 2-inch dial size.
   2. Accuracy: 2 percent of span.
   3. Scale Range: Such that normal operating pressure lies between
      50 percent and 80 percent of scale range.
   4. Connection: 1/4-inch NPT through bottom, unless otherwise noted.
   5. Manufacturers and Products:
      a. Ashcroft Utility; Gauge Series 1000.
      b. Marsh; Standard Gauge Series.
      d. Acculite; Series 2000.

D. Valve, Needle:
   1. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by
      manufacturer for designated service, unless otherwise shown on
      Drawings.
   2. Size: 0.020-inch orifice.
   3. Manufacturers and Products:
      a. Whitey; Model 21RF2.
      b. Hoke; 3700 Series.

E. ON/OFF Valves:
   1. Type: Ball valve.
   2. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by
      manufacturer for designated service, unless otherwise shown on
      Drawings.
   3. Manufacturers and Products:
      a. Whitey; Series 41 through Series 43.
      b. Hoke; Flomite 7100 Series.
F. Regulating Valves:

1. Type: Needle valves, with regulating stems and screwed bonnets.
2. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
3. Manufacturers and Products:
   a. Whitey; Catalog No. RF or No. RS.
   b. Hoke; 3100 through 3300 Series.

G. Valve, Three-Way:

1. Type: Ball valve.
2. Materials: Brass or stainless steel with nylon handle as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
3. Manufacturers and Products:
   a. Whitey; Series 41 through Series 43.
   b. Hoke; Selecto-Mite Series.

H. Valve, Four-Way:

1. Type: Four-way, two-position ball valve.
2. Materials:
   a. Body and Stem: Type 316 stainless steel.
   b. Handle: Black nylon.
3. Ball and stem bed, one-piece assembly.
4. Machined handle stops and directional nameplates.
5. Manufacturers and Products:
   a. Whitey; Series 457.
   b. Hoke; Multi-Mite Series.

I. Solenoid Valve, Two-Way:

1. Type: Globe valve directly actuated by solenoid and not requiring minimum pressure differential for operation.
2. Materials:
   a. Body: Brassed or stainless steel globe valves as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
   b. Valve Seat: Buna-N.
3. Size: Normally closed or opened, as noted.
4. Coil: 115V ac, unless noted otherwise.
6. Manufacturer and Product: ASCO; Red Hat Series 8260.

J. Pressure Regulator, Air:

1. Provide air at reduced pressures, as shown, constant to within plus or minus 10 percent for flows from 0 scfh to 300 scfh with 100 psi supply pressure.
2. Setscrew for outlet pressure adjustment.
3. Integral filter and relief valve.
4. Manufacturers and Products:
   a. Masoneilan; Series 77-4.
   b. Fisher; Series 67FR.

K. Pressure Regulator, Water:

1. Materials:
   a. Body: Bronze.
   b. Spring Case: Cast iron.
   c. Seat Rings: Brass.
   d. Valve Disk and Holder: Buna-N and bronze.
   e. Diaphragm: Buna-N diaphragm.
2. Sizing: For maximum of 7 psi offset pressure.
3. Manufacturers and Products:
   a. Fisher; Controls Type 95H or 95L.
   b. Masoneilan; Series 17.

L. Test Tap:

1. Manufacturers and Products:
   a. Imperial-Eastman; quick-disconnect couplings No. 292-P and caps No. 259-P.
   b. Crawford Fitting Co.; Swagelok quick-connects Series QC4 and caps QC4-DC.
   c. Parker; CPI Series precision quick couplings.

M. Copper Tubing and Fittings:

1. Type K hard copper, ASTM B88, with commercially pure wrought copper solder joint fittings. Make joints with 95-5 wire solder, ASTM B32, Grade 95 TA. Do not use cored solder.
2. Alternatively, Type K, soft temper copper tubing, ASTM B88, with brass compression type fittings may be used where shown on Drawings.
3. Manufacturers:
   a. Parker-Hannifin.
   b. Swagelok tube fittings.

N. Plastic Tubing and Fittings:

1. Tubing:
   a. Polyethylene capable of withstanding 190 psig at 175 degrees F.
   b. Manufacturers and Products:
      1) Dekoron; Type P.
      2) Imperial Eastman; Poly-Flo black instrument tubing.

2. Fittings:
   a. Type: Brass compression.
   b. Manufacturers and Products:
      1) Imperial Eastman; Poly-Flo tube fittings.
      2) Dekoron; E-Z fittings.

O. Stainless Steel Tubing: ASTM A312/A312M, Type 316, 0.065-inch wall, seamless, soft annealed, as shown on Drawings.

P. Stainless Steel Fittings:

1. Compression Type:
   a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, flareless.
   b. Manufacturers and Products:
      1) Parker Flodar; BA Series.
      2) Swagelok tube fittings.
      3) Parker CPI tube fittings; Parker A-LOK dual ferrule tube fittings.

2. Socket Weld Type:
   a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, 3,000 psi maximum working pressure, safety factor 4:1.
   b. Manufacturers:
      1) Cajon.
      2) Swagelok.
      3) Parker WELDLOK.

Q. Air Set: Consists of a shutoff valve, pressure regulator, discharge pressure gauge, and interconnecting tubing.
R. Purge Set:
   1. Parts: Purge rotameter flow element, pressure regulator, pressure gauge, test tap, shut-off valve, spool valve, and interconnecting tubing as shown on Drawings and as required in this section.
   2. Pressure Gauge Scale Range: 150 percent of the process variable.
   3. Mounting:
      a. Within consoles, panels, or a separate enclosure as shown.
      b. For separate enclosure mounted purge sets, refer to paragraphs Nonfreestanding Panel Construction and Factory Finishing for enclosure requirements.

S. Tubing Raceways:
   1. Cable tray systems complete with tees, elbows, reducers, and covers.
   2. Size in accordance with manufacturer’s recommendations for intended service.
   3. Materials: Galvanized steel or aluminum brass as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
   4. Manufacturers:
      a. Globetray.
      b. Cope.

T. Air Supply Sets:
   1. Parts: Integrally Mounted:
      a. Pressure Controls: Automatic START/STOP, factory set at 30 psig to 50 psig.
      c. Pressure gauge.
      d. Inlet filter muffler.
      e. Power: 120V ac.
      f. Compressor: Oilless, single cylinder, rated for at least 1 scfm at 50 psig.
      g. Manufacturers and Products:
         1) ITT Pneumotive; GH Series.
         2) Gast.
   2. Simplex Air Supply Sets:
      a. Air Receiver: 2 gallons.
      b. Compressors: One.
3. Duplex Air Supply Sets:
   a. Air Receiver: 20 gallons.
   b. Compressors: Two.

2.03 ELECTRICAL COMPONENTS

A. Terminal Blocks for Enclosures:

1. General:
   a. Connection Type: Screw compression clamp.
   b. Compression Clamp:
      1) Complies with DIN-VDE 0611.
      2) Hardened steel clamp with transversal grooves that
         penetrate wire strands providing a vibration-proof
         connection.
      3) Guides strands of wire into terminal.
   d. Current Bar: Copper or treated brass.
   e. Insulation:
      1) Thermoplastic rated for minus 55 degrees C to plus
         110 degrees C.
      2) Two funneled shaped inputs to facilitate wire entry.
   f. Mounting:
      1) Standard DIN rail.
      2) Terminal block can be extracted from an assembly without
         displacing adjacent blocks.
      3) End Stops: Minimum of one at each end of rail.
   g. Wire Preparation: Stripping only permitted.
   h. Jumpers: Allow jumper installation without loss of space on
      terminal or rail.
   i. Features:
      1) Color: Gray or beige body, or as noted.
      2) Spacing: 0.25 inch, or as noted.
      3) Rated Wire Size: 10 AWG.
   j. Marking System:
      1) Terminal number shown on both sides of terminal block.
      2) Allow use of preprinted and field marked tags.
      3) Terminal strip numbers shown on end stops.
      4) Mark terminal block and terminal strip numbers as shown
         on panel control diagrams and loop diagrams.
      5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and
         amperage rating shown on top of terminal block.
k. Manufacturers:
   1) Entrelec.
   2) Phoenix Contact.

2. Terminal Block, General Purpose:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 30 amp.
   c. Wire Size: 24 AWG to 10 AWG.

3. Terminal Block, Ground:
   a. Wire Size: 24 AWG to 10 AWG.
   b. Color: Green and yellow body.
   c. Grounding: Electrically grounded to mounting rail.

4. Terminal Block, Blade Disconnect Switch:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 10 amp.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Color: Gray body, orange switch.

5. Terminal Block Diode:
   a. Rated Voltage: 24V dc.
   b. Rated Current: 30 ma.
   c. Wire Size: 16 AWG.

6. Terminal Block, Fused, 24V dc:
   a. Rated Voltage: 600V dc.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Fuse: 0.25 inch by 1.25 inches.
   e. Indication: LED diode 24V dc.
   f. Spacing: 0.512 inch, maximum.

7. Terminal Block, Fused, 120V ac:
   a. Rated Voltage: 600V ac.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Fuse: 0.25 inch by 1.25 inches.
   e. Indication: Neon lamp, 110V ac.
   f. Leakage Current: 1.8 mA, maximum.
   g. Spacing: 0.512 inch, maximum.

8. Terminal Block, Fused, 120V ac, High Current:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 35 amps.
   c. Wire Size: 18 AWG to 8 AWG.
   d. Rated Wire Size: 8 AWG.
   e. Fuse: 13/32 inch by 1.5 inches.
   f. Spacing: 0.95 inch, maximum.
B. Relays:

1. General:
   b. Relay Enclosure: Furnish dust cover.
   c. Socket Type: Screw terminal interface with wiring.
   d. Socket Mounting: Rail.
   e. Provide holddown clips.

2. PLC Interface Relay:
   a. Type: Narrow design for high density and direct connection of field wiring to relay terminals.
   b. Function: Covert PLC output to dry contact for isolated discrete signal interface.
   c. Relay Mounting: Plug into terminal block style socket.
   e. Socket Width: 0.25-inch nominal.
   f. Coil Voltage: 120V ac.
   g. Coil Power: 0.5 VA.
   h. Expected Mechanical Life: 10,000,000 operations.
   i. Operating Indicator: LED lights when coil is energized.
   j. Contact Arrangement: One Form C, SPDT contact.
   k. Contact Rating: 5A, at 24V dc and 250V ac.
   l. Connection Type: Screw compression clamp.
   m. Terminal Marking: Numbered with preprinted or field-marked tags.
   n. Manufacturers and Products:
      1) Phoenix Contact; PLC-RSC-120UC.
      2) Allen-Bradley; Bulletin 700-HL Terminal Block Relays.
      3) Idec; RV8H series.

3. Control Circuit Switching Relay, Nonlatching:
   a. Type: Compact general purpose plug-in.
   b. Contact Arrangement: 3 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac, and 6.6A at 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.
   h. Expected Electrical Life at Rated Load: 100,000 operations.
   i. Indication Type: Neon or LED indicator lamp.
   j. Push-to-test button.
   k. Manufacturer and Product: Potter and Brumfield; Series KUP.

4. Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: 2 Form C contacts.
c. Contact Rating: 10A at 28V dc or 120V ac.
d. Contact Material: Silver cadmium oxide alloy.
e. Coil Voltage: As noted or shown.
f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
g. Expected Mechanical Life: 500,000 operations.
h. Expected Electrical Life at Rated Load: 50,000 operations.
i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.

5. Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: 2 Form C contacts.
c. Contact Rating: 10A at 30V dc or 277V ac.
d. Contact Material: Silver cadmium oxide alloy.
e. Coil Voltage: As noted or shown.
f. Operating Temperature: Minus 10 degrees C to 55 degrees C.
g. Repeatability: Plus or minus 2 percent.
h. Delay Time Range: Select range such that time delay setpoint fall between 20 percent to 80 percent of range.
i. Time Delay Setpoint: As noted or shown.
j. Mode of Operation: As noted or shown.
k. Adjustment Type: Integral potentiometer with knob external to dust cover.
l. Manufacturer and Products: Potter and Brumfield; Series CB for 0.1-second to 100-minute delay time ranges, Series CK for 0.1-second to 120-second delay time ranges.

C. Surge Suppressors:

   1. General:
      a. Construction: First-stage, high-energy metal oxide varistor and second-stage, bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
      b. Response: 5 nanoseconds maximum.
      d. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
      e. Enclosure Mounted: Encapsulated flame retardant epoxy.

   2. Suppressors on 120V ac Power Supply Connections:
      a. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
      b. First-Stage Clamping Voltage: 350 volts or less.
      c. Second-Stage Clamping Voltage: 210 volts or less.
      d. Power Supplies for Continuous Operation:
         1) Four-Wire Transmitter or Receiver: Minimum 5 amps at 130V ac.
         2) All Other Applications: Minimum 30 amps at 130V ac.
3. Suppressors on Analog Signal Lines:
   a. Test Waveform: Linear 8-microsecond rise in current from 0 amps to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
   b. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
      1) dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
      2) dc Clamping Voltage Tolerance: Plus or minus 10 percent.
      3) Maximum Loop Resistance: 18 ohms per conductor.

4. Manufacturers and Products:
   a. Analog Signals Lines: Emerson Edco PC-642 or SRA-64 series.
   b. 120V ac Lines: Emerson Edco HSP-121.
   c. Field Mounted at Two-Wire Instruments:
      1) Encapsulated in stainless steel pipe nipples.
      2) Emerson Edco SS64 series.
   d. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
      1) Enclosure:
         a) NEMA 4X Type 316 stainless steel with door.
         b) Maximum Size: 12 inches by 12 inches by 8 inches deep.
      2) Emerson Edco; SLAC series.

D. Power Supplies:
   1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.
   2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
   3. Provide output over voltage and over current protective devices to:
      a. Protect instruments from damage due to power supply failure.
      b. Protect power supply from damage due to external failure.
   5. Mount such that dissipated heat does not adversely affect other components.
   6. Fuses: For each dc supply line to each individual two-wire transmitter.
      a. Type: Indicating.
      b. Mount so fuses can be easily seen and replaced.
E. Intrinsic Safety Barriers:

1. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.

2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.

2.04 LEVEL COMPONENTS

A. L18 Level Switch, Non-Mercury:

1. General:
   a. Function: Actuate contact at preset liquid level.
   b. Type:
      1) Direct-acting, stainless steel float with enclosed, encapsulated switch and integral cable.
      2) Mercury-free.

2. Service (Liquid): Wastewater, unless otherwise noted.

3. Performance:
   a. Setpoint: As noted.
   b. Differential: 8 inches maximum.
   c. Temperature: 32 degrees F (nonfreezing) to 160 degrees F.

4. Features:
   a. Entire Assembly: Watertight and impact-resistant.
   b. Float
      1) Material and Size: 5.5-inch diameter polymer-coated, Type 316 stainless steel float.
      2) Buoyancy: 2 pounds.
   c. Cable:
      1) Length as noted or as necessary per mounting requirements.
      2) Plastic-jacketed cable, oil-resistant, and suitable for continuous service.
   d. Mounting: Pipe, unless otherwise noted.
      1) Pipe Mounting:
         a) Cable clamp, suitable for connection to 1-inch pipe.
         b) Pipe-to-wall bracket, suitable for connection to 1-inch pipe.
      2) Anchor Mounting Kit: If noted.
         a) 15-pound vinyl-coated cast-iron anchor.
         b) 1/8-inch, Type 316 stainless steel wire rope.
         c) Stainless steel cable clips.
5. Signal Interface:
   a. Switch Type: Magnetic reed.
   b. Switch Contacts:
      1) Isolated, rated at least 0.8 amp continuous at 120V ac.
      2) Contact Type: Either NO or NC, as required by application or as noted; or SPDT (NO and NC).

6. Accessories: As noted.

7. Manufacturers and Products:
   a. Siemens Water Technologies; Model 9G-EF Direct Acting Float Switch (B100).
   b. Contegra; Model FS90.

B. L41 Level Element/Transmitter, Submersible:

1. General:
   a. Function: Measure and transmit signal proportional to level.
   b. Type: Totally submersible pressure sensor (loop powered).
   c. Parts: Sensor, interconnecting cable, other parts as noted.

2. Service:
   a. Fluid: Well water, unless otherwise noted.

3. Performance:
   a. Process Range:
      1) As noted.
      2) Provide calibrated factory range to match noted process range.
   b. Accuracy: 0.3 percent of full scale.
   c. Temperature, Operating: 14 degrees F to plus 140 degrees F.
   d. Overpressure:
      1) Proof: At least 1.5 times full scale.
      2) Burst: At least 2.0 times full scale.

4. Features:
   a. Element:
      1) Approved for drinking water.
      2) Type 316 stainless steel or titanium pressure module assembly, unless otherwise noted.
      3) NEMA 6/IP 68 rating (submersible).
      4) Dimensions, Nominal:
         a) Diameter: 0.92 inches or less, suitable for installation in 1-inch diameter well sensor pipe.
         b) Length: 10 inches maximum.
      5) Loop powered, 10V dc to 30V dc.
b. Interconnecting Cable:
1) Length: As required.
2) Strain relief cord.
3) Integral vent tube.

c. Element Termination Enclosure: Required, unless otherwise noted.
1) Enclosure: NEMA 4X.
2) Termination of cable wiring.
3) Houses moisture control element.

d. Accessories:
1) Moisture Control:
   a) Terminate the integral vent tube with one of the following:
      (1) Moisture filter cap.
      (2) Aneroid bellows.
      (3) Desiccant module.
   2) Spare Desiccant Modules: One per element when desiccant modules are provided.
   3) Cable Hanger, Kellems Type Grip: Required, unless otherwise noted.
   4) Anchor Assembly: If noted.
      a) Marine anchor, clamps, Type 316 stainless steel cable or chain, length as required, nominally 3 feet longer than interconnecting cable.

5. Signal Interface: 4 mA to 20 mA dc output, for load impedance of 0 ohm to 600 ohms, minimum for 24V dc supply without load adjustment.

6. Manufacturers and Products:
   a. Endress and Hauser; FMX 167.
   b. Siemens; LH100.
   c. GE Sensing; Druck PTX 1830.

2.05 PRESSURE COMPONENTS

A. P9 Pressure Transmitter:

1. General:
   a. Function: Measure pressure and transmit signal proportional to pressure.
   b. Type:
      1) Electronic variable capacitance or silicon strain gauge.
      2) Two-wire transmitter; “smart electronics”.
   c. Parts: Transmitter and accessories.
2. Performance:
   a. Range: As noted. Select transmitter’s factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL, but does not exceed it.
   b. Accuracy: Plus or minus 0.075 percent of span, unless otherwise noted.
   c. Ambient Operating Temperature: Minus 40 degrees F to plus 175 degrees F, with integral meter.
   d. Process Operating Temperature: Minus 40 degrees F to plus 250 degrees F.
   e. Humidity: 0 percent to 100 percent relative humidity.
   f. Hazardous Location Certifications: If and as noted.

3. Features:
   a. Type: Gauge pressure, unless otherwise noted.
   b. Adjustable damping.
   c. LCD indicator, unless otherwise noted. Display in either percent or engineering units, field configurable.
   d. Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted. Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
   e. Wetted O-Rings: Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise noted.
   f. Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
   g. Fill Fluid: Silicone, unless otherwise noted.

4. Process Connections:
   a. Line Size: 1/2 inch.
   b. Connection Type: FNPT.

5. Signal Interface: 4 mA dc to 20 mA dc output with digital signal based on HART protocol, unless otherwise noted below.

6. Enclosure:
   a. Type: NEMA 4X, minimum, unless otherwise noted.
   b. Materials: Coated aluminum, unless otherwise noted.
   c. Mounting bracket, unless otherwise noted.
      1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.

7. Accessories: Two-valve (isolate and vent) Stainless Steel Manifold: Required unless otherwise noted.

8. Manufacturers and Products:
   a. Gauge Pressure Units:
      1) Endress and Hauser; Deltapilot FMB70.
      2) Siemens; P310.
3) Rosemount; Model 3051S.
4) Foxboro; Model IGP20.

b. Absolute Pressure Units:
1) Endress and Hauser; Cerabar S PMC71.
2) Siemens; PDS III.
3) Rosemount; Model 3051S.
4) Foxboro; Model IAP20.

PART 3 EXECUTION (NOT USED)

END OF SECTION
SECTION 40 99 90
PACKAGE CONTROL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
   c. ICS 2, Industrial Control Devices, Controllers and Assemblies.

1.02 SYSTEM DESCRIPTION

A. Assemble panels and install instruments, plumbing, and wiring in equipment manufacturer’s factories.

B. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer’s factory.

1.03 SUBMITTALS

A. Action Submittals:

1. Bill of material, catalog information, descriptive literature, wiring diagrams, and Shop Drawings for components of control system.
2. Catalog information on electrical devices furnished with system.
3. Shop Drawings, catalog material, and dimensional layout drawings for control panels and enclosures.
4. Panel elementary diagrams of prewired panels. Include in diagrams control devices and auxiliary devices, for example, relays, alarms, fuses, lights, fans, and heaters.
5. Plumbing diagrams of preplumbed panels and interconnecting plumbing diagrams.
6. Interconnection wiring diagrams that include numbered terminal
designations showing external interfaces.
7. Anchorage and bracing data sheets and drawings as required by
Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:
1. Anchorage and bracing calculations as required by Section 01 88 15,
   Anchorage and Bracing.
2. Programmable Controller Submittals:
   a. Complete set of user manuals.
   b. Fully documented ladder logic listings.
   c. Function listing for function blocks not fully documented by
      ladder logic listings.
   d. Cross-reference listing.
   e. Final copy of PLC program in electronic format for backup.
3. Manufacturer’s list of proposed spares, expendables, and test
equipment.
4. Manufacturer’s Certificate of Proper Installation, in accordance with
   Section 01 43 33, Manufacturers’ Field Services.

1.04 DELIVERY, STORAGE, AND HANDLING
A. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping
   containers and related equipment as recommended by capsule manufacturer.

1.05 EXTRA MATERIALS
A. Spares, Expendables, and Test Equipment:
   1. Light Bulb: 100 percent, two minimum of each type used.
   2. Fuse: 100 percent, five minimum of each type used.
   3. Surge Suppressors: 10 percent, one minimum of each type used.

PART 2 PRODUCTS
2.01 GENERAL
A. Section 40 90 01, Instrumentation and Control for Process Systems.

2.02 SIGNAL CHARACTERISTICS
A. Analog Signals:
   1. 4 mA to 20 mA dc, in accordance with compatibility requirements of
      ISA S50.1.
2. Unless otherwise specified or shown, use Type 2, two-wire circuits.
3. Transmitters: Load resistance capability conforming to Class L.
4. Fully isolate input and output signals of transmitters and receivers.

B. Discrete Signals:
   1. Two-state logic signals.
   2. Utilize 120V ac sources for control and alarm signals.
   3. Discrete signals shall be normally open, close to alarm isolated contacts rated for 5-ampere at 120V ac and 2-ampere at 30V dc.

2.03 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers:
   1. Northern Instruments; Model Zerust VC.
   2. Hoffmann Engineering; Model A-HCI.

2.04 CONTROL PANEL

A. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), UL 508, state and local codes, and applicable sections of NEMA, ANSI, and ICECA.

B. Conform to NEMA ratings as specified in individual equipment sections.

C. Minimum Metal Thickness: 14 gauge.

D. NEMA 250, Type 4X Panels: Type 316 stainless steel construction unless otherwise specified.

E. Doors:
   1. Three-point latching mechanisms in accordance with NEMA 250 Type 1 and Type 12 panels with doors higher than 18 inches.
   2. For other doors, stainless steel quick release clamps.

F. Cutouts shall be cut, punched, or drilled and finished smoothly with rounded edges.

G. Access: Front, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.

H. Temperature Control:
   1. Size panels to adequately dissipate heat generated by equipment mounted on or in the panel.
2. Furnish cooling fans with air filters if required to dissipate heat. For panels outdoors or in unconditioned spaces, provide refrigerant air conditioner where necessary to maintain internal panel temperature below 104 degrees F.

3. For panels outdoors or in unheated areas, furnish thermostatically controlled heaters to maintain temperature above 40 degrees F.

I. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.

J. Lighting: Minimum of one hand switch controlled internal 15-watt LED light for panels 12 cubic feet and larger.

K. Minimum of one 120-volt GFCI duplex receptacle for panels 12 cubic feet and larger.

L. Finish:

1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel): Manufacturer’s standard gray unless otherwise specified.
2. Internal Surfaces: White enamel.

M. Panel Manufacturers:

1. Hoffman.
2. H.F. Cox.

N. Breather and Drains: Furnish with NEMA 250, Type 4 and Type 4X panels.

1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECD1-N4D, Breather Model ECD1-N4B.

2.05 CONTROL PANEL ELECTRICAL

A. UL Listing Mark for Enclosures: Mark stating “Listed Enclosed Industrial Control Panel” per UL 508A.

B. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.

C. Control Panels without Motor Starters:

1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
2. Locate to provide clear view of and access to breakers when door is open. Group on single subpanel. Provide typed directory.
3. Circuit Breakers:
   a. Coordinate for fault in branch circuit trips, branch breaker, and not main breaker.
   b. Branch Circuit Breakers: 15 amps at 250V ac.
   c. Breaker Manufacturers and Products:
      1) Heineman Electric Co.; Series AM.
      2) Airpax/North American Philips Controls Corp.; Series 205.

D. Control Panels with Three-Phase Power Supplies and Motor Starters:

1. Interlock Main Circuit Breaker with Panel Door.
   a. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.
   b. Mount operator controls and indications on front access door.

2. Circuit Breakers:
   a. In accordance with NEMA AB 1.
   b. Breakers, except Motor Branch Breakers: Molded case thermal magnetic.
   c. 42,000-ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified in package system equipment specification sections.
   d. Tripping: Indicate with operator handle position.

3. Magnetic Motor Starters:
   a. Full voltage, NEMA ICS 2, Class A, Size O minimum.
   b. Include three-pole bimetallic or eutectic alloy thermal overload relays sized for each motor.
   c. Manual reset type with reset button mounted on panel door.

4. Motor Control: 120V ac (except intrinsically safe circuits where applicable).
   a. Power Control Transformer:
      1) Sufficient capacity to serve connected load, including 200VA for duplex outlet plus 100VA (minimum).
      2) Limit voltage variation to 15 percent during contact pickup.
      3) Fuse one side of secondary winding and ground the other.
      4) Furnish primary winding fuses in ungrounded conductors.

5. Power Monitoring Relay:
   a. Protect three-phase equipment from single phasing, phase imbalance, or phase reversal.
   b. Separate, isolated contact outputs to stop motors and activate alarm light during abnormal conditions.
   c. Transient Voltage Protection: 10,000 volts.
   d. Manufacturer and Product: Furnas; Class 47.

7. Terminations for Power Conductors: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Wiring:

1. ac Circuits:
   a. Type: 600-volt, Type MTW stranded copper.
   b. Size: For current to be carried, but not less than 14 AWG.
2. Analog Signal Circuits:
   a. Type: 300-volt, Type 2 stranded copper, twisted shielded pairs.
   b. Size: 18 AWG, minimum.
3. Other dc Circuits.
   a. Type: 600-volt, Type MTW stranded copper.
   b. Size: 18 AWG, minimum.
4. Separate analog and other dc circuits by at least 2 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
5. Enclose wiring in sheet metal raceways or plastic wiring ducts.
6. Wire Identification: Numbered and tagged at each termination.
   a. Wire Tags: Machine printed, heat shrink.
   b. Manufacturers:
      1) Brady PermaSleeve.
      2) Tyco Electronics.

F. Wiring Interface:

1. For analog and discrete signal, terminate at numbered terminal blocks.
2. For special signals, terminate power (240 volts or greater) at manufacturer’s standard connectors.
3. For panel, terminate at equipment on/with which it is mounted.

G. Terminal Blocks:

1. Quantity:
   a. For external connections.
   b. Wire spare or unused panel mounted elements to their panels’ terminal blocks.
   c. Spare Terminals: 20 percent of connected terminals, but not less than 10.
2. General: Group to keep 120V ac circuits separate from 24V dc circuits.
   a. Connection Type: Screw connection clamp.
   b. Compression Clamp:
      1) Hardened steel clamp with transversal grooves penetrating wire strands providing a vibration-proof connection.
      2) Guides strands of wire into terminal.
d. Current Bar: Copper or treated brass.
e. Insulation:
   1) Thermoplastic rated for minus 55 to plus 110 degrees C.
   2) Two funnel shaped inputs to facilitate wire entry.
f. Mounting:
   1) Rail.
   2) Terminal block can be extracted from an assembly without
      displacing adjacent blocks.
   3) End Stops: One at each end of rail, minimum.
g. Wire Preparation: Stripping only.
h. Jumpers: Allow jumper installation without loss of space on
   terminal or rail.
i. Marking System:
   1) Terminal number shown on both sides of terminal block.
   2) Allow use of preprinted and field marked tags.
   3) Terminal strip numbers shown on end stops.
   4) Mark terminal block and terminal strip numbers as shown.

3. Manufacturers:
a. Entrelec.
b. Phoenix Contact.

4. Terminal Block, 120-Volt Power:
a. Rated Voltage: 600V ac.
b. Rated Current: 30 amp.
c. Wire Size: 22 AWG through 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Spacing: 0.25 inch, maximum.

5. Terminal Block, Ground:
a. Wire Size: 22 AWG through 12 AWG.
b. Color: Green and yellow body.
c. Spacing: 0.25 inch, maximum.
d. Grounding: Ground terminal blocks electrically grounded to the
   mounting rail.

6. Terminal Block, Blade Disconnect Switch:
a. Use: Provide one for each discrete input and output field interface
   wire.
b. Rated Voltage: 600V ac.
c. Rated Current: 10 amp.
d. Wire Size: 22 AWG through 12 AWG.
e. Color: Gray body, orange switch.
f. Spacing: 0.25 inch, maximum.

7. Terminal Block, Fused, 24V dc:
a. Rated Voltage: 600V dc.
b. Rated Current: 6.3 amp.
c. Wire Size: 22 AWG through 12 AWG.
d. Fuse: 5 by 20 GMA fuses.
e. Fuse Marking: Fuse amperage rating shown on top of terminal block.
g. Leakage Current: 5.2 mA, maximum.
h. Spacing: 0.32 inch, maximum.

8. Terminal Block, Fused, 120V ac:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 6.3 amp.
   c. Wire Size: 22 AWG through 12 AWG.
   d. Fuse: 5 by 20 GMA fuses.
   e. Fuse Marking: Fuse amperage rating shown on top of terminal block.
   f. Indication: Neon lamp 110V ac.
   g. Leakage Current: 1.8 mA, maximum.
   h. Spacing: 0.32 inch, maximum

H. Grounding:
   1. Ground metal enclosure and back-panel.
   2. Provide ground terminations for all power circuits.
   3. Provide individual ground terminal block for grounding of analog signal shields, one per signal. Ground shields at one location only.

I. Relays:
   1. General:
      b. Relay Enclosure: Provide dust cover.
      c. Socket Type: Screw terminal interface with wiring.
      d. Socket Mounting: Rail.
      e. Furnish holddown clips.
   2. PLC Interface Relay:
      a. Type: Narrow design for high density and direct connection of field wiring to relay terminals.
      b. Function: Covert PLC output to dry contact for isolated discrete signal interface.
      c. Relay Mounting: Plug into terminal block style socket.
      e. Socket Width: 0.25-inch nominal.
      f. Coil Voltage: 120V ac.
      g. Coil Power: 0.5 VA.
      h. Expected Mechanical Life: 10,000,000 operations.
      i. Operating Indicator: LED lights when coil is energized.
      j. Contact Arrangement: One Form C, SPDT contact.
k. Contact Rating: 5A, at 24V dc and 250V ac.
l. Connection Type: Screw compression clamp.
m. Terminal Marking: Numbered with preprinted or field-marked tags.
n. Manufacturers and Products:
   1) Phoenix Contact; PLC-RSC-120UC.
   2) Allen-Bradley; Bulletin 700-HL Terminal Block Relays.
   3) Idec; RV8H series.

3. Control Circuit Switching Relay, Nonlatching:
   a. Type: Compact general purpose plug-in.
   b. Contact Arrangement: 3 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.
   h. Expected Electrical Life at Rated Load: 100,000 operations.
   i. Indication Type: Neon or LED indicator lamp.
   j. Push-to-test button.
   k. Manufacturer and Product: Potter and Brumfield; Series KUP.

4. Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
   g. Expected Mechanical Life: 500,000 operations.
   h. Expected Electrical Life at Rated Load: 50,000 operations.
   i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.

5. Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As specified or shown.
   f. Operating Temperature: Minus 10 degrees C to 55 degrees C.
   g. Repeatability: Plus or minus 2 percent.
   h. Delay Time Range: Select range such that time delay setpoint fall between 20 percent to 80 percent or range.
   i. Time Delay Setpoint: As specified or shown.
   j. Mode of Operation: As specified or shown.
   k. Adjustment Type: Integral potentiometer with knob external to dust cover.
ZINK DAM IMPROVEMENTS

I. Manufacturer and Products: Potter and Brumfield.
   1) Series CB for 0.1-second to 100-minute delay time ranges.
   2) Series CK for 0.1- to 120-second delay time ranges.

J. Intrinsic Safety Barriers:
   1. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
   2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.

K. Front-of-Panel Devices in Conjunction with NEMA 250, Type 1 and 12 Panels:
   1. Potentiometer Units:
      a. Three-terminal, oiltight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
      b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 inch and 1/4 inch.
      c. Include legend plates with service markings.
      d. Manufacturers and Products:
         1) Allen-Bradley; Model 800T.
         2) Eaton/Cutler-Hammer; Model 10250T.
   2. Indicating Lights:
      a. Heavy-duty, push-to-test type, oiltight, industrial type with LED bulb for 120V ac applications.
      b. Screwed on prismatic glass lenses in colors noted and factory engraved legend plates for service legend.
      c. Manufacturers and Products:
         1) Eaton/Cutler-Hammer; Type 10250T.
         2) General Electric; CR2940U.
   3. Pushbutton, Momentary:
      a. Heavy-duty, oiltight, industrial type with full guard and momentary contacts rated for 10 amperes continuous at 120V ac.
      b. Standard size legend plates with black field and white markings for service legend.
      c. Manufacturers and Products:
         1) Square D; Class 9001, Type K.
         2) Eaton/Cutler-Hammer; Type T.
         3) General Electric; Type CR-2940.
4. **Selector Switch:**
   a. Heavy-duty, oiltight, industrial type with contacts rated for 120V ac service at 10 amperes continuous.
   b. Standard size, black field, legend plates with white markings, for service legend.
   c. Operators: Black knob type.
   d. Single-hole mounting, accommodating panel thicknesses from 1/16 inch to 1/4 inch.
   e. Manufacturers and Products for Units with up to Four Selection Positions:
      1) Eaton/Cutler-Hammer; Type T.
      2) Square D; Type K.

L. **Front-of-Panel Devices Used in Conjunction with NEMA 250, Type 4X Panels:**

1. **Potentiometer, Watertight:**
   a. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
   b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 inch and 1/4 inch.
   c. Include engraved legend plates with service markings.
   d. Manufacturer and Product: Allen-Bradley; Bulletin 800H.

2. **Indicating Lights, Watertight:**
   a. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial type with LED bulb for 120V ac applications and corrosion-resistant service.
   b. Screwed on prismatic lenses and factory engraved legend plates for service legend.
   c. Manufacturers and Products:
      1) Square D; Type SK.
      2) Allen-Bradley; Type 800H.

3. **Pushbutton, Momentary, Watertight:**
   a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
   b. Standard size, black field, legend plates with white markings for service legend.
   c. Manufacturers and Products:
      1) Square D; Type SK.
      2) Allen-Bradley; Type 800H.
4. Selector Switch, Watertight:
   a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
   b. Standard size, black field, legend plates with white markings, for service legend.
   c. Operators: Black knob type.
   d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
   e. Manufacturers and Products:
      1) Square D; Class 9001, Type SK.
      2) Allen-Bradley; Type 800H.

2.06 PROGRAMMABLE LOGIC CONTROLLER

A. Programmable Controller:
   1. Solid state unit capable of performing same function as conventional relays, timers, counters, sequencers, arithmetic, PID, and other special functions necessary to perform required control functions.
   2. Discrete inputs shall be 120V ac or 24V dc. Discrete outputs shall be rated for 2 amps at 120V ac and 24V dc, minimum. Each input and output shall have an LED ON/OFF status indicator.
   3. Discrete outputs for interface to external equipment and systems. Provide dry contact interface using one of the following methods:
      a. Power interposing relay to generate dry contact.
      b. Provide relay type discrete output module.
   4. Analog Inputs and Outputs: 4 mA to 20 mA dc per channel.
   5. Minimum of 25 percent excess capacity for inputs, outputs, internal memory, and other necessary functions.
   6. Capable of operating in a hostile industrial environment (for example, heat, electrical transients, RFI, and vibration) without fans, air conditioning, or electrical filtering. Units operate from 0 degree C to 60 degrees C and up to 95 percent humidity, noncondensing.
   7. Manufacturer and Product: Allen-Bradley; Control Logix. Provide L7 or L8 series CPU with firmware version 24.

B. Operator Interface Unit:
   1. Color LCD display with graphics and text displays, screen navigation, status and alarm indication, and operator control and setpoint adjustment.
   2. Touch screen or membrane keypad interface.
3. Manufacturers and Products:
   a. Allen Bradley; Panelview Plus 6; size 1000 or higher.
   b. Configuration Software: Developed with Rockwell Software

C. Communication with Remote PLC and SCADA:
   1. Method: PLC data communicated over network via Rockwell
      EtherNet/IP.
   2. IP Address: Assigned during construction to integrate into plant subnet.
   3. Connection: Provide an independent Ethernet copper connection
directly from the PLC, Ethernet module, or industrial Ethernet switch.
      Connection must be separate from any other internal I/O network. A
      single operator interface unit (OIU) is permitted to share the network
      connection to SCADA.
   4. Communication Method: Communicate via EtherNet/IP using address
      arrays to allow CIP messaging reads and writes initiated by remote PLC
      and/or SCADA.
   5. Communicated Data:
      a. All alarm conditions.
      b. All equipment running status.
      c. Process data such as level, flow, pressure.
      d. Additionally as specified in package system specification.

2.07 NAMEPLATES, NAMETAGS, AND SERVICE LEGENDS

A. Nametags: Permanently mounted bearing entire ISA tag number.
   1. Panel Mounted: Plastic, mounted to instrument behind panel face.
   2. Field Mounted: Engraved Type 316 stainless steel, 22-gauge minimum
      thickness, attached with stainless steel.

B. Service Legends (Integrally Mounted with Instrument) and Nameplates:
   1. Engraved, rigid, laminated plastic type with adhesive back. Furnish
      service legends and nameplates to adequately describe functions of
      panel face mounted instruments.
   2. Color: White with black letters.
   3. Letter Height: 3/16 inch.
   4. For each panel, face mounted laminated nameplate inscribed with the
      panel name and tag number. Color shall be white with black letters
      1/2 inch high.
C. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions:

<table>
<thead>
<tr>
<th>Tag</th>
<th>Inscription(s)</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>ON</td>
<td>Red</td>
</tr>
<tr>
<td>OFF</td>
<td>OFF</td>
<td>Green</td>
</tr>
<tr>
<td>OPEN</td>
<td>OPEN</td>
<td>Red</td>
</tr>
<tr>
<td>CLOSED</td>
<td>CLOSED</td>
<td>Green</td>
</tr>
<tr>
<td>LOW</td>
<td>LOW</td>
<td>Amber</td>
</tr>
<tr>
<td>FAIL</td>
<td>FAIL</td>
<td>Amber</td>
</tr>
<tr>
<td>HIGH</td>
<td>HIGH</td>
<td>Amber</td>
</tr>
<tr>
<td>AUTO</td>
<td>AUTO</td>
<td>White</td>
</tr>
<tr>
<td>MANUAL</td>
<td>MANUAL</td>
<td>Yellow</td>
</tr>
<tr>
<td>LOCAL</td>
<td>LOCAL</td>
<td>Yellow</td>
</tr>
<tr>
<td>REMOTE</td>
<td>REMOTE</td>
<td>White</td>
</tr>
<tr>
<td>FORWARD</td>
<td>FORWARD</td>
<td>Red</td>
</tr>
<tr>
<td>REVERSE</td>
<td>REVERSE</td>
<td>Blue</td>
</tr>
</tbody>
</table>

2.08 ELECTRICAL SURGE AND TRANSIENT PROTECTION

A. Equip control panels with surge-arresting devices to protect equipment from damage as a result of electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

B. Suppressor Locations:

1. At point of connection between an equipment item, including ac powered transmitters, and power supply conductor (direct-wired equipment).
2. On analog pairs at each end when the pair travels outside of building.
3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.
C. Suppressor Design:
   1. Construction: First-stage, high-energy metal oxide varistor and second-stage, bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
   2. Response: 5 nanoseconds maximum.
   4. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
   5. Enclosure Mounted: Encapsulated in flame retardant epoxy.

D. Suppressors on 120V ac Power Supply Connections:
   1. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
   2. First-Stage Clamping Voltage: 350 volts or less.
   3. Second-Stage Clamping Voltage: 210 volts or less.
   4. Power Supplies for Continuous Operation:
      a. Four-Wire Transmitter or Receiver: Minimum 5 amps at 130V ac.
      b. All Other Applications: Minimum 30 amps at 130V ac.

E. Suppressors on Analog Signal Lines:
   1. Test Waveform: Linear 8-microsecond rise in current from 0 amp to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
   2. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
      a. dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
      b. dc Clamping Voltage Tolerance: Plus or minus 10 percent.
      c. Maximum Loop Resistance: 18 ohms per conductor.

F. Manufacturers and Products:
   1. Analog Signals Lines: Emerson Edco; PC-642 or SRA-64 series.
   2. 120V ac Lines: Emerson Edco; HSP-121.
   3. 480-Volt, Three-Phase Power Supplies: Square D; Model SDSA3650.
   4. Field Mounted at Two-Wire Instruments:
      a. Encapsulated in stainless steel pipe nipples.
      b. Emerson Edco; SS64 series.
   5. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistor on signal line, all in enclosure.
      a. Enclosure:
         1) NEMA 4X Type 316 stainless steel with door.
         2) Maximum Size: 12 inches by 12 inches by 8 inches deep.
      b. Emerson Edco; SLAC series.
PART 3  EXECUTION

3.01  ELECTRICAL POWER AND SIGNAL WIRING

A. Restrain control and signal wiring in control panels by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect bend area with a sleeve.

B. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.

C. Use manufacturer’s recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single crimp lug. No more than two lugs may be installed on a single screw terminal.

D. Do not splice or tap wiring except at device terminals or terminal blocks.

3.02  PROTECTION

A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.

B. During Work, periodically replace capsules in accordance with capsule manufacturer’s recommendations. Replace capsules at Substantial Completion.

END OF SECTION