# TABLE OF CONTENTS

## CONSULTANT REPRESENTATIVES

### DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS

#### GC/CM PROCUREMENT REQUIREMENTS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Addendum #</th>
</tr>
</thead>
<tbody>
<tr>
<td>00 11 16</td>
<td>INVITATION TO BID</td>
<td>ADDENDUM #1</td>
</tr>
<tr>
<td>00 11 20</td>
<td>INSTRUCTIONS TO BIDDERS</td>
<td>ADDENDUM #1</td>
</tr>
<tr>
<td>00 11 30</td>
<td>BID PACKAGE DESCRIPTIONS &amp; SCHEDULE</td>
<td>ADDENDUM #1</td>
</tr>
<tr>
<td>00 11 50</td>
<td>BID FORM</td>
<td>ADDENDUM #1</td>
</tr>
<tr>
<td>AIA A312</td>
<td>PERFORMANCE AND PAYMENT BOND</td>
<td>ADDENDUM #1</td>
</tr>
<tr>
<td>AIA A 401</td>
<td>STANDARD FORM OF AGRMT BTWN CONTRACTORSUBCONTRACTOR</td>
<td>ADDENDUM #1</td>
</tr>
</tbody>
</table>

#### GC/CM REQUIREMENTS FOR TRADE CONTRACTORS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01006</td>
<td>SUBTRADE CONTRACTOR BONDS &amp; CERTIFICATES OF INSURANCE</td>
</tr>
<tr>
<td>01250</td>
<td>SUBTRADE CONTRACT MODIFICATION PROCEDURES</td>
</tr>
<tr>
<td>01291</td>
<td>SUBTRADE CONTRACTOR APPLICATIONS FOR PAYMENT</td>
</tr>
<tr>
<td>01310</td>
<td>SUBTRADE PROJECT MANAGEMENT AND COORDINATION</td>
</tr>
<tr>
<td>01500</td>
<td>TEMPORARY FACILITIES AND CONTROLS</td>
</tr>
<tr>
<td>01741</td>
<td>CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL</td>
</tr>
</tbody>
</table>

#### STATE OF MONTANA DOCUMENTS

- ST OF MT: GENERAL CONDITIONS OF THE CONTRACT FOR CONSTRUCTION – GC/CM – LATEST ED.
- ST OF MT: MONTANA PREVAILING WAGE RATES FOR BUILDING CONST. SERVICES – LATEST ED.
- MSU: SUPPLEMENTAL CONDITIONS OF THE CONTRACT FOR CONSTRUCTION – LATEST ED.

### DIVISION 1 - GENERAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 10 00</td>
<td>SUMMARY</td>
</tr>
<tr>
<td>01 23 00</td>
<td>ALTERNATES</td>
</tr>
<tr>
<td>01 25 00</td>
<td>SUBSTITUTION PROCEDURES</td>
</tr>
<tr>
<td>CSI 13.1A</td>
<td>CSI SUBSTITUTION REQUEST</td>
</tr>
<tr>
<td>01 32 00</td>
<td>CONSTRUCTION PROGRESS DOCUMENTATION</td>
</tr>
<tr>
<td>01 32 33</td>
<td>PHOTOGRAPHIC DOCUMENTATION</td>
</tr>
<tr>
<td>01 33 00</td>
<td>SUBMITTAL PROCEDURES</td>
</tr>
<tr>
<td>AIA C106</td>
<td>DIGITAL DATA LICENSING AGREEMENT</td>
</tr>
<tr>
<td>CSI 12.1A</td>
<td>SUBMITTAL TRANSMITTAL</td>
</tr>
<tr>
<td>01 40 00</td>
<td>QUALITY REQUIREMENTS</td>
</tr>
<tr>
<td>01 42 00</td>
<td>REFERENCES</td>
</tr>
<tr>
<td>01 60 00</td>
<td>PRODUCT REQUIREMENTS</td>
</tr>
<tr>
<td>01 70 00</td>
<td>EXECUTION</td>
</tr>
<tr>
<td>01 77 00</td>
<td>CLOSEOUT PROCEDURES INCLUDING MSU CLOSEOUT REQUIREMENTS</td>
</tr>
<tr>
<td></td>
<td>MSU FINISH SCHEDULE</td>
</tr>
<tr>
<td></td>
<td>MSU WARRANTY</td>
</tr>
<tr>
<td>CSI 14.1A</td>
<td>PUNCH LIST FORM</td>
</tr>
<tr>
<td>01 78 23</td>
<td>OPERATION AND MAINTENANCE DATA</td>
</tr>
<tr>
<td>01 78 39</td>
<td>PROJECT RECORD DOCUMENTS</td>
</tr>
</tbody>
</table>

## TABLE OF CONTENTS
## TABLE OF CONTENTS

### PROJECT MANUAL – VOLUME TWO

#### TABLE OF CONTENTS

#### CONSULTANT REPRESENTATIVES

<table>
<thead>
<tr>
<th>Division</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIVISION 2 – EXISTING CONDITIONS</strong></td>
<td></td>
</tr>
<tr>
<td>02 32 00</td>
<td>GEOTECHNICAL DATA</td>
</tr>
<tr>
<td>02 41 00</td>
<td>SITE DEMOLITION</td>
</tr>
<tr>
<td><strong>DIVISION 3 – CONCRETE</strong></td>
<td></td>
</tr>
<tr>
<td>03 30 00</td>
<td>CAST-IN-PLACE CONCRETE</td>
</tr>
<tr>
<td>03 35 43</td>
<td>POLISHED CONCRETE</td>
</tr>
<tr>
<td><strong>DIVISION 4 – MASONRY</strong></td>
<td></td>
</tr>
<tr>
<td>04 26 13</td>
<td>MASONRY VENEER</td>
</tr>
<tr>
<td><strong>DIVISION 5 – METALS</strong></td>
<td></td>
</tr>
<tr>
<td>05 12 00</td>
<td>STRUCTURAL STEEL FRAMING</td>
</tr>
<tr>
<td>05 21 00</td>
<td>STEEL JOIST FRAMING</td>
</tr>
<tr>
<td>05 31 00</td>
<td>STEEL DECKING</td>
</tr>
<tr>
<td>05 40 00</td>
<td>COLD FORMED METAL FRAMING</td>
</tr>
<tr>
<td>05 50 00</td>
<td>METAL FABRICATIONS</td>
</tr>
<tr>
<td>05 51 13</td>
<td>METAL PAN STAIRS</td>
</tr>
<tr>
<td>05 73 00</td>
<td>DECORATIVE METAL RAILINGS</td>
</tr>
<tr>
<td>05 75 00</td>
<td>DECORATIVE FORMED METAL</td>
</tr>
<tr>
<td><strong>DIVISION 6 – WOOD, PLASTICS, AND COMPOSITES</strong></td>
<td></td>
</tr>
<tr>
<td>06 10 53</td>
<td>MISCELLANEOUS ROUGH CARPENTRY</td>
</tr>
<tr>
<td>06 20 23</td>
<td>INTERIOR FINISH CARPENTRY</td>
</tr>
<tr>
<td>06 41 16</td>
<td>PLASTIC-LAMINATE-FACED ARCHITECTURAL CABINETS</td>
</tr>
<tr>
<td>06 64 00</td>
<td>PLASTIC PANELING</td>
</tr>
<tr>
<td><strong>DIVISION 7 – THERMAL AND MOISTURE PROTECTION</strong></td>
<td></td>
</tr>
</tbody>
</table>

---

TABLE OF CONTENTS 2
<table>
<thead>
<tr>
<th>Section Category</th>
<th>Code Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>07 17 13 Bentonite Panel Waterproofing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 21 00 Thermal Insulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 26 00 Vapor Retarders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 27 15 Nonbituminous Self-Adhering Sheet Air Barriers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 42 13.13 Formed Metal Wall Panels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 42 19 Metal Plate Wall and Soffit Panels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 53 23 Ethylene-Propylene-Diene-Monomer (EPDM) Roofing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 62 00 Sheet Metal Flashing and Trim</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 72 00 Roof Accessories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 81 00 Applied Fireproofing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 81 23 Intumescent Fireproofing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 84 00 Firestopping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 92 00 Joint Sealants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 92 19 Acoustical Joint Sealants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 95 13.13 Interior Expansion Joints Cover Assemblies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 95 13.16 Exterior Expansion Joint Cover Assemblies</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DIVISION 8 - DOORS AND WINDOWS

<table>
<thead>
<tr>
<th>Section Category</th>
<th>Code Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>08 11 13 Hollow Metal Doors and Frames</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 14 16 Flush Wood Doors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 31 13 Access Doors and Frames</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 33 23 Overhead Coiling Doors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 36 13 Sectional Doors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 41 13 Aluminum-Framed Entrances and Storefronts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 44 13 Glazed Aluminum Curtain Walls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 62 00 Unit Skylights</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 71 00 Door Hardware</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 71 00 Door Hardware Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 80 00 Glazing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DIVISION 9 – FINISHES

<table>
<thead>
<tr>
<th>Section Category</th>
<th>Code Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>09 05 02 Finish Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 21 16.23 Gypsum Board Shaft Wall Assemblies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 22 16 Non-Structural Metal Framing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 29 00 Gypsum Board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 30 13 Ceramic Tiling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 51 13 Acoustical Panel Ceilings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 64 00 Wood Flooring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 65 13 Resilient Base and Accessories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 65 16 Resilient Sheet Flooring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 68 13 Tile Carpeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 72 00 Wall Coverings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 84 33 Sound-Absorbing Wall Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 91 13 Exterior Painting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 9123 Interior Painting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 93 00 Staining and Transparent Finishing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DIVISION 10 – SPECIALTIES

<table>
<thead>
<tr>
<th>Section Category</th>
<th>Code Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 11 00 Visual Display Units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10 14 23.13  ROOM IDENTIFICATION SIGNAGE
10 21 13.19  PLASTIC TOILET COMPARTMENTS
10 28 00   WALL AND DOOR PROTECTION
10 28 00   TOILET, BATH, AND LAUNDRY ACCESSORIES
10 44 13   FIRE PROTECTION CABINETS
10 44 16   FIRE EXTINGUISHERS

DIVISION 11 – EQUIPMENT

11 52 13   PROJECTION SCREENS
11 53 10   LABORATORY CASEWORK AND OTHER FURNISHINGS
11 53 13   FUME HOOD AND OTHER AIR CONTAINMENT UNITS
11 53 43   LABORATORY SERVICE FITTINGS AND FIXTURES

DIVISION 12 – FURNISHINGS

12 24 13   ROLLER WINDOW SHADES
12 36 61.16  SOLID SURFACING COUNTERTOPS
12 48 13   ENTRANCE FLOOR MATS AND FRAMES
12 61 00   FIXED AUDIENCE SEATING (Future Installation Only)
12 66 00   TELESCOPING STANDS

DIVISION 14 – CONVEYING EQUIPMENT

14 24 00   HYDRAULIC ELEVATORS

END OF VOLUME TWO

PROJECT MANUAL – VOLUME THREE

TABLE OF CONTENTS
CONSULTANT REPRESENTATIVES

DIVISION 21 – FIRE SUPPRESSION

21 13 13   FIRE PROTECTION SYSTEMS

DIVISION 22 – PLUMBING

22 00 00   PLUMBING GENERAL REQUIREMENTS
22 05 00   COMMON WORK RESULTS FOR PLUMBING
22 05 13   COMMON MOTOR RESULTS FOR PLUMBING
22 05 17   SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING
22 05 18   ESCUTCHEONS FOR PLUMBING PIPING
22 05 19   METERS AND GAGES FOR PLUMBING PIPING
22 05 23.12  BALL VALVES FOR PLUMBING PIPING
22 05 23.14  CHECK VALVES FOR PLUMBING PIPING
22 05 23.15  GATES VALVES FOR PLUMBING PIPING
22 05 29   HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
22 05 48   VIBRATIONS AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

TABLE OF CONTENTS 4
TABLE OF CONTENTS

DIVISION 22 - PLUMBING AND PIPEWORK

22 05 53 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
22 07 19 PLUMBING PIPING INSULATION
22 08 00 COMMISSIONING OF PLUMBING
22 11 13 FACILITY WATER DISTRIBUTION PIPING
22 11 16 DOMESTIC WATER PIPING
22 11 19 DOMESTIC WATER PIPING SPECIALTIES
22 13 13 FACILITY SANITARY SEWERS
22 13 16 SANITARY WASTE AND VENT PIPING
22 13 19 SANITARY WASTE PIPING SPECIALTIES
22 13 29 SANITARY SEWERAGE PUMPS
22 14 13 FACILITY STORM DRAINAGE PIPING
22 14 23 STORM DRAINAGE PIPING SPECIALTIES
22 15 13 GENERAL-SERVICE COMPRESSED-AIR PIPING
22 15 19 GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS
22 20 00 LABORATORY PLUMBING
22 35 00 DOMESTIC WATER HEAT EXCHANGERS
22 35 13 MODULAR SCROLL CHILLER/HEAT PUMP
22 42 13.13 COMMERCIAL WATER CLOSETS
22 42 13.16 COMMERCIAL URINALS
22 42 16.13 COMMERCIAL LAVATORIES
22 42 16.16 COMMERCIAL SINKS
22 45 00 EMERGENCY PLUMBING FIXTURES
22 47 16 PRESSURE WATER COOLERS
22 66 00 CHEMICAL-WASTE SYSTEMS FOR LABORATORY FACILITIES

DIVISION 23 - HEATING VENTILATING AND AIR CONDITIONING

23 00 00 HVAC GENERAL REQUIREMENTS
23 01 00 OWNER TRAINING
23 05 00 COMMON WORK RESULTS FOR HVAC
23 05 13 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
23 05 16 EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
23 05 17 SLEEVES AND SLEEVE SEALS FOR HVAC PIPING
23 05 18 ESCUTCHEONS FOR HVAC PIPING
23 05 19 METERS AND GAGES FOR HVAC PIPING
23 05 23.12 BALL VALVES FOR HVAC PIPING
23 05 23.14 CHECK VALVES FOR HVAC PIPING
23 05 23.15 GATE VALVES FOR HVAC PIPING
23 05 29 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
23 05 53 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC
23 07 13 DUCT INSULATION
23 07 19 HVAC PIPING INSULATION
23 08 00 COMMISSIONING OF HVAC
23 08 50 ATRIUM SMOKE CONTROL SYSTEM SPECIAL INSPECTION AND COMMISSIONING
23 09 01 AIR QUALITY MONITORING SYSTEM
23 09 23 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
23 09 23.11 CONTROL VALVES
23 09 23.12 CONTROL DAMPERS
23 09 23.13 ENERGY METERS
23 09 23.14 FLOW INSTRUMENTS
23 09 23.16 GAS INSTRUMENTS
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 09 23.17</td>
<td>LEVEL INSTRUMENTS</td>
</tr>
<tr>
<td>23 09 23.22</td>
<td>POSITION INSTRUMENTS</td>
</tr>
<tr>
<td>23 09 23.23</td>
<td>PRESSURE INSTRUMENTS</td>
</tr>
<tr>
<td>23 09 23.24</td>
<td>SPEED INSTRUMENTS</td>
</tr>
<tr>
<td>23 09 23.27</td>
<td>TEMPERATURE INSTRUMENTS</td>
</tr>
<tr>
<td>23 09 23.43</td>
<td>WEATHER STATIONS</td>
</tr>
<tr>
<td>23 09 93.11</td>
<td>SEQUENCE OF OPERATIONS FOR HVAC DDC</td>
</tr>
<tr>
<td>23 21 13</td>
<td>HYDRONIC PIPING</td>
</tr>
<tr>
<td>23 21 13.33</td>
<td>GROUND-LOOP HEAT-PUMP PIPING</td>
</tr>
<tr>
<td>23 21 16</td>
<td>HYDRONIC PIPING SPECIALTIES</td>
</tr>
<tr>
<td>23 21 23</td>
<td>HYDRONIC PUMPS</td>
</tr>
<tr>
<td>23 22 13</td>
<td>STEAM AND CONDENSATE HEATING PIPING</td>
</tr>
<tr>
<td>23 22 16</td>
<td>STEAM AND CONDENSATE PIPING SPECIALTIES</td>
</tr>
<tr>
<td>23 22 23</td>
<td>STEAM CONDENSATE PUMPS</td>
</tr>
<tr>
<td>23 25 13</td>
<td>WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS</td>
</tr>
<tr>
<td>23 31 13</td>
<td>METAL DUCTS</td>
</tr>
<tr>
<td>23 33 00</td>
<td>AIR DUCT ACCESSORIES</td>
</tr>
<tr>
<td>23 34 16</td>
<td>CENTRIFUGAL HVAC FANS</td>
</tr>
<tr>
<td>23 34 23</td>
<td>HVAC POWER VENTILATORS</td>
</tr>
<tr>
<td>23 36 00</td>
<td>AIR TERMINAL UNITS</td>
</tr>
<tr>
<td>23 37 13</td>
<td>DIFFUSERS, REGISTERS, AND GRILLES</td>
</tr>
<tr>
<td>23 37 23</td>
<td>HVAC GRAVITY VENTILATORS</td>
</tr>
<tr>
<td>23 72 00</td>
<td>AIR-TO-AIR ENERGY RECOVERY EQUIPMENT</td>
</tr>
<tr>
<td>23 73 13</td>
<td>MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS</td>
</tr>
<tr>
<td>23 81 46.13</td>
<td>WATER-TO-AIR HEAT PUMPS</td>
</tr>
<tr>
<td>23 82 36</td>
<td>FINNED-TUBE RADIATION HEATERS</td>
</tr>
<tr>
<td>23 82 39.13</td>
<td>CABINET UNIT HEATERS</td>
</tr>
</tbody>
</table>

END OF VOLUME THREE

PROJECT MANUAL – VOLUME FOUR

TABLE OF CONTENTS
CONSULTANT REPRESENTATIVES

DIVISION 26 – ELECTRICAL

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 00 00</td>
<td>ELECTRICAL GENERAL REQUIREMENTS</td>
</tr>
<tr>
<td>26 01 00</td>
<td>OWNER TRAINING</td>
</tr>
<tr>
<td>26 01513.16</td>
<td>MEDIUM VOLTAGE, SINGLE- AND MULTI-CONDUCTOR CABLES</td>
</tr>
<tr>
<td>26 05 19</td>
<td>LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES</td>
</tr>
<tr>
<td>26 05 26</td>
<td>GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS</td>
</tr>
<tr>
<td>26 05 29</td>
<td>HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS</td>
</tr>
<tr>
<td>26 05 33</td>
<td>RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS</td>
</tr>
<tr>
<td>26 05 43</td>
<td>UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS</td>
</tr>
<tr>
<td>26 05 43.13</td>
<td>EXCAVATION AND BACKFILL</td>
</tr>
<tr>
<td>26 05 43.19</td>
<td>MANHOLES AND HARDWARE</td>
</tr>
<tr>
<td>26 05 48.16</td>
<td>SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS</td>
</tr>
<tr>
<td>26 05 53</td>
<td>IDENTIFICATION FOR ELECTRICAL SYSTEMS</td>
</tr>
<tr>
<td>26 05 72</td>
<td>OVERCURRENT PROTECTIVE DEVICE SHORTCIRCUIT STUDY</td>
</tr>
<tr>
<td>26 05 73</td>
<td>OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY</td>
</tr>
<tr>
<td>26 05 74</td>
<td>OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY</td>
</tr>
<tr>
<td>26 08 00</td>
<td>COMMISSIONING OF ELECTRICAL</td>
</tr>
<tr>
<td>26 08 12</td>
<td>POWER DISTRIBUTION ACCEPTANCE TESTS</td>
</tr>
<tr>
<td>26 08 13</td>
<td>POWER DISTRIBUTION ACCEPTANCE TEST TABLES (FORTHCOMING)</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>26 09 23</td>
<td>LIGHTING CONTROLS</td>
</tr>
<tr>
<td>26 12 19</td>
<td>PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS</td>
</tr>
<tr>
<td>26 22 00</td>
<td>LOW-VOLTAGE TRANSFORMERS</td>
</tr>
<tr>
<td>26 24 13</td>
<td>SWITCHBOARDS</td>
</tr>
<tr>
<td>26 24 16</td>
<td>PANELBOARDS</td>
</tr>
<tr>
<td>26 27 13</td>
<td>ELECTRICITY METERING</td>
</tr>
<tr>
<td>26 27 26</td>
<td>WIRING DEVICES</td>
</tr>
<tr>
<td>26 28 13</td>
<td>FUSES</td>
</tr>
<tr>
<td>26 28 16</td>
<td>ENCLOSED SWITCHES AND CIRCUIT BREAKERS</td>
</tr>
<tr>
<td>26 29 13</td>
<td>ENCLOSED CONTROLLERS</td>
</tr>
<tr>
<td>26 32 13</td>
<td>ENGINE GENERATORS</td>
</tr>
<tr>
<td>26 41 13</td>
<td>LIGHTNING PROTECTION</td>
</tr>
<tr>
<td>26 51 00</td>
<td>INTERIOR LIGHTING</td>
</tr>
<tr>
<td>26 56 00</td>
<td>EXTERIOR LIGHTING</td>
</tr>
<tr>
<td>26 60 00</td>
<td>LABORATORY ELECTRICAL REQUIREMENTS</td>
</tr>
</tbody>
</table>

**DIVISION 27 – COMMUNICATIONS**

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>27 00 00</td>
<td>COMMUNICATIONS PROJECT OVERVIEW</td>
</tr>
<tr>
<td>27 01 00</td>
<td>BASIC TELECOMMUNICATIONS REQUIREMENTS</td>
</tr>
<tr>
<td>27 11 00</td>
<td>TELECOMMUNICATIONS ROOMS</td>
</tr>
<tr>
<td>27 12 00</td>
<td>PATHWAYS, FITTINGS, AND BOXES</td>
</tr>
<tr>
<td>27 15 00</td>
<td>BACKBONE CABLING REQUIREMENTS</td>
</tr>
<tr>
<td>27 16 00</td>
<td>HORIZONTAL CABLING REQUIREMENTS</td>
</tr>
</tbody>
</table>

**DIVISION 28 – ELECTRONIC SAFETY AND SECURITY**

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 31 11</td>
<td>DIGITAL, ADDRESSABLE EVACUATION FIRE-ALARM SYSTEM</td>
</tr>
<tr>
<td>28 31 11.15</td>
<td>ASPIRATING SMOKE DETECTION SYSTEM</td>
</tr>
</tbody>
</table>

END OF VOLUME FOUR

**PROJECT MANUAL VOLUME FIVE**

**TABLE OF CONTENTS**

**CONSULTANT REPRESENTATIVES**

**DIVISION 31 – EARTHWORK**

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>31 10 00</td>
<td>SITE CLEARING</td>
</tr>
<tr>
<td>31 11 00</td>
<td>TREE PROTECTION</td>
</tr>
<tr>
<td>31 20 00</td>
<td>EARTH MOVING</td>
</tr>
<tr>
<td>31 25 00</td>
<td>EROSION AND SEDIMENT CONTROL</td>
</tr>
<tr>
<td>31 63 10</td>
<td>VERTICALLY RAMMED ENGINEERED AGGREGATE PIERS</td>
</tr>
</tbody>
</table>

**DIVISION 32 – EXTERIOR IMPROVEMENTS**

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 1216</td>
<td>ASPHALT PAVING</td>
</tr>
<tr>
<td>32 13 13</td>
<td>CONCRETE PAVING</td>
</tr>
<tr>
<td>32 13 73</td>
<td>CONCRETE PAVING JOINT SEALANTS</td>
</tr>
<tr>
<td>32 17 23</td>
<td>PAVEMENT MARKINGS</td>
</tr>
</tbody>
</table>
32 84 00  IRRIGATION SYSTEM
32 92 00  LAWNS COMPREHENSIVE
32 93 00  TREES, SHRUBS, AND GROUNDCOVERS

DIVISION 33 – UTILITIES

33 10 00  WATER DISTRIBUTION PIPING
33 30 00  SANITARY SEWERS
33 41 00  STORM UTILITY DRAINAGE PIPING

APPENDIX

GEOTECHNICAL INVESTIGATION REPORT

END OF VOLUME FIVE

END OF TABLE OF CONTENTS
## PROJECT DIRECTORY

### Design Team

**Architects: A&E / ZGF**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty Eaton</td>
<td>Project Principal</td>
<td><a href="mailto:deaton@aearchitects.com">deaton@aearchitects.com</a></td>
<td>406.248.2633</td>
</tr>
<tr>
<td>Bill DuBeau</td>
<td>Project Manager</td>
<td><a href="mailto:bdubeau@aearchitects.com">bdubeau@aearchitects.com</a></td>
<td>406.248.2633</td>
</tr>
<tr>
<td>Paul Siderius</td>
<td>Project Manager</td>
<td><a href="mailto:psiderius@aearchitects.com">psiderius@aearchitects.com</a></td>
<td>406.248.2633</td>
</tr>
<tr>
<td>Kris Koessl</td>
<td>Construction Administrator</td>
<td><a href="mailto:kkoessl@aearchitects.com">kkoessl@aearchitects.com</a></td>
<td>406.248.2633</td>
</tr>
<tr>
<td>Allyn Stellmacher</td>
<td>Project Designer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Todd Stine</td>
<td>Project Principal</td>
<td><a href="mailto:todd.stine@zgf.com">todd.stine@zgf.com</a></td>
<td>206.623.9414</td>
</tr>
<tr>
<td>Dana Forfylow</td>
<td>Project Manager</td>
<td><a href="mailto:dana.forfylow@zgf.com">dana.forfylow@zgf.com</a></td>
<td>206.521.3535</td>
</tr>
</tbody>
</table>

**M-E-P Engineers: ACE / AEI**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Todd Meling</td>
<td>ACE Project Manager</td>
<td><a href="mailto:toddm@acemt.com">toddm@acemt.com</a></td>
<td>406.245.0136</td>
</tr>
<tr>
<td>Jeffrey Kraft</td>
<td>ACE Electrical Engineer</td>
<td><a href="mailto:jeffk@acemt.com">jeffk@acemt.com</a></td>
<td>406.245.0136</td>
</tr>
<tr>
<td>Paul Erickson</td>
<td>AEI Building Performance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lab Consultant: RFD**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terry Brown</td>
<td>Laboratory Consultant</td>
<td><a href="mailto:tdb@rfd.com">tdb@rfd.com</a></td>
<td>619.297.0159</td>
</tr>
</tbody>
</table>

**Civil, Geotech, Transportation, and Survey Engineers: DOWL HKM**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clint Little</td>
<td>Civil Engineer</td>
<td><a href="mailto:clittle@dowlhk.com">clittle@dowlhk.com</a></td>
<td>406.586.8834</td>
</tr>
<tr>
<td>Greg Underhill</td>
<td>Geotechnical Engineer</td>
<td><a href="mailto:gunderhill@dowlhk.com">gunderhill@dowlhk.com</a></td>
<td>406.586.8834</td>
</tr>
</tbody>
</table>

**Structural Engineer: Morrison-Maierle**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kurt Keith</td>
<td>Structural Engineer</td>
<td><a href="mailto:kkeith@m-m.net">kkeith@m-m.net</a></td>
<td>406.587.0721</td>
</tr>
<tr>
<td>Jay Fischer</td>
<td>Structural Engineer</td>
<td><a href="mailto:jfischer@m-m.net">jfischer@m-m.net</a></td>
<td>406.587.0721</td>
</tr>
</tbody>
</table>

**Landscape Architect: Land Design**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stacey Robinson</td>
<td>Landscape Architect</td>
<td><a href="mailto:stacey@ldinc.net">stacey@ldinc.net</a></td>
<td>406.655.3550</td>
</tr>
<tr>
<td>Michael Vereman</td>
<td>Project Manager</td>
<td><a href="mailto:michael@ldinc.net">michael@ldinc.net</a></td>
<td>406.655.3550</td>
</tr>
</tbody>
</table>

**Acoustic Consultant: Big Sky Acoustics**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sean Connolly</td>
<td>Acoustic Designer</td>
<td><a href="mailto:sean@bigskyacoustics.com">sean@bigskyacoustics.com</a></td>
<td>406.457.0407</td>
</tr>
</tbody>
</table>

**Technology Consultant: Access Consulting**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paul DeWolf</td>
<td>Data/Technology Design</td>
<td><a href="mailto:paul@access-consulting.net">paul@access-consulting.net</a></td>
<td>406.327.0629</td>
</tr>
<tr>
<td>Pete Weber</td>
<td>Data/Technology Design</td>
<td><a href="mailto:pete@access-consulting.net">pete@access-consulting.net</a></td>
<td>406.327.0629</td>
</tr>
</tbody>
</table>

**Audio Visual Design: Onpoint Designs**

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeff Sanderson</td>
<td>Audio Visual Consultant</td>
<td><a href="mailto:jeff@onpointdesigns.net">jeff@onpointdesigns.net</a></td>
<td>360.352.3808</td>
</tr>
</tbody>
</table>
PART 1 - GENERAL

1.1 ELECTRICAL REQUIREMENTS

A. The electrical requirements are supplemental to the General and Supplementary Conditions and the General Requirements of these Specifications. The Electrical Sections shall apply to phases of the work specified, shown on the Drawings, or required to provide for the complete installation of Electrical Systems for this project.

B. The work shall include all items, articles, materials, operations and methods listed, mentioned or scheduled in these specifications and the accompanying drawings. All material, equipment and labor shall be furnished together with all incidental items required by good practice to provide the complete systems described.

C. Examine and refer to all Architectural, Structural, Utility, Landscape and Mechanical drawings and specifications for construction conditions which may affect the electrical work. Inspect the building site and existing facilities for verification of present conditions. Make proper provisions for these conditions in performance of the work and cost thereof.

D. See general requirements for listed Alternate Bids. Note alternates listed and include any changes in work and price required to meet the requirements of the respective alternate.

1.2 CODES AND STANDARDS

A. Work shall meet the requirements of the plans and specifications and shall not be less than the minimum requirements of applicable sections of the latest Codes and Standards of the following organizations:

1. American National Standards Institute (ANSI)
2. Americans with Disabilities Act (ADA)
3. Certified Ballast Manufacturers (CBM)
4. Electrical Testing Laboratories (ETL)
5. Independent Testing Laboratories (ITL)
8. National Electrical Manufacturers Association (NEMA)
9. National Fire Protection Association (NFPA)
10. Occupational Safety & Health Act (OSHA)
11. Underwriters Laboratories (UL)
12. Rules and Regulations of the State Fire Marshal
13. Requirements of the Serving Utility Company
14. Local and State Codes and Ordinances

1.3 FEES AND PERMITS

A. The electrical contractor shall pay all fees and arrange for all permits required for work done under his contract and under his supervision by subcontract.
1.4 MATERIALS AND EQUIPMENT

A. Manufacturer’s trade names and catalog numbers listed are intended to indicate the quality of equipment or materials desired. Manufacturers not listed must have prior approval. Written prior approval must be obtained from the Architect/Engineer ten (10) business days prior to bid opening. Requests are to be submitted sufficiently ahead of the deadline to give ample time for examination. The items approved will be listed in an addendum and only this list of equipment will be accepted in lieu of specified products. Submittals must indicate the specific item or items to be furnished in lieu of those specified, together with complete technical and comparative data on specified items and proposed items.

B. Electrical equipment shall be installed with manufacturer’s standard finish and color except where specific color, finish or choice is indicated. If the manufacturer has no standard finish, equipment shall have a prime coat and two finish coats of gray enamel.

C. The electrical contractor shall be responsible for materials and equipment installed under this contract. Contractor shall also be responsible for the protection of materials and equipment of others from damage as a result of his work.

D. Manufactured material and equipment shall be applied, installed, connected, erected, used, cleaned and conditioned as directed by the manufacturer unless herein specified to the contrary.

E. The electrical contractor shall make the required arrangement with General Contractor for the introduction into the building of equipment too large to pass through finished openings.

F. Materials and equipment shall be stored indoors at the job site or, if this is not possible, stored on raised platforms and protected from the weather by means of waterproof covers. Coverings shall permit circulation of air around the materials to prevent condensation of moisture. Screen or cap openings in equipment to prevent the entry of vermin.

G. Lighting fixtures proposed as substitutes to those specified must have prior approval by Architect/Engineer as noted above. Approval will not be considered unless the request has all of the following information:

1. Manufacturers data showing catalog number.
2. Construction details.
3. Photometrics.
4. Recommended maintenance factor.

1.5 INTENT OF DRAWINGS

A. The drawings are partly diagrammatic and do not necessarily show exact location of conduit unless specifically dimensioned. Riser and other diagrams are schematic and do not necessarily show the physical arrangement of the equipment. They shall not be used for obtaining quantities or lineal runs of conduit. Discrepancies shown on different plans, or between plans and actual field conditions shall be brought to the attention of the Architect/Engineer for resolution.

1.6 RESPONSIBILITY

A. The electrical contractor shall be responsible for the installation of satisfactory and complete systems in accordance with the intent of the drawings and specifications and shall provide, at no extra cost, all
incidental items required for completion of the work even though they are not specifically mentioned or indicated on the drawings or in the specifications.

B. The drawings do not attempt to show complete details of the building construction which affect the electrical installation; and reference is therefore required to the Architectural, Structural, Landscape and Mechanical drawings and specifications and to shop drawings of all trades for additional details which affect the installation of the work covered under this Division of the Contract.

C. Location of electrical system components shall be checked for conflicts with openings, structural members and components of other systems having fixed locations. In the event of any conflicts, the Architect/Engineer shall be consulted and his decision shall govern. Necessary changes shall be made at no additional expense to the Architect/Engineer or Owner.

D. The electrical contractor shall determine, and be responsible for, the proper location and character of inserts for hangers, chases, sleeves and other openings in the construction required for the work, and obtain this information well in advance of the construction progress so work will not be delayed. Roughing-in fixtures, etc., must be laid out accurately. Connections to equipment of the same class shall be equal heights, plumb, and at right angles to the wall, unless otherwise directed.

E. Final location of inserts, hangers, etc., required for each installation, must be coordinated with facilities required for other installations to prevent interference.

F. The electrical contractor shall take extreme caution not to install work that connects to equipment until such time as complete Shop Drawings of such equipment have been approved by the Architect/Engineer. Any work installed by the Contractor, prior to approval of Shop Drawings, will be at the Contractor's risk.

G. At all times during the performance of this contract, the electrical contractor shall properly protect work from damage and protect the Owner's property from injury of loss. The contractor shall make good any damage, injury or loss, except such as may be directly due to errors in the Bidding Documents or caused by Agents or Employees of the Owner. The electrical contractor shall adequately protect adjacent property as provided by law and the Bidding Documents. The electrical contractor shall provide and maintain passageways, guard fences, lights and other facilities for protection required by Public Authority or Local conditions.

H. Circuiting and switching shall be exactly as shown on drawings. Combining of home runs is acceptable but neutrals shall not be shared. Contractor shall refer to NEC Article 310-15 and adjust accordingly. Combining of wiring of various systems in conduit runs is not acceptable unless otherwise specified herein or noted on drawings.

I. Neutrals shall not be shared to avoid the requirement of installing handle-ties on breakers. Neutrals to be installed at all line voltage switch locations per NEC.

J. Contractor is responsible for providing UL-listed fire rated materials where required by applicable codes and other sections of this specification to seal fire-rated membrane penetrations. In particular this applies to requirements of IBC Section 712 as it pertains to:

1. Electrical Boxes: Provide minimum 6 inch separation in non-rated walls. Provide minimum 24 inch horizontal separation in fire rated walls. In rated walls locate boxes so as to comply with IBC Section 712 separation and membrane penetration requirements. Apply fire-rated putty pads (SpecSeal Series SSP Intumescent Putty Pads, or equal) to all boxes where 24" box-to-box separation cannot be maintained or where openings exceed allowable limits under IBC section 712.

2. Flush-Mounted Panels (panelboards, fire alarm panels and any other flush-mounted electrical enclosure exceeding 16 square inches of area): Coordinate with the general contractor for
gypsum board lined framing pockets where any flush-mounted panelboards are located in 1 or 2-hour rated walls. Provide fire-rated putty pads on top and bottom of panelboards to seal around conduits.

3. **Conduit and Cable**: Apply fire seal where conduit or cables penetrate fire-rated assemblies as required by NEC Article 300-21 and IBC section 712. Fire seal shall be equal to International Protective Coating Corp. #FSC or #FS series or Chase Technology Corp. #PR-855 Fire Stop.

1.7 **INSPECTION**

A. All work and material is subject to inspection at any time by the Architect/Engineer or his representative. If the Architect/Engineer or his representative finds material that does not conform with these specifications or that is not properly installed or finished, correct the deficiencies in a manner satisfactory to the Architect/Engineer at no additional expense to the Owner.

1.8 **WORKMANSHIP**

A. **GENERAL**

1. Work under this contract shall be performed by workmen skilled in the particular trade conducting all work necessary to properly complete the installation in a workmanlike manner to present a neat and finished appearance.

B. **EXCAVATION AND BACKFILL**

1. Provide all excavating and backfilling as required, with backfilling only after approval of the Architect. Backfill to be free of all debris and decayable matter. See Excavation and Backfill requirements in DIVISION 1 -- GENERAL REQUIREMENTS.

C. **CUTTING, PATCHING AND FRAMING**

1. Obtain Architect's/Engineer's approval before performing any cutting on structural members or patching of building surfaces. Any damage to the building or equipment by this Contractor shall be the responsibility of this Contractor and shall be repaired by skilled craftsmen of the trades involved at no additional expense to the Owner.

2. Chases, openings, sleeves, hangers, anchors, recesses, equipment pads, and framing for equipment are provided by others only if so noted on the drawings. Otherwise, they will be provided by this contractor for his work. Whether chases, etc., are provided by this contractor or others, this contractor is responsible for correct size and locations.

1.9 **COORDINATION**

A. The electrical contractor shall plan his work to proceed with a minimum interference with other trades and it shall be his responsibility to inform the General Contractor of all openings required in the building structure for installation of work, and to provide sleeves as required. Dimensions of equipment installed and/or provided by others shall be checked in order that correct clearances and connections may be made.

1.10 **CLEAN UP**
A. The electrical contractor shall keep the premises free from accumulation of waste material or rubbish caused by his work or employees.

B. Upon completion of work, remove materials, scraps and debris relative to his work and leave the premises, including tunnels, crawl spaces, and pipe chases in clean and orderly condition. Remove all dirt and debris from the interior and exterior of all devices and equipment. After construction is completed, wash all light fixtures and lamps, remove all labels from fixture lenses.

1.11 DUST PROTECTION

A. Contractor will provide suitable dust protection for all existing areas prior to beginning of cutting or demolition. Contractor will obtain approval of partition from Owner before proceeding with work involved in these rooms.

1.12 TEMPORARY FACILITIES

A. OFFICES

1. The electrical contractor shall provide temporary offices for himself including lights, heat and telephone, if required.

B. REMOVAL

1. The electrical contractor shall completely remove his temporary installations when no longer needed and the premises shall be completely clean, disinfected, patched, and refinished to match adjacent areas.

C. LADDERS AND SCAFFOLDS

1. The electrical contractor shall provide their own ladders, scaffolds, etc. of substantial construction for access to their work in various portions of the building as may be required. When no longer needed, they shall be removed by the contractor.

D. PROTECTION DEVICES

1. The electrical contractor shall provide and maintain his own necessary barricades, fences, signal lights, etc. required by all governing authorities or shown on the drawings. When no longer needed, they shall be removed by the contractor. The contractor shall assume all responsibility for which the owner may be held responsible because of lack of above items.

E. TEMPORARY WATER

1. The electrical contractor shall provide all water required by his trade for construction. Temporary drinking water shall be provided from a proven safe source dispensed by single service containers, until such time as the construction water outlet has been install, disinfected and approved for drinking purposes.

F. TEMPORARY FIRE PROTECTION

1. The electrical contractor shall provide all necessary first-aid hand fire extinguishers for Class A, B, C and special hazards as may exist in his own work area only in accordance with good and
safe practice and as required by jurisdictional safety authority. The contractor shall provide general area fire extinguishers only.

1.13 TEMPORARY ELECTRICAL FACILITIES

A. ELECTRICAL POWER

1. The electrical contractor shall provide temporary construction power to the remodel area to support construction activities of all trades. All temporary power shall be derived from a separate temporary construction service arranged and paid for by the contractor. No tie-ins or connections to the Owner’s system shall be made without the Owner’s consent. Construction power shall the following unless otherwise agreed to by the General Contractor:

a. One temporary panel located as directed by the General Contractor with provision for 100A, 3-phase, 4-wire service at voltage available.

b. Power centers for miscellaneous tools and equipment used in the construction period, so that power can be secured at any desired point from temporary service panel within building proper.

c. Lighting for safe and adequate working conditions throughout the buildings, stairways, and crawl spaces. Provide at least 1/2 watt of incandescent lighting per square foot of floor area. Maintain a socket voltage of at least 110 volts. Use a minimum of 100 watt bulbs.

d. Power for construction site offices and for other temporary storage and construction buildings.

e. Power to maintain continuous construction during changeover of electrical equipment.

f. Power for testing and checking equipment.

B. TEMPORARY FIRE ALARM SYSTEM

1. Provide and maintain the following minimum fire alarm devices at all time in construction zones:

a. A pull station at each exit.

b. A minimum of one smoke or heat detector.

2. All temporary devices shall be connected to the facility fire alarm system.

C. TEMPORARY EGRESS/EXIT LIGHTING

1. Provide and maintain the following minimum temporary egress/exit devices at all time in construction zones:

a. Illuminated exit lights at each construction zone exit.

b. A minimum of two unswitched light fixtures in each construction zone connected to the Owner’s Life Safety emergency power branch.

2. In any temporary public corridors passageways required by construction walls, provide temporary lights fixtures as required. Fixture shall be fluorescent corridor wraps or other fluorescent fixture acceptable to the Owner. Connect at least one fixture to Owner’s Life Safety emergency power branch.

1.14 SHOP DRAWINGS
A. Provide eight (8) copies of manufacturer’s literature and/or certified prints as soon as possible but within thirty (30) days after awarding of Contract, for items of materials, equipment, or systems where called for in specifications. Shop drawings and literature complete showing item used, size, dimensions, capacity, rough-in, etc., as required for complete check and installation. Manufacturer’s literature showing more than one item shall be clearly marked as to which item is being furnished or it will be rejected and returned without review.

B. Each copy of each item submitted must be clearly marked as follows for purposes of identification and record. Submittals not marked (typewritten only) as described below will be rejected and returned without review.

Date:
Name of Project:
Branch of Work:
Submitted by:
Specification or Plan Reference:

C. Prior to their submission, each submittal shall be thoroughly checked by the contractor for compliance with the Contract Document requirements, accuracy of dimensions, relationship to the work of other trades, and conformance with sound, safe practices as to erection and installation. Each submittal shall then bear a stamp evidencing such checking and shall show corrections made, if any. Submittals requiring extensive corrections shall be revised before submission. Each submittal not stamped and signed by the contractor evidencing such checking will be rejected and returned without review.

D. All submittals will be examined when submitted in proper form for compliance. Such review shall not relieve the contractor of responsibility for errors, for deviation from the contract Documents, nor for violation of sound safety practices.

E. The contractor shall keep in the field office one print of each submittal which has been reviewed and stamped by the Architect or Engineer.

F. Submittals will be required for each item of material and equipment furnished as noted in specifications.

G. All submittals shall be organized into a single binder, PDF or hard copy and transmitted in one delivery. Transmittal of individual sections is not permitted. Exceptions will be considered upon request for exceptionally long-lead equipment or voluminous submittals that cannot reasonably fit into a single binder. PDF packages shall be organized to be less then 8MB each when email is the transmittal method. Should submittal package require file size larger than 8MB it shall be the contractor’s responsibility to configure a file share site/ folder for transmittal of files.

H. Submittals which are incomplete relative to quality requirements, capacity, engineering data, dimensional data or detailed list of specialty or control equipment will be rejected. Lists shall include descriptive coding as specified or shown on drawings.

THE ENGINEER WILL PERFORM SHOP DRAWING REVIEW OF EACH ITEM, HOWEVER, SUBSEQUENT REVIEW OF ITEMS PREVIOUSLY REJECTED WILL BE BILLED TO THE CONTRACTOR AT A RATE OF $75 PER HOUR.

I. Schedule of Shop Drawings.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MFG LIT</th>
<th>SHOP DWG</th>
<th>WIRING DIAG.</th>
<th>O&amp;M BOOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>RACEWAYS AND FITTINGS</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WIRE AND CABLE</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>OUTLET BOXES</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>WIRING DEVICES</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIRE SEAL PRODUCTS</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(see specifications 260533)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUPPORTING DEVICES</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>FUSES</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISCONNECT SWITCHES</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PANELBOARDS</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOTOR CONTROLS</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIGHTING FIXTURES</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIRE ALARM SYSTEM</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

1.15 OPERATION AND MAINTENANCE MANUALS

A. At the time orders are placed for any item of equipment requiring service or operating maintenance, the contractor shall request the manufacturer furnish three (3) copies of OPERATION AND MAINTENANCE INSTRUCTIONS for each piece of equipment. These shall be included in the brochure of equipment.

1.16 BROCHURE OF EQUIPMENT

A. Upon completion of work, prepare a "Brochure of Equipment" containing data pertinent to equipment and systems on job. Binders containing materials shall be one or more three ring binders of sufficient number to hold all literature. Contained in binders shall be: Installation, maintenance, and operating instructions for each piece of equipment; parts lists; wiring diagrams; one copy of each shop drawing and literature submittal; record drawings, etc.

B. All literature shall be clean, unused and filed under divider headings corresponding to the specifications.

C. These brochures shall be submitted to the Architect/Engineer and approved by him before authorization of final payment.

1.17 "AS-BUILT" DRAWINGS

A. The electrical contractor shall furnish to the Owner and Architect/Engineer a red line marked print set of drawings, each sheet stamped as the "As-Built" drawing and bearing the contractor's name, date and signature. The As-Built drawing shall show the location of all concealed or underground conduit runs and other equipment, devices, outlets, etc., installed other than as shown on the drawings. Dimension underground lines from established building lines. As-Built drawings to be developed from a job site record drawing set and shall be clean, neat and all changes legible and shown in the same format and
symbols used on the contract drawings. The As-Built drawing set shall be submitted to the architect/engineer for approval, and any deficiencies noted by the architect/engineer corrected and resubmitted until approved by the architect/engineer at no cost to architect/engineer or owner.

1.18 PLACING SYSTEMS IN OPERATION

A. At the completion of the work and at such time as the Owner shall direct, prior to final acceptance, the electrical contractor performing this work shall put into satisfactory operation the various systems installed under the specifications. At no additional cost to the Owner, furnish the services of a person completely familiar with the installations performed under this specification, to instruct the Owners operating personnel in the proper operation and servicing of the equipment and systems. These services shall be available for a period of no less than one (1) day.

B. Upon placing systems in operation the contractor shall measure phase currents at each main and branch panel within the facility, including existing panels, and balance the phase currents to within 20% of each other by moving circuit breakers to different phases.

1.19 GUARANTEE-WARRANTY

A. The electrical contractor shall and hereby does warrant and guarantee that all work executed under this Division will be free from defects of materials and workmanship for a period of one year from the date of final acceptance of this work and that he will, at his own expense, repair and/or replace all such defective materials and work and all other work damaged thereby which becomes defective during the term of warranty, except that lamps and tubes shall be his responsibility only for normal lamp life or one year, whichever occurs first.

END OF SECTION 26 00 00
SECTION 26 01 00 - OWNER TRAINING

PART 1 - GENERAL

1.1 SUMMARY

A. Training:

1. General:
   a. The system training is intended to familiarize the Owner’s operating and maintenance staff with all systems requiring maintenance. Training is to be provided after the systems are in place and operational, after issues noted during the Demonstration have been resolved, and before final acceptance.
   b. Provide second set of training sessions for automatic control systems about 6-9 months after the first sessions.
   c. Training to be held on separate weeks and training agenda to be submitted to owner and Commissioning Agent.

2. Systems Requiring Training:
   a. All mechanical, electrical, safety, standby generator, and automatic control systems in the project, and other systems specified elsewhere to have training.

3. Attendance:
   a. Training is to be provided by contractor’s representatives that are familiar with the system’s operation and maintenance requirements. Individual training sessions (modules) are to be provided for each type or group of systems, separated roughly by trade group that will be performing maintenance on the system. MSU trades groups and systems typically requiring training are:
      1) Electricians (Power, lighting, lighting controls, fire alarm and detection, smoke exhaust, standby power systems)
      2) Grounds Maintenance (Grounds surfaces, lawn sprinkler systems)
      3) Heating Plant (Hydronic and steam heating systems, fan systems, controls)
      4) Plumbers (Plumbing, gas-fired heating, lawn sprinkler systems, fire sprinklers, miscellaneous process piping systems)
      5) Refrigeration (Refrigeration, chilled water, packaged cooling systems)

4. Schedule:
   a. Duplicate training sessions are to be provided for each training module, so that Owner’s operating personnel can be split into two groups during training. Duplicate training sessions to be scheduled on different days. Length of training sessions will be determined by scope of training indicated below, and as coordinated with Owner after draft copy of training documents have been reviewed.

1.2 EXECUTION
A. Training:

1. Training Documentation:
   
   a. Contractor to submit draft copy of agenda and training documents to Owner for review at least two weeks prior to training date.
   
   b. Provide a copy of the following items for each person that will be attending the training sessions. Coordinate required number with the Owner.

   1) Training agenda.
   
   2) Summary of new systems and existing systems affected by this project.
   
   3) Summary of work performed under this project.
   
   4) Control system drawings and sequences of operation.
   
   5) List of important maintenance and trouble-shooting operations for all systems.

   c. Provide minimum of 2 copies of following items:

   1) Contract documents including all drawings, specifications, addendums, and change orders.

2. Training Sessions:

   a. Assemble at location to be determined by the Owner.
   
   b. Distribute training documentation as indicated above.
   
   c. Provide classroom style training if required for orientation, discussion of new systems and existing systems affected by this project, and other issues appropriate for a classroom format.
   
   d. Visit site and review locations, and perform detailed review of operation and maintenance requirements for current systems.

   e. All training sessions to be video taped and recorded and (6) DVD’s provided to the owner for each training session.

END OF SECTION 26 01 00
SECTION 26 05 13.16 - MEDIUM-VOLTAGE, SINGLE- AND MULTI-CONDUCTOR CABLES

PART 1 - GENERAL

1.1 RELATED WORK
   A. Section 26 0543 – Underground Ducts and Raceways for Electrical Systems
   B. Section 26 0812 – Power Distribution Acceptance Tests
   C. Section 26 0813 – Power Distribution Acceptance Test Tables

1.2 DESCRIPTION
   A. Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.
   B. Cables are for use in underground duct applications.
   C. Conductors shall be rated to operate at conductor temperature of 90°C for continuous normal operation, 130°C for emergency overload conditions, and 250°C for short circuit conditions, based on 40°C maximum ambient temperature.
   D. Conductor sizes in Section are based on copper wire and only copper wire shall be used.

1.3 REFERENCE STANDARDS
   A. AEIC CS6 – Specification for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 through 69kV
   B. ASTM B-8 – Standard Specification for Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard or Soft
   C. ICEA S-94-649 – 5-46kV Concentric Neutral Cables Rated 5000 to 46000 Volts
   D. IEEE 48 – Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5kV through 765kV
   E. IEEE 386 – Standard for Separable Insulated Connector Systems for Power Distribution Systems above 600 V (ANSI)
   F. IEEE 404 – Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 – 500000 V (ANSI)
   G. IEEE 576 – Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications (ANSI)
   H. NFPA 70 – National Electrical Code
   I. UL 1072 – Medium-Voltage Power Cable
1.4 SUBMITTALS

A. Product Data: For each type of cable indicated. Include splices and terminations for cable and cable accessories.
   1. Include cable drawings with the following data:
      a. Longitudinal cutback and cross-sectional view of cable.
      b. Identification and structure of cable components.
      c. Dimensions of cable components in English and SI units.

B. Material Certificates: For each cable and accessory type, signed by manufacturer.

C. Manufacturer Testing Certificate: For each type and voltage class of cable indicated.

D. Certified Field Quality Control Test Reports per requirements in Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables for each type and voltage class of cable indicated. Indicate applicable standards compliance. Interpret test results and corrective action taken for compliance with specification requirements.

E. Qualification Data: For testing agency.

F. Manufacturer’s Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.

G. Installation Guide: Include the following:
   1. Maximum allowable pulling tension (in pounds and newtons)
   2. Minimum allowable bending radius
   3. Recommended pulling compounds
   4. Splicing and termination instructions with diagrams, dimensions, and material lists
   5. Weight per 1,000 ft
   6. Standard “packaging” of reels (i.e., lengths, lagging, banding, etc.)
   7. Reactance and AC resistance (ohms to neutral) of each size and voltage class of cable, both in magnetic and non-magnetic duct, based on 3-1/C cables or 1-3/C cable in one duct.

H. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of cables, splices, and terminations.
   2. Operation and Maintenance Data:
      a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

1.5 QUALITY ASSURANCE

A. Installer: Engage cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable, having not less than 3 yrs experience as licensed electrician.
B. Regulatory Requirements:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

C. Source Limitations: Obtain cables and accessories through one source from single manufacturer.

D. All cables shall be of a single type and configuration. Date of manufacture shall not precede contract date by more than one year.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with manufacturer to provide protective covering over cable and reel to prevent damage during shipping, storage, or handling.

B. Store in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.7 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cables:

1. General Cable (Cablec)
2. Kerite
3. Okonite
4. Prysmian (Pirelli)

B. Cable Splicing and Terminating Products and Accessories:

1. Raychem Corporation
2. RTE Components; Cooper Power Systems, Inc.
3. Thomas & Betts Corporation/Elastimold
4. 3M; Electrical Products Division

2.2 CABLES

A. Cable Type: MV90

B. Comply with UL 1072, AEIC CS6, ICEA S-93-639, and ICEA S-94-649
C. Conductor: Copper

D. Conductor Insulation: Ethylene-propylene-rubber

E. Voltage Rating: 15 kV

F. Insulation Thickness: 133 percent (220 mil) insulation level

G. Concentric Neutral: Solid copper wires shall be spirally applied to provide neutral rating equal to 1/3 of the cable conductor current rating.

H. Cable Jacket: 80 mil extruded, chlorinated, polyethylene jacket. Color: black, unless otherwise designated

I. Cables utilizing combination insulation shield and jacket are acceptable.

J. Cable lengths shall be supplied with factory-installed, moisture-proof end seals on conductors on each end. Cable seals shall be rubber or plastic caps, and shall prevent moisture from seeping into cable ends.

K. Each cable reel shall be tagged with the following:

1. Manufacturer
2. Cable Size
3. Cable Type
4. Voltage Class
5. Manufacture Date
6. Cable Length
7. Tolerances
8. Reel Number
10. Customer Name

L. Surface Marking:

1. Cables shall be permanently printed (or imprinted) on jacket surface at regular intervals over entire length of cable with the following:
   a. Manufacturer’s name
   b. Cable type
   c. Insulation type and thickness
   d. Conductor size and type
   e. Voltage class
   f. Sequential footage number
   g. Year of manufacture
   h. UL designation

M. Cables shall be constructed and rated for continuous and intermittent submersion in water and shall be suitable for installation in conduit and underground duct.

N. Cable shield shall be capable of withstanding fault current indicated on drawings for 1/10 second.
2.3 SPlice KItS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include components required for complete splice, with detailed instructions.
   1. Combination tape and cold-shrink-rubber sleeve kit with re-jacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.

2.4 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Load-Break Cable Terminators: Elbow-type units with 200A and 600A, 15 kV class, 95 KV BIL load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated, with steel-reinforced hook-stick eye, grounding eye, and arc-quenching material. Include capacitance coupled test point on terminator body. Include cold shrinkable metallic shield adapter kit to ground metallic shielded cable. Include connection bus with parking stand for wall mounting.

C. Test-Pont Fault Indicators: Sealed and self-contained applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

D. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.5 ARC-PROOFING MATERIALS

A. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3” thick, compatible with cable jacket.

2.6 FAULT INDICATORS

A. Indicators: Automatic current reset fault indicator, arranged to clamp to cable sheath and provide a display after fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

2.7 CONDUCTOR IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend.

B. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MRI), Seton, or approved equal.

C. Color-Coding Conductor Tape: Orange, self-adhesive vinyl tape not less than 3 mils thick by 1” to 2” wide.

D. Metal Tags: Brass or aluminum, 2” x 2” x 0.05”, with stamped legend, punched for use with self-locking nylon tie fastener.

E. Identification shall include:
1. Circuit (CKT11A")
2. Phase ("PhA, PhB, PhC")
3. Destination Station Number ("ToSTA11A-1")

F. Tags shall not start with the word "FROM".

### 2.8 SOURCE QUALITY CONTROL

A. Test and inspect cables according to Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Pull Conductors: Do not exceed manufacturer’s recommended minimum installation temperature, maximum pulling tensions, and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
3. Cut off cable damaged by cable grips or pulling make-ups so as to provide clean, undamaged cable for termination. Continuously record pulling tension during installation.
4. Make attachment to cable by compression or epoxy filled pulling eye and provide break away (clutch) tension device.

C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

D. Support cables in handholes and manholes from walls on heavy-duty, non-metallic cable rack arms, at least 3” above the floor. Support cables with reinforced nylon cradles. Anchor to wall with stainless steel anchor bolts. Refer to drawings for details.

E. In manholes and cable vaults, train cables around walls by longest route from entry to exit and support cables at intervals adequate to prevent sag. Fill lowest ducts first, avoid covering or blocking duct entrances and allow space for future cable installation.

F. Provide loop around each manhole as designated on plans.

G. Cut cable in clean, dry environment. Seal cut ends with waterproof seal immediately after cutting. Maintain a seal during and after pulling.

H. Install cable splices at pull points (accessible locations) and elsewhere as indicated.

I. Install terminations at ends of conductors. Do not install exterior terminations during inclement weather or damp atmospheric conditions.

J. Install stress cones at cable splices and terminations, grounded per cable and connector manufacturer recommendations.
K. Check phase rotation before connections are made to existing circuits. Clearly letter cable terminations. Identify phases with phase designations lettered on terminal boxes and other terminations throughout the system.

L. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape and/or manufacturer’s written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10 mil pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with 1”-wide bands of half-lapped, adhesive, glass-cloth tape 2” o.c.

M. Seal around cables passing through fire-rated elements according to Section 26 0593 – Electrical Systems Firestopping.

N. Install fault indicators on each phase where indicated.

O. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

P. Power-Circuit Conductor Identification: For primary conductors in vaults and manholes use color-coding conductor tape for 15kV system identification. Use metal tags to identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above. Phase identification shall be consistent throughout the system.

3.2 FIELD QUALITY CONTROL

A. Perform cable acceptance tests on cable circuits after installing cables and before electrical circuitry has been energized. Splices and terminations required as part of this project are to be completed and acceptance tested as part of cable tests. For cables not spliced or terminated as part of project, ends should be clean, dry and long enough to eliminate leakage from conductor to ground along outer surface of cable.

B. Perform acceptance tests and damage investigations under constant supervision of Owner’s representative. Contractor shall coordinate and provide labor, material, equipment, and services necessary to test each completed cable circuit.

C. Remove and replace defective cables and retest as required.

D. Refer to Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables for visual and mechanical inspection and electrical tests. Certify compliance with test parameters.

END OF SECTION 26 0513.16
SECTION 26 05 19 - ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.
   3. Sleeves and sleeve seals for cables.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Field quality-control test reports.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70.
B. Conductor Insulation: Comply with NEMA WC 70 for Types THW, THHN-THWN, XHHW.
C. Multiconductor Cable: Not permitted.
D. Aluminum conductors not permitted.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division.
   5. Tyco Electronics Corp.
B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
C. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

A. Basis-of-Design Product: Subject to compliance with requirements, provide a product by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex Co.
   4. Pipeline Seal and Insulator, Inc.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Size and material per feeder schedule on plans. All conductors copper unless otherwise noted on plans.
B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THHN, single conductors in raceway, single conductors in raceway.
B. Exposed Feeders: Type THHN-THHN, single conductors in raceway.
C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THHN, single conductors in raceway.
D. Coordinate first paragraph below with Division 26 Section "Underground Ducts and Raceways for Electrical Systems."
E. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THHN, single conductors in raceway.
F. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THHN, single conductors in raceway.
G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
   1. Type MC not permitted.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

J. Class 1 Control Circuits: Type THHN-THWN, in raceway.

K. Class 2 Control Circuits: Type THHN-THWN, in raceway or power-limited tray cable, in cable tray.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

I. Wiring at Outlets: Install conductor at each outlet, with at least EIGHT inches of slack.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

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

C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
D. Cut sleeves to length for mounting flush with both wall surfaces.

E. Extend sleeves installed in floors 2 inches above finished floor level.

F. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

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

K. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

L. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.5 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

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

3.6 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
   1. After installing conductors and cables and before electrical circuitry has been energized, test all service entrance, switchboard, panelboard, motor or equipment feeder conductors larger than #6 AWG for compliance with requirements.

3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
   a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
   b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 19
SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes methods and materials for grounding systems and equipment.

1.2 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Field quality-control test reports.

1.3 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS
   A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
   B. Bare Copper Conductors:
      4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
      5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
      6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
      7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.2 CONNECTORS
   A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES
A. Ground Rods: Copper-clad, zinc-coated or stainless steel; 3/4 inch by 10 feet or as otherwise accepted by local authority having jurisdiction.

PART 3 - EXECUTION

3.1 APPLICATIONS
A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, sized per plans. Bury at least 24 inches below grade.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

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

3.2 EQUIPMENT GROUNDING
A. Install insulated equipment grounding conductors in all circuits. Provide equipment grounding conductor in all armored or metalclad cable assemblies.

B. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

C. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
D. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum, unless larger is stated in plans, insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

E. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
2. For grounding electrode system, install at least rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

D. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

E. Where indicated on the plans provide a concrete-encased ("UFER") ground. Use bare conductor no smaller than #4 AWG and encase in bottom of concrete slab or footer no less than 2" from bottom of concrete. Bond to reinforcing bars or encase at least 20' of bare conductor.
3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
   a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
   b. Perform tests by fall-of-potential method according to IEEE 81.

B. Report measured ground resistances that exceed the following values:

Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.

1. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
2. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26
SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY
   A. Section includes:
      1. Hangers and supports for electrical equipment and systems.
      2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS
   A. Provide supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
   B. Provide equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
   C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads imposed with a minimum structural safety factor of five times the necessary force.

1.3 SUBMITTALS
   A. Product Data: Submit product data for all proposed materials.

1.4 QUALITY ASSURANCE
   A. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS
   A. Do not use wooden materials for support, anchorage or attachment components unless the facility is framed of wooden materials.
   B. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         a. Allied Tube & Conduit.
         b. Cooper B-Line, Inc.; a division of Cooper Industries.
         c. ERICO International Corporation.
d. GS Metals Corp.

e. Thomas & Betts Corporation.

f. Unistrut; Tyco International, Ltd.

g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

5. Channel Dimensions: Selected for applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; galvanized or painted.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

       1) Hilti Inc.
       2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
       3) MKT Fastening, LLC.
       4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-plated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

   a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

       1) Cooper B-Line, Inc.; a division of Cooper Industries.
       2) Empire Tool and Manufacturing Co., Inc.
3) Hilti Inc.
4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 40 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single or two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lbs.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts. Use washers.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or Spring-tension clamps.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Coordinate with general contractor for the construction of concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors (if present) will be a minimum of 10 bolt diameters from edge of the base.

B. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 09 for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29
SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes raceways, fittings, boxes, floor-boxes, enclosures, and cabinets for electrical wiring.

1.2 SUBMITTALS
A. Product Data: For boxes, surface raceways, wireways and fittings, hinged-cover enclosures, and cabinets.

1.3 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING
A. Rigid Steel Conduit: ANSI C80.1.
B. IMC: ANSI C80.6.
C. EMT: ANSI C80.3.
D. FMC: Zinc-coated steel.
E. LFMC: Flexible steel conduit with PVC jacket.
   1. Not permitted for use as a low voltage raceway, such as serving tel/data rough-ins.
F. Fittings for Conduit (Including all types and flexible and liquid-tight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
   2. Fittings for EMT: Steel or die-cast, set-screw or compression type.
Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Butler Manufacturing Company; Walker Division.

b. Enduro Systems, Inc.; Composite Products Division.

c. Hubbell Incorporated; Wiring Device-Kellems Division.

d. Lamson & Sessions; Carlon Electrical Products.

e. Panduit Corp.


g. Wiremold Company; Electrical Sales Division.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Sheet Metal Outlet and Device Boxes: NEMA OS 1. Provide 2-1/8” x 4” square boxes with mud ring for wall-mounted boxes and 2-1/8” x 4” octagonal boxes for fixture outlets.

B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover.

C. Nonmetallic Outlet and Device Boxes: Not permitted unless specifically noted otherwise on plans.

D. Floor Boxes:

1. Non-Rated Floorboxes, Concrete Slabs:

   a. Floor boxes in slab-on-grade or non-rated floor assemblies shall be nonmetallic, rectangular, of PVC construction, suited for concrete floors. Design shall allow ganging of boxes up to three gang. Boxes shall be equal to Carlon E976RFB, ganged as shown on plans. Provide an activation kit for each gang.

   b. Box covers shall be brass, ganged as required for boxes, with separate access doors for device and cable exit and shall allow for complete concealment of the cord plug within the floor box.

2. Non-Rated Floorboxes, Wooden Floors:

   a. Floor boxes in wooden floors shall be steel, rectangular, designed for wooden floors. Boxes shall be Wiremold 880 series, ganged as shown on plans.

   b. Box covers shall be brass, ganged as required for boxes. Provide bronze cover suitable for specified devices. Coordinate requirements with tel/data contractor for data cover requirements.

3. Fire-Rated Floor Boxes:

   a. Boxes in fire-rated floor assemblies shall be flush, fire-rated poke-through style, UL listed for floors with a 1-4 hour rating, Hubbell PT4XBR52C or equal. Covers shall be brass with four 15-amp receptacles. Provide four Hubbell PTX4XCAT5 RJ-45 jacks.

   b. Where shown on plans, provide flush, fire-rated poke-through style with three-service furniture feed service fitting, Hubbell PT73SD-FRF3GY or equal. Provide flex connections and power wiring from floorbox to modular furniture connection for power. Provide flex connection from floorbox to modular furniture connection for data cabling. Provide data cabling, jacks and terminations if required by other specification sections.
4. In slab-on-grade construction provide a dedicated 1” conduit from an accessible ceiling space to each floorbox intended for tel/data use. This is in addition to the power conduit required.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

G. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel. Provide backplate.
   2. Nonmetallic Enclosures: Not permitted unless noted on plans.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
   1. Exposed Conduit: EMT or RNC, Type EPC-40-PVC, as identified on plans.
   2. Concealed Conduit, Aboveground: EMT or RNC, Type EPC-40-PVC, as identified on plans.
   3. Underground Conduit: RNC, Type EPC-40 PVC, direct buried.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC or LFNC.
   5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R unless noted otherwise on plans.

B. Comply with the following indoor applications, unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed and Subject to Severe Physical Damage: IMC. Includes raceways in the following locations:
      a. Loading docks.
      b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   3. Concealed in Ceilings and Interior Walls and Partitions: EMT
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   5. Damp or Wet Locations: EMT.
   6. Raceways for Optical Fiber or Communications Cable: EMT.
   7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations. See plans for specific enclosure or box specifications.

C. Minimum Raceway Size: 3/4-inch trade size. 1-inch for communications.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2.2 NONMETALLIC CONDUIT AND TUBING

A. Nonmetallic conduit or tubing is not permitted above-grade under any circumstance in plenums or healthcare projects unless specifically noted on plans.

B. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, Type EPC-40-PVC unless otherwise indicated.

D. LFNC: UL 1660.

E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, 12, or 3R, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type, screw-cover type, or flanged-and-gasketed type as necessary or as indicated on plans.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Permitted only in utility spaces (mechanical or electrical rooms, crawl spaces, data closets), or where indicated on plans or with written permission from the Architect.

B. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   
a. Thomas & Betts Corporation.
   c. Wiremold Company; Electrical Sales Division.

C. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color indicated on plans.
3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways not permitted embedded slabs.

I. Raceways Routed under Slabs:
   1. Provide at least 8" of cover under slabs for all conduit.
   2. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. Install pull wires in ALL empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 24 inches of slack at each end of pull wire.

L. Raceways for Optical Fiber and Communications Cable: Install as follows:
   1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
   2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
   3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
   1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
   2. Where otherwise required by NFPA 70.

N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet.
1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
   c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
   d. Attics: 135 deg F (75 deg C) temperature change.

2. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit or pre-wired fixture whips for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

   1. Use LFMC in damp or wet locations subject to severe physical damage.
   2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

P. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

Q. Set floor boxes level and flush with finished floor surface. Provide a dedicated 1” conduit from an accessible ceiling space to each floorbox intended for tel/data use. This is in addition to the power conduit required.

R. Support all wall-mounted boxes with B-Line BB8 (or equal) mounting brackets or BB4 (or equal) box support brackets. Do not use materials not specifically intended for the purpose such as scrap EMT and ty-wraps.

S. Mark all junction boxes with panel and circuit numbers. Mark boxes of emergency systems as required by NEC 700.9. Use indelible ink.

T. Do not install boxes back to back in walls. Provide minimum 6 inch separation in non-rated walls. Provide minimum 24 inch horizontal separation in fire rated walls. In rated walls locate boxes so as to comply with IBC Section 712 separation and membrane penetration requirements. Apply fire-rated putty pads (SpecSeal Series SSP Intumescent Putty Pads, or equal) to all boxes where 24” box-to-box separation cannot be maintained or where openings exceed allowable limits under IBC section 712.

U. Wherever receptacles are shown adjacent to tel/data, video or other low voltage locations, install boxes side-by-side with a consistent distance separating the boxes of no more than 3” between adjacent faceplates. Provide or coordinate additional framing as required.

V. Set non-metallic floor boxes level. Trim after installation to fit flush with finished floor surface. Provide a dedicated 1” conduit from an accessible ceiling space to each floorbox intended for tel/data use. This is in addition to the power conduit required.

W. Coordinate all device locations with architectural elevations and other plans before rough-in. Adjust device locations to accommodate casework elevations or knee-space locations or any other architectural or other trade obstruction. Contact the architect or engineer if any conflicts are present that cannot be resolved without substantially changing the layout of devices. The contractor shall be responsible to relocate any devices that are improperly coordinated.
3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.

2. Install backfill as specified in Division 31 Section "Earth Moving."

3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

4. Install all conduits 24" below grade, 36" for switchboard feeders.

5. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

6. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.

   b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

7. Warning Planks: Bury warning planks or tape approximately 12 inches above direct-buried conduits, placing them 24 inches o.c. Align planks along the width and along the centerline of conduit.

3.4 FIRESTOPPING

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

END OF SECTION 26 05 33
SECTION 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 03 3000 - Cast-In-Place Concrete
B. Section 26 0543.13 - Excavation and Backfill
C. Section 26 0543.19 - Manholes and Hardware

1.2 DESCRIPTION

A. Section includes conduits, ducts, and duct accessories for concrete encased for underground primary power distribution.

B. The terms duct and duct bank, as used in this Section, are defined as follows:
   2. Duct Bank: Two or more ducts run together.

1.3 REFERENCE STANDARDS

B. ANSI C80.1 – Rigid Steel Conduit-Zinc Coated (GRC)
D. NEMA RN 1 – Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
E. NEMA TC2 – Electrical Polyvinylchloride (PVC) Conduit
F. NEMA TC3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
G. NEMA TC6&8 – PVC Plastic Utilities Duct for Underground Installation
H. NEMA TC9 – Fittings for PVC Plastic Utility Duct for Underground Installation
I. NFPA 70 – National Electrical Code
J. UL 651 – Schedule 40 and 80 Rigid PVC Conduit
K. UL 651A – Type EB and A Rigid PVC Conduit and HDPE Conduit
L. ULG – Electrical Rigid Metallic Conduit-Steel
1.4 SUBMITTALS

A. Product data for the following:
   1. Duct bank materials, including spacers and miscellaneous components
   2. Ducts and conduits and their accessories, including elbows, end bells, bushings, seals, bends, fittings, plugs, pull tape, and solvent cement
   3. Warning tape

B. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

C. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual routing of conduits and duct banks.
   2. Operation and Maintenance Data:
      a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with NFPA 70
   2. Comply with ANSI C2
   3. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.

B. Deliver ducts to project site with end capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

1.7 WARRANTY

A. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.
PART 2 - PRODUCTS

2.1 CONDUITS

A. Rigid Nonmetallic Conduit (RNC): NEMA TC 2 Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer, complying with NEMA TC 3 and UL 651, listed for underground use, concrete encased.

B. Size:
   1. 4” nominal for voltages above 600 V

2.2 DUCT ACCESSORIES

A. Duct Spacers:
   1. Rigid PVC interlocking spacers.
   2. Factory-fabricated, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling. Horizontal and vertical locking separation between ducts as shown on drawings.

B. Elbows: Material to match conduit; minimum bend radius of 48”.

C. Bell Ends: Manufactured bell ends of appropriate sizes at each end of conduit; pre-manufactured system for PVC with conduit seals, provisions for roughing into the concrete pour and waste stops, when entering a new building or a new manhole.

D. Plugs: Closure plugs or caps of same material as conduit at ends of unused sections.

E. Pull Tape: Nylon pull tape with measurement markings in uniform lengths in each empty duct.

F. Warning Tape: Permanent, bright-colored, continuous-printed, polyethylene tape with embedded continuous metallic strip or core. Not less than 6” wide by 4 mils thick.
   1. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MRI), Seton, or approved equal.

G. Concrete Dye

H. Solvent Cement: Recommended by conduit manufacturer.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate layout and installation of ducts with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct bank entrances into manholes, pad-mounted switchgear vaults and pad-mounted transformer vaults with final locations and profiles of ducts and duct banks as
determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes, and as approved by Architect. For manholes construction, refer to Section 26 0543.19 – Manholes and Hardware.

C. Adjust the depth of electrical utilities to avoid existing utilities with no change to contract price.

D. Utility Coordination: When duct lines are being constructed for use by a utility serving the project, consult with them for duct size and quantity, minimum bending radii, maximum distance between pulling points, grounding details, termination arrangement, and other criteria.

3.2 EXISTING UTILITIES

A. The existing utilities shown on contract drawings have been plotted from available records. No guarantee is made as to accuracy of locations indicated, and is shown for the benefit of Contractor.

B. Contact all serving utility companies and have them locate their lines prior to commencing work. Coordinate with Owner all existing utility lines prior to commencing work.

C. Protect shown, visible and located utilities from damage. Promptly repair all active shown, visible and located utilities damaged by construction. This repair shall be made solely at the expense of the Contractor.

D. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with Owner to shut off services if lines are active.

3.3 PROJECT CONDITIONS

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

1. Notify Owner no fewer than 10 business days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner’s written permission.

3.4 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and away from equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends, both horizontally and vertically, at other locations, unless otherwise indicated.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer’s written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane. Do not use conduit that requires the use of couplings for straight runs.

D. Sealing: Provide temporary closure at termination of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand minimum of 15 psig hydrostatic pressure. Provide watertight entrance sealing device where an underground conduit enters a structure through a concrete roof or membrane waterproofed wall or floor.
E. Pulling Cord: Install 100 lbf test nylon cord in ducts, including spares. Identify with tags at each end and at any intermediate pull point the origin and destination of each spare duct. Provide a removable permanent cap over each end of each spare duct.

F. Concrete Encased Ducts: Support ducts on duct spacers.
   1. Spacer Installation:
      a. Provide spacers close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 ft of duct. Secure spacers to earth and to ducts to prevent floating during concreting. Stagger spacers approximately 6” between tiers. Tie entire assembly together using tie wires and reinforcing steel. Install base and intermediate spacers at every coupling point of each duct line for a separation horizontally and vertically per NEC.
   2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
      a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer’s written recommendations, or use other specific measures to prevent expansion-contraction damage.
      b. Terminate each pour in a vertical plane if more than one pour is necessary, and install 3/4” reinforcing rod dowels extending 18” into concrete on both sides of joint near corners of envelope. Obtain Architect’s approval for the number and location of dowels.
   3. Pouring Concrete: Space concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct bank application.
   4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing bars and ties without forming conductive or magnetic loops around ducts or duct groups. Size reinforcing bars and wire ties as indicated on drawings. Provide rebars with minimum of 3” of concrete on sides, top and bottom. Reinforcing bars shown in sections are required throughout.
   5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms of materials and in a manner acceptable to Architect.
   6. Maintain a grade of at least 4” per 100 ft, either from one manhole or pull box to the next, or from a high point between them, depending on surface contour.
   7. Warning Tape: Bury warning tape approximately 12” above all concrete-encased ducts and duct banks. Align tape parallel to and within 3” of the centerline of duct bank. Provide an additional warning tape for each 12” increment of duct bank width over a nominal 18”. Space additional tapes 12” apart, horizontally.
   8. Place duct banks on an undisturbed soil base if possible. Where concrete encased duct bank is installed over an extensive area of disturbed earth such that within the periphery of a building, provide a separate concrete base under the duct bank to ensure stability of raceways during installation. Allow this base to set before duct bank is installed.

G. Arrangement and Routing:
   1. Arrange multiple duct runs in accordance with details shown on drawings. Locate underground ducts where indicated on drawings and grade to the elevations shown on civil drawings.
   2. Make minor changes in location or cross-section as necessary to avoid obstructions or conflicts. Where duct runs cannot be installed substantially as shown because of conditions not
discoverable prior to digging of trenches, refer the condition to the Architect for written instructions before further work is done.

3. Maintain a 12” minimum vertical separation between ducts and other systems at crossings where other utility piping systems are encountered or being installed along a raceway route. Maintain a 12” minimum separation between ducts and other systems in parallel runs. Do not place ducts over valves or couplings in other piping systems. Refer conflicts with these requirements to the Architect for written instructions before further work is done.

4. Provide markers at grade to indicate direction of underground conduits provided under this contract. Provide markers consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction. Provide markers at all bends and at intervals not exceeding 100 ft in straight runs. Use markers made of sheet bronze not less than 1/4” thick embedded in and secured to the top of concrete posts. User markers not less than 10” long and 3/4” wide and marked ELECTRIC CABLES in letters 1/4” high incised into the bronze to a depth of 3/32”.

5. Enter manholes and structures with ducts at right angles.

3.5 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables Over 600V: RNC, NEMA Type Schedule 40-PVC, in concrete encased duct bank, unless otherwise indicated.

B. Underground Ducts Crossing Paved Driveways and Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.6 EARTHWORK

A. Excavation and Backfill: Comply with Section 26 0543.13 - Excavation and Backfill, do not use heavy-duty, hydraulic-operated compaction equipment.

3.7 CONCRETE

A. Concrete: 3000 psi, 28-day strength, complying with Division 03 – Concrete, where concrete encased.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts.

2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80% fill of duct. If obstructions are indicated, remove obstructions and retest.

B. Preparation for pulling in conductors:

1. Do not install crushed or deformed raceways. Avoid traps in raceways where possible. Take care to prevent the lodging of plaster, concrete, dirt, or trash in raceways, boxes, fittings, and equipment during the course of construction. Make raceways entirely free of obstructions or replace them. Ream all raceways, remove burrs, and clean raceway interior before introducing conductors or pull wires.

2. Immediately after installation, plug or cap all raceway ends with watertight and dust-tight seals until the time for pulling in conductors.
C. Do not backfill underground direct buried and concrete encased ducts until the Architect has inspected them. Notify Architect 24 h in advance of duct concrete pour, or backfill of direct buried ducts.

3.9 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 26 0543
SECTION 26 05 43.13 – EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 31 2000 - Earth Moving
B. Section 26 0543 - Underground Ducts and Raceways for Electrical Systems

1.2 DESCRIPTION

A. Section lists methods and materials for trench excavation and backfill for electrical and communications conduits in duct banks. Refer to Section 26 0543 – Underground Ducts and Raceways for Electrical Systems.

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
B. Excavation: Removal of material encountered above sub-grade elevations and to lines and dimensions indicated.
C. Duct: A single underground conduit encased in concrete or direct buried.
D. Duct Bank: Two or more ducts run together.
E. Fill: Soil materials used to raise existing grades.
F. Sub-grade: Surface or elevation remaining after completing excavation, or top surface of fill or backfill immediately below subbase, drainage fill, or topsoil materials.
G. Utilities: On-site underground ducts and duct banks as well as underground services within buildings.

1.4 SUBMITTALS

A. Submit list of materials to be used for backfill.

1.5 QUALITY ASSURANCE

A. Pre-excavation Conference: Conduct conference at project site to comply with requirements in Division 01 Section “Project Coordination.”

PART 2 - PRODUCTS

2.1 FILL MATERIAL

A. Type 1 Fill:
1. Material from excavation separated from materials, which do not compact by tamping and rolling. No stones larger than 3” and no building, organic, or corrosive or frozen materials and no lumps larger than 6”.

B. Type 2 Fill:
1. Sand or gravel materials with none larger than 2” and of that portion passing the #4 sieve less the 5% to pass #200 sieve.

C. Type 3 Fill:
1. Gravel of rounded to sub-angular shape, screened, which will pass 3/4” sieve and retained on #4 sieve.

D. Type 4 Fill:
1. Pit run rock or gravel with maximum stone size of 1”.

E. Type 5 Fill:
1. Pea gravel, screened, which will pass 3/8” sieve and retained on #4 sieve.

2.2 CRUSHED ROCK

A. Crushed Rock: 1-1/4” minus, unless smaller is required for bedding material.

2.3 SAND

A. Sand: Clean and washed building sand.

2.4 TOPSOIL

A. Topsoil: Equal in quality to that removed.

2.5 SOD

A. New Sod: Mature, densely rooted grass free of weeds and objectionable grasses.

2.6 PLANTS

A. Plants: Obtained from a commercial nursery and be similar to those replaced.

PART 3 - EXECUTION

3.1 PREPARATION

A. Establish grade lines and locations of roadways and sidewalks, grade beams, and pill caps. Provide necessary stakes and batter boards.

B. Verify elevations of existing utilities prior to excavation for new ducts.

C. Verify locations of vaults and manholes with civil drawings.

D. Coordinate excavation and backfill with Section 31 2000 – Earth Moving.
3.2 EXCAVATION

A. Provide excavation for underground work, including ducts, vaults, manholes, unless otherwise shown or specified.

B. Excavate trench to 24” wider than duct or duct bank dimensions and minimum of 3” below bottom of duct.

C. Include clearing, tree removal, grubbing, pavement removal, substructure removal such as walls, footings, and piers, and all incidental work such as tunneling, sheet piling, shoring, underpinning, pumping, bailing, and transportation. Coordinate excavation extending beyond construction limits with Construction Manager and Owner.

D. Do not provide blasting on this project without written permission of Architect and Owner.

E. Dispose of excess excavation material on site in location designated by Construction Manager.

F. Over excavate 3” and fill with 3” of sand, where trench bottom is rock, or rocky, or contains debris larger than 1”, or material with sharp edges.

G. Perform all crossings of concrete or asphalt after surface material has been saw cut to required width and removed.

H. Conform to utility company requirements for excavation and vault installation in addition to contract document requirements where excavations are for installing utility company’s ducts and vaults.

3.3 ROCK EXCAVATION

A. Use mechanical methods to remove rock in trenches for underground ducts.

B. Refer to Geotechnical Report available from Architect/Engineer for data on rock.

C. Include rock excavation in the Bid, unless otherwise indicated.

3.4 INSTALLATION

A. Keep underground ducts to proper line and grade and sealed to prevent entrance of animals or foreign matter.

B. Provide bracing and sheet piling as necessary to support trenches. Comply with Local Regulations, applicable provisions of OSHA Regulations on trenching, or with provisions of “Manual of Accident Prevention in Construction” published by Associated General Contractors of America.

C. Do not lay duct in water.

D. Keep trench free from water until duct joint material has hardened and concrete encasement is in place.
E. Do not increase the contract cost due to presence of ground water in soil or necessity of sheet piling or bracing trenches. Adjust contract cost when sheet piling is left in place, on written order of Owner.

F. Do not remove sheet piling until trench is substantially backfilled. Cut off sheet piling left in place not less than 2 ft below new, finished grade.

G. Place underground ducts on 3" compacted bedding of sand. Shape bedding for clearance for joints and fittings, tamped in place and graded evenly to ensure uniform bearing for the full length of duct. Do not support duct by blocking, planking or mounding of bedding material.

H. Install lines passing under foundations with minimum of 3" clearance to concrete and ensure there is no disturbance of bearing soil.

3.5 BACKFILL

A. Backfill around ducts by hand to depth of 12" above top of duct with specified fill in 6" layers. Compact backfill thoroughly with compactor of suitable weight or with approved mechanical tamper. Do not use flooding or jetting with water.

B. Place backfill from 12" above duct to elevation of subgrade in layers not exceeding 8" in depth with specified fill.

C. Backfill from 12" above duct to sub-grade with specified fill, when excavating through areas which are to become walks, roads, driveways or parking areas of concrete, bituminous or exposed gravel surfacing or such areas are existing to remain. Backfill in 12" layers and compact with mechanical means to density 95% modified proctor.

D. Conform excavation, duct laying, backfilling, grading and surfacing, as herein specified, when excavation occurs on public property or areas beyond the property line. Comply with additional requirements for public utility or other authorities. Check with each utility and incorporate cost of any additional requirements in base bid.

E. Backfill around vaults to be free of debris larger than 1-3/4" in all directions to 1 ft from vault.

F. Provide 6" of pea gravel or sand bedding for vaults.

G. Other backfill shall be free of debris larger than 6" in diameter.

H. Place backfill material so as to obtain a minimum degree of compaction of 95% of maximum density at optimum moisture content. Moisten backfill material as required to obtain proper compaction.

I. Broken pavement, concrete, sod, roots, and debris shall not be used for backfill.

3.6 DEWATERING

A. Provide, operate, and maintain all pumps or other dewatering equipment required for control of water in trenches and excavations for electrical and communications site work during the entire construction period.
3.7 SHORING

A. Provide as required by trenching and excavating to secure site work. Comply with applicable safety regulations.

3.8 FINISHING

A. On completion of trenching and backfilling operations, restore grades to original elevation or to new sub-grade elevation.

B. Replace surfaces to existing conditions when trenching is through existing areas or beyond construction limits.

C. Use 6” of topsoil and sod to match existing elevations in landscaped areas or as otherwise approved by Landscape Architect.

3.9 SURFACE FINISHING

A. Refinish every disturbed surface to its original condition.

B. Replace planted materials not surviving 90 days after contract acceptance at Contractor’s own expense.

C. Return after 1 year and re-fill, compact and refinish settled areas to grade.

3.10 CARE OF PLANTS AND TREES

A. Remove and safely store plants and trees with trunks smaller than 6” diameter prior to commencing site work. Avoid trees larger than 6” diameter when so indicated on drawings. Replace plants and trees upon completion of site work.

END OF SECTION 26 05 43.13
SECTION 26 05 43.19 – MANHOLES AND HARDWARE

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 0543 – Underground Ducts and Raceways for Electrical Systems

B. Section 26 0543.13 – Excavation and Backfill

1.2 DESCRIPTION

A. Section includes underground utility structures: vaults, manholes and accessories for power cable systems.

1.3 REFERENCED STANDARDS

A. AASHTO HB 17 – Standard Specifications for Highway Bridges

B. ANSI C2 – National Electrical Safety Code

C. ASTM A 48/A 48M – Specification for Gray Iron Castings

D. ASTM C 270 – Specification for Mortar for Unit Masonry

E. ASTM C 387 – Specification for Packaged, Dry, Combined Materials for Mortar and Concrete

F. ASTM C 858 – Specification for Underground Precast Concrete Utility Structures

G. ASTM C 891 – Standard Practice for Installation of Underground Precast Concrete Utility Structures

H. ASTM C 1037 – Practice for Inspection of Underground Precast Concrete Utility Structures


J. ISO 9000 – Quality Management

K. ISO 10012 – Measurement Management Systems

L. NFPA 70 – National Electrical Code

M. SCTE 77 – Specification for Underground Enclosure Integrity
1.4 SUBMITTALS

A. Product Data:
   1. Accessories for underground utility structures.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
   1. Duct entry provisions, including locations and duct sizes
   2. Reinforcement details
   3. Frame and cover design and manhole frame support rings
   4. Ladder details
   5. Grounding details
   6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps
   7. Joint details

C. Product Certificates: For concrete and steel used in precast concrete vaults and manholes, as required by ASTM C 858.

D. Field quality-control test reports.
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

E. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual location of underground utility structures.
   2. Operation and Maintenance Data:
      a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.5 QUALITY ASSURANCE

A. Comply with ANSI C2

B. Comply with NFPA 70
1.6  DELIVERY, STORAGE, AND HANDLING

A. Store precast concrete and other factory-fabricated underground utility structures at project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

B. Life and support precast concrete units only at designated lifting or supporting points.

1.7  WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1  PRECAST CONCRETE VAULTS AND MANHOLES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom. Frame and cover shall form top of enclosure and shall have load rating consistent with that of vault and manhole.

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

1. Carder Concrete Products
2. Christy Concrete Products
3. Elmhurst-Chicago Stone Co.
4. Oldcastle Precast Group
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
8. Wausau Tile, Inc.
9. Jensen Precast

C. Comply with ASTM C 858, with structural design loading as specified in Part 3 “Underground Enclosure Application” Article and with interlocking mating sections, complete with accessories, hardware, and features.

1. Duct Entrances in Vault and Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

   a. Type and size: Fittings matched to duct or conduit to be terminated.
   b. Fittings: Aligned with elevations of approaching ducts and located near interior corners of vaults and manholes to facilitate racking of cable.
D. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the groundwater level at grade.

2.2 UTILITY STRUCTURE ACCESSORIES

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

1. Bilco Company (The)
2. Campbell Foundry Company
3. Carder Concrete Products
4. Christy Concrete Products
5. East Jordan Iron Works, Inc.
7. Jensen Precast
8. McKinley Iron Works, Inc.
9. Neenah Foundry Company
10. NewBasis
11. Oldcastle Precast Group
13. Pennsylvania Insert Corporation
14. Riverton Concrete Products; a division of Cretex Companies, Inc.
15. Strongwell Corporation; Lenoir City Division
17. Utility Concrete Products, LLC.
18. Utility Vault Co.
19. Wausau Tile, Inc.

B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surface; diameter as indicated on drawings.
   a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
2. Cover Legend: Cast in. Selected to suit system.
   a. Legend: “ELECTRIC” for duct systems with medium-voltage cables.
3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
   a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 ft³ where packaged mix complying with ASTM C 387, Type M, may be used.

C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2” diameter eye, and 1” x 4” bolt.

D. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts for noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2” ID by 2-3/4” deep, flared to 1-1/4” minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
E. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.
   1. Stanchions: T-section or channel; 2-1/4” nominal size; punched with 14 holes on 1-1/2” centers for cable-arm attachment.
   2. Arms: 1-1/2” wide, lengths ranging from 3” with 450 lb minimum capacity to 18” with 250 lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.

F. Duct-Sealing Compound: Non-hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35°F. Capable of withstanding temperature of 300°F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

G. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder, mounting brackets and braces: Fabricated from hot-dip galvanized steel.

H. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Minimum two required.

2.3 SOURCE QUALITY CONTROL
   A. Test and inspect precast concrete utility structures according to ASTM C 1037.

PART 3 - EXECUTION

3.1 UNDERGROUND ENCLOSURE APPLICATION
   A. Manholes: Precast concrete:
      1. Manholes Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.2 INSTALLATION OF CONCRETE VAULTS AND MANHOLES
   A. Precast Concrete Vault and Manhole Installation
      1. Comply with ASTM C 891, unless otherwise indicated.
      2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
      3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1” sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
      4. Concrete: 5000 psi 28-day strength, complying with Division 03 – Concrete.

   B. Elevations:
      1. Vault and Manhole Roof: Install with rooftop as indicated on drawings.
      2. Manhole Frame: In paved areas and traffic-ways, set frames flush with finished grade. Set other manhole frames 1” above finished grade.
C. Manhole Access: Circular opening in manhole roof; sized to match cover size.
   1. Manhole with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
   2. Install chimney, constructed of precast concrete collars and rings, to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.

D. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

E. Pack and smooth non-shrink grout at all rough edges around duct entrances at each vault and manhole.

3.3 GROUNDING

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes: Install a driven ground rod through manhole floor, close to wall, and set rod depth so 4" will extend above finished floor. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2" above to 6" below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, catch basins, metallic cover frame and cable shields within each manhole, to ground rod or grounding conductor. Make connections with #4 AWG minimum, stranded, copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground utility structures.
   2. Test vault and manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 0526 - Grounding and Bonding for Electrical Systems.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Interpret test results in writing and submit to Engineer.

3.5 CLEANING

A. Clean internal surfaces of vaults and manholes, including sump and remove foreign material, after completing the installation of all devices, equipment, cables and terminations.
B. Remove water from vaults and manholes. If vaults and manholes continue to fill up with water, Contractor shall pump them regularly until the source of water has been detected and corrected.

END OF SECTION 26 0543.19
SECTION 26 05 48.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Restraint channel bracings.
   2. Restraint cables.
   4. Mechanical anchor bolts.
   5. Adhesive anchor bolts.

B. Related Requirements:
   1. Section 26 05 29 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
      b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.
   1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic restraints and for designing vibration isolation bases.
      a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
   3. Seismic-Restraint Details:
a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.

b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Design Category, Occupancy Category: See Structural.
2. Component Importance Factor: 1.5.
3. Design Spectral Response Acceleration at Short Periods (0.2 Second): See Structural.

2.2 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Unistrut; an Atkore International company.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Kinetics Noise Control, Inc.
2. Loos & Co., Inc.
3. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. TOLCO; a brand of NIBCO INC.
B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Hilti, Inc.
4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.6 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Hilti, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 30 00 "Cast-in-Place Concrete." and/or Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer’s recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days’ advance notice.
   4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
   5. Test to 90 percent of rated proof load of device.

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

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 05 48.16
SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1  SUMMARY
   A. This Section includes the following:
      1. Identification for conductors and communication and control cable.
      2. Warning labels and signs.
      3. Equipment identification labels.

1.2  SUBMITTALS
   A. Product Data: For each electrical identification product indicated.

1.3  QUALITY ASSURANCE
   A. Comply with ANSI A13.1.

1.4  COORDINATION

PART 2 - PRODUCTS

2.1  CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS
   A. Marker Tape: Vinyl or vinyl -cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.2  WARNING LABELS AND SIGNS
   B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
   C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.
D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

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

F. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES".

2.3 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

PART 3 - EXECUTION

3.1 APPLICATION

A. Auxiliary Electrical Systems Conductor and Cable Identification: Use marker tape to identify field-installed alarm, control, signal, sound, intercommunications, voice, and data wiring connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and cable pull points. Identify by system and circuit designation.
2. Use system of designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

B. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply metal-backed, butyrate warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
   a. Power transfer switches.
   b. Controls with external control power connections.

2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

C. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
   a. Indoor Equipment: self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch high letters on 1-1/2-inch high label; where 2 lines of text are required, use labels 2 inches high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label, drilled for screw attachment.
   c. Elevated Components: Increase sizes of labels and legend to those appropriate for viewing from the floor.
   d. All labels to include equipment tag (e.g. HWP-1), equipment description (e.g. HOT WATER PUMP 1), voltage and phase (e.g. 208V 3-Ø), and panel and circuit number of source (e.g. 1N1L-23/25/27).
   e. All labels shall be black letters on white background. Use red letters on white background for any equipment fed from an emergency (generator or UPS) power source.
   f. Receptacle and switch labels shall be clear self-adhesive with Black Text. Label shall identify power source (panel name and circuit number).

2. Equipment to Be Labeled:
   a. Panelboards, electrical cabinets, and enclosures.
   b. Electrical switchgear and switchboards.
   c. Transformers.
   d. Motor-control centers.
   e. Disconnect switches.
   f. Enclosed circuit breakers.
   g. Motor starters.
   h. Push-button stations.
   i. Power transfer equipment.
   j. Contactors.
   k. Receptacles
   l. Switches

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors in all cases where the insulation of the wire is not color coded.

1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:
a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.

3. Colors for 480/277-V Circuits:
   b. Phase B: Orange.
   c. Phase C: Yellow.

END OF SECTION 26 05 53
SECTION 26 05 72 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

PART 1 - GENERAL

1.1 SUMMARY

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

B. Study shall be conducted by the overcurrent protective device manufacturer.

1.2 ACTION SUBMITTALS

A. Other Action Submittals: Submit the following prior to the approval of system protective devices submittals. Submittals shall be in digital form.

1. Short-circuit study input data, including completed computer program input data sheets.
2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
   a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
   b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.
   c. Provide recommendations for alternate devices and equipment to meet short-circuit requirements.

1.3 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. Power Analytics, Corporation.
6. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.


G. Short-Circuit Study Output:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
a. Voltage.
b. Calculated fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Calculated asymmetrical fault currents:
      1) Based on fault-point X/R ratio.
      2) Based on calculated symmetrical value multiplied by 1.6.
      3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

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

PART 3 - EXECUTION

3.1 EXAMINATION

A. Obtain all data necessary for the conduct of the study.

   1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
   2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support the short-circuit study:

   1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Obtain electrical power utility impedance at the service.
   3. Power sources and ties.
   4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
   5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
   6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
8. Motor horsepower and NEMA MG 1 code letter designation.
9. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

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

3.3 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.
3.4 REPEATING STUDY
   A. Repeat study up to two additional times after adjustments are made to the equipment.

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

END OF SECTION 26 05 72
SECTION 26 05 73 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1. Study results shall be used to determine coordination of series-rated devices.

B. Study shall be conducted by the overcurrent protective device manufacturer.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

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

b. Provide recommendations for alternate devices and equipment to meet short-circuit requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

   a. The following parts from the Protective Device Coordination Study Report:

      1) One-line diagram.
      2) Protective device coordination study.
      3) Time-current coordination curves.

   b. Power system data.

1.6 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society’s Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

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

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. Power Analytics, Corporation.
6. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:
   a. Arcing faults.
   b. Simultaneous faults.
   c. Explicit negative sequence.
   d. Mutual coupling in zero sequence.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study:
   1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. Equivalent impedance.

   2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Calculated asymmetrical fault currents:
   1) Based on fault-point X/R ratio.
   2) Based on calculated symmetrical value multiplied by 1.6.
   3) Based on calculated symmetrical value multiplied by 2.7.

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

F. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
   a. Phase and Ground Relays:
      1) Device tag.
      2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
      3) Recommendations on improved relaying systems, if applicable.
   b. Circuit Breakers:
      1) Adjustable pickups and time delays (long time, short time, ground).
      2) Adjustable time-current characteristic.
      3) Adjustable instantaneous pickup.
      4) Recommendations on improved trip systems, if applicable.
   c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
a. Power utility's overcurrent protective device.
b. Medium-voltage equipment overcurrent relays.
c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
f. Cables and conductors damage curves.
g. Ground-fault protective devices.
h. Motor-starting characteristics and motor damage points.
i. Generator short-circuit decrement curve and generator damage point.
j. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.

6. Provide adequate time margins between device characteristics such that selective operation is achieved.

7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the primary side of the service transformer, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.

2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to, the following:
      a. Inrush current when first energized.
      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:
   1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
   2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

K. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
   1. Electric utility's supply termination point.
   2. Switchgear.
   3. Unit substation primary and secondary terminals.
   4. Low-voltage switchgear.
   5. Motor-control centers.

M. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.

3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 241 and IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
17. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.

d. Generator thermal-damage curve.

e. Ratings, types, and settings of utility company’s overcurrent protective devices.

f. Special overcurrent protective device settings or types stipulated by utility company.

g. Time-current-characteristic curves of devices indicated to be coordinated.

h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.

i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.

j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.

k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.4 REPEATING STUDY

A. Repeat study up to two additional times after adjustments are made to the equipment.

3.5 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

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

END OF SECTION 26 05 73
SECTION 26 05 74 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 SUMMARY

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

B. Study shall be conducted by the overcurrent protective device manufacturer.

1.2 ACTION SUBMITTALS

A. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

   1. Arc-flash study input data, including completed computer program input data sheets.
   2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

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

1.3 CLOSEOUT SUBMITTALS

A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

B. Operation and Maintenance Procedures: In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

   1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located.
D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. Power Analytics, Corporation.
6. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in “Power System Data” Article.

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

F. Incident Energy and Flash Protection Boundary Calculations:
   1. Arcing fault magnitude.
   2. Protective device clearing time.
   3. Duration of arc.
   5. Working distance.
   6. Incident energy.

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

2.3 ARC-FLASH WARNING LABELS
   A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems." Produce a 3.5-by5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.
   B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
      1. Location designation.
      2. Nominal voltage.
      3. Flash protection boundary.
      5. Incident energy.
      7. Engineering report number, revision number, and issue date.
   C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

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

A. Perform study following the general study procedures contained in IEEE 399.
B. Calculate short-circuit currents according to IEEE 551.
C. Base study on the device characteristics supplied by device manufacturer.
D. The extent of the electrical power system to be studied is indicated on Drawings.
E. Begin analysis at the primary side of the service transformer, extending down to the system overcurrent protective devices as follows:
   1. To normal system low-voltage load buses where fault current is 10 kA or less.
   2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.
G. The calculations shall include the ac fault-current decay from induction motors and shall apply to low-voltage, three-phase ac systems.
H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
   1. Electric utility’s supply termination point.
   2. Switchgear.
   3. Low-voltage switchgear.
   4. Motor-control centers.
   5. Standby generators and automatic transfer switches.

3.3 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.
B. Use the short-circuit study output and the field-verified settings of the overcurrent devices.
C. Calculate maximum and minimum contributions of fault-current size.
   1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
   2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
E. Include low-voltage equipment locations, except 240-V ac and 208-V ac systems fed from transformers less than 125 kVA.
F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.4 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support coordination study.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
5. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
6. Motor horsepower and NEMA MG 1 code letter designation.
7. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.5 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Motor-control center.
2. Low-voltage switchboard.
3. Switchgear.
4. Medium-voltage switch.
3.6 APPLICATION OF WARNING LABELS

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

3.7 DEMONSTRATION

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

END OF SECTION 26 05 74
SECTION 26 08 00 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.
   B. The OPR and BOD documentation are included by reference for information only.

1.2 SUMMARY
   A. This section includes commissioning process requirements for Electrical systems, assemblies, and equipment.
   B. Related Sections:
      1. Division 01 Section 01 91 13 "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION
   A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for the description of commissioning.

1.4 DEFINITIONS
   A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for definitions.

1.5 SUBMITTALS
   A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for CxA’s role.
   B. Refer to Division 01 Section “Submittals” for specific requirements. In addition, provide the following:
   C. In addition, provide the following:
      1. Certificates of readiness
      2. Certificates of completion of installation, prestart, and startup activities.
      3. O&M manuals
      4. Test reports

1.6 QUALITY ASSURANCE
   A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer’s calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been
repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

A. Refer to Division 01 Section 01 91 13 "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the electrical contractor of Division 26 shall ultimately be responsible for all standard testing equipment for the electrical systems and controls systems in Division 26. A sufficient quantity of two-way radios shall be provided by each contractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems

B. Red-lined Drawings:
   1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.

3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.

4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. Operation and Maintenance Data:
   1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
   2. The CxA will review the O&M literature once for conformance to project requirements.
   3. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.

D. Demonstration and Training:
   1. Contractor will provide demonstration and training as required by the specifications.
   2. A complete training plan and schedule must be submitted by the Contractor to the CxA four weeks (4) prior to any training.
   3. A training agenda for each training session must be submitted to the CxA one (1) week prior to the training session.
   4. The CA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CA and Owner's representative. A copy of the test record shall be provided to the CA, Owner, and Architect.
   5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
   6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
   7. Review data in O&M Manuals.

E. Systems manual requirements:
   1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.
   2. The GC shall include final approved versions of the following information for the Systems Manual:
      a. As-Built System Schematics
      b. Verified Record Drawings
      c. Test Results (not otherwise included in Cx Record)
      d. Periodic Maintenance Information for computer maintenance management system
      e. Recommendations for recalibration frequency of sensors and actuators
      f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
      g. Training Records, Information on training provided, attendees list, and any on-going training
   3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
   4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.
3.2 CONTRACTOR’S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meetings.

C. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

D. Provide information requested by the CxA for final commissioning documentation.

E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

F. Prepare preliminary schedule for Electrical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to commissioning team members.

G. Update schedule as required throughout the construction period.

H. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.

I. Assist the CxA in all verification and functional performance tests.

J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.

L. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

M. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

N. Participate in, and schedule vendors and contractors to participate in the training sessions.

O. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
   1. Electrical equipment including switchgear, panel boards, motor control centers, lighting, receptacles, dimmers and all other equipment furnished under this Division.
   2. Emergency generators, ATS switches and emergency power systems.
   3. Lightning protection
   4. UPS systems

P. The equipment supplier shall document the performance of his equipment.

Q. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
R. Provide training of the Owner’s operating staff using expert qualified personnel, as specified.

S. Equipment Suppliers
1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with contractors.
3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

T. Refer to Division 01 Section “General Commissioning Requirements” for additional Contractor responsibilities.

3.3 OWNER’S RESPONSIBILITIES
A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for Owner’s Responsibilities.

3.4 DESIGN PROFESSIONAL’S RESPONSIBILITIES
A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for Design Professional’s Responsibilities.

3.5 CxA’S RESPONSIBILITIES
A. Refer to Division 01 Section 01 91 13 “General Commissioning Requirements” for CxA’s Responsibilities.

3.6 TESTING PREPARATION
A. Certify in writing to the CxA that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.
3.7 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of Electrical testing shall include the entire Electrical installation, from the incoming power equipment throughout the distribution system. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the Electrical contractor and other contracted subcontractors, including the fire alarm Subcontractor shall prepare detailed testing plans, procedures, and checklists for Electrical systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.8 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 26 sections. Provide submittals, test data, inspector record, infrared camera and certifications to the CA.

B. Emergency Generator Testing and Acceptance Procedures: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

C. Fire Detection and Alarm System Testing: Provide technicians, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

D. Electrical Distribution System Testing: Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the
direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Coordination and functionality with the Building Automation System/Building Management Controls System
2. Automatic Transfer Switch
3. Emergency Generator
4. Emergency Power System
5. Lighting Controls
6. Lightning Protection System
7. Power Monitoring/Metering System

3.9 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.10 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.11 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.12 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.13 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

B. Electrical Contractor. The electrical contractor shall have the following training responsibilities:
1. Provide the CA with a training plan two weeks before the planned training.

2. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.

3. Training shall start with classroom sessions, if necessary, followed by hands on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer’s representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

7. Training shall include:
   a. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shutdown, seasonal changeover and any emergency procedures.
   c. Discuss relevant health and safety issues and concerns.
   d. Discuss warranties and guarantees.
   e. Cover common troubleshooting problems and solutions.
   f. Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discuss any peculiarities of equipment installation or operation.

8. Hands-on training shall include start-up, operation in all modes possible, including manual, shutdown and any emergency procedures and preventative maintenance of all pieces of equipment.

9. The electrical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

10. Training shall occur after functional testing is complete, unless approved otherwise by the Owner’s.

END OF SECTION 26 08 00
PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 0513.16 – Medium-Voltage, Single- and Multi-Conductor Cables

B. Section 26 0813 – Power Distribution Acceptance Test Tables

C. Section 26 1219 – Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers

D. Section 26 1323 - Medium-Voltage Pad-Mounted Switchgear

1.2 DESCRIPTION

A. Section includes acceptance testing requirements for assessing the suitability for service and reliability of the power distribution system.

B. Contractor to ensure all tested electrical equipment, both contractor and Owner supplied, is operational and within industry and manufacturer’s tolerances and is installed in accordance with design specifications.

C. Tests and inspections shall be performed after installation.

D. Tests and inspections shall determine suitability for energization.

E. Electrical systems shall pass tests prior to substantial completion or Owner occupancy.

F. This specification requires contractor to engage services of testing agency.

G. All tests tables referenced in this specification provided in Section 26 0813 – Power Distribution Acceptance Test Tables.

H. Items to be tested and inspected as follows:

1. 15kV primary cable and terminations
2. Liquid filled transformers – (1) 2000 kVA, 12.47kV – 480Y/277 V pad mounted transformer
3. Medium-voltage oil switches
4. Thermographic survey

1.3 REFERENCE STANDARDS


B. ANSI/IEEE C57 – Distribution, Power, and Regulating Transformers
C. ANSI/IEEE C57.104 – Guide for the Interpretation of Gases Generated in Oil-immersed Transformers
D. ANSI/IEEE Std. 48 – Standard Test Procedure and Requirements for High-Voltage Alternating-Current Cable Terminations
E. ANSI/IEEE Std. 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
F. ANSI/IEEE Std. 141 – IEEE Recommended Practice for Electrical/Power Distribution for Industrial Plants (IEEE Red Book)
I. ANSI/IEEE Std. 242 – IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)
K. ANSI/IEEE Std. 400 – Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field
N. ANSI/IEEE Std. 1100 – IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book)
P. ASTM D3612 – Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography
Q. ASTM D3613 – Standard Practice for Sampling Insulating Liquids for Gas Analysis and Determination of Water Content
R. NETA – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems
S. NEMA MG1 – Motors and Generators
T. NFPA 70 – National Electrical Code
U. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
V. NFPA 70E – Electrical Safety Requirements for Employee Workplaces
W. NIST – National Institute of Standards and Technology


1.4 SUBMITTALS

A. Test Reports: Include the following:
   1. Summary of project
   2. Description of equipment tested
   3. Equipment used to conduct the test
   4. Description of test
   5. Test results, as compared to manufacturers’ or industry accepted standards and tolerances
   6. Conclusions and recommendations
   7. Signature of responsible test organization authority

B. List of equipment used to perform tests. Identify the following:
   1. Type
   2. Manufacturer
   3. Model number
   4. Serial number
   5. Date of last calibration
   6. Documentation of calibration leading to NIST standards

1.5 QUALITY ASSURANCE

A. Qualifications of Testing Agency:
   1. Testing firm shall be a corporately and financially independent testing organization that can function as an unbiased testing authority, professionally independent of the manufacturer, supplier, and installers of equipment or system evaluated by the testing firm.
   2. Testing firm shall be regularly engaged in testing of electrical equipment, devices, installations and systems.
   3. Testing firm shall meet Federal Occupational Safety and Health Administration (OSHA) requirements for accreditation of independent testing laboratories.
   4. On-site technical person shall be currently certified by the International Electrical Testing Association in electrical power distribution system testing.
   5. Testing firm shall use technicians who are regularly employed by the firm for testing services.
   6. Testing firm shall submit proof of above qualifications with bid documents when requested.
PART 2 - PRODUCTS

2.1 NOT APPLICABLE TO THIS SECTION.

PART 3 - EXECUTION

3.1 PREPARATION

A. Documentation: Deliver the following to testing firm, minimum two weeks prior to commencement of testing:
   1. Complete set of electrical plans and specifications, with available short circuit indicated on power riser diagrams.
   2. Approved submittals and shop drawings of equipment being tested.
   3. Pertinent change orders.

B. Schedule: Notify Owner and Engineer 15 working days prior to performance of any tests.

C. Coordination: Coordinate with Construction Manager/Owner/Engineer the testing schedule and availability of equipment ready for testing.

D. Test Power: Provide test power (including specialized) for equipment testing before and after service energizing.

3.2 FIELD QUALITY CONTROL

A. Inspection and Test Procedures: Comply with NETA.

1. Medium-Voltage Cables:
   a. Visual and Mechanical Inspection:
      1) Compare cable date with drawings and specifications.
      2) Inspect exposed sections of cables for physical damage.
      3) Verify tightness of accessible bolted connections by calibrated torque wrench in accordance with manufacturer's published data or Table 12.
      4) Perform thermographic survey of all terminations and splices in accordance with paragraph “Thermographic Survey.”
      5) Inspect compression-applied connectors for correct cable match and indentation.
      6) Inspection for c grounding, cable support, and termination.
      7) Verify visible cable bends meet or exceed ICEA and manufacturer's minimum allowable bending radius.
      8) Inspect for adequate arc proofing in common cable areas, if specified.
      9) Inspect jacket and insulation condition.
     10) Inspect for correct identification and arrangements.

   b. Electrical Tests:
1) Perform concentric neutral-continuity test on each power cable by ohmmeter method and record value.

2) Perform insulation-resistance test using megohm meter with voltage output of at least 2500 V. Individually test each conductor with other conductors and concentric neutral grounded. Test duration shall be 1 minute.

3) Perform DC high-potential test on cables, including terminations and joints after cable system installation and before placing cable in service. Adhere to precautions and limits as specified in applicable NEMA/ICEA Standards for the specific cable. Perform tests in accordance with ANSI/IEEE Standard 400. Test voltages shall not exceed 80% of cable manufacturer’s factory test value or maximum test voltage in Table 6.
   a) Insure input voltage to test set is regulated.
   b) Current-sensing circuits in test equipment shall measure only leakage current associated with cable under test and shall not include internal leakage of test equipment.
   c) Record wet- and dry-bulb temperatures or relative humidity and temperature.
   d) Test each section of cable individually.
   e) Individually test each conductor with other conductors grounded. Ground concentric neutrals.
   f) Terminations shall be adequately corona-suppressed by guard ring, field reduction sphere, or other suitable method as necessary.
   g) Insure maximum test voltage does not exceed limits for terminators specified in ANSI/IEEE Standard 48 or manufacturer’s specifications.
   h) Apply DC high-potential test in at least 5 equal increments until maximum test voltage is reached. No increment shall exceed voltage rating of the cable. Record DC leakage current at each step after constant stabilization time consistent with system charging current.
   i) Raise conductor to specified maximum test voltage and hold for 15 minutes. Record readings of leakage current at 30 seconds and one minute and at one-minute intervals thereafter.
   j) Reduce conductor test potential to zero and measure residual voltage at discrete intervals.
   k) Apply grounds for time period adequate to drain insulation stored charge.

4) Perform high voltage phase test after successful completion of continuity and high potential tests. Testing agent shall conduct a high voltage phase test at normal line voltage to verify that segments of the system can be paralleled together.

c. Test Values:

   1) Concentric neutral must exhibit continuity. Investigate resistance values in excess of 10 ohms per 1000 ft of cable.
   2) Graphic plots may be made of leakage current versus step voltage at each increment and leakage current versus time at final test voltages.
      a) Step voltage slope should be reasonably linear.
      b) Capacitive and absorption current should decrease continually until steady state leakage is approached.

2. Liquid Filled Transformers:

   a. Visual and Mechanical Inspection:
1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition for physical damage, cracked insulators, and tightness of connection.
3) Verify removal of shipping bracing after final placement.
4) Inspect impact recorder prior to unloading, if applicable.
5) Verify alarm, control, and trip settings on temperature and level indicators are as specified.
6) Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay.
7) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data or Table 12.
8) Perform thermographic survey in accordance with paragraph “Thermographic Survey.”
9) Verify correct liquid level in tanks and bushings.
10) Perform specific inspections and mechanical tests as recommended by manufacturer.
11) Verify correct equipment grounding.

b. Electrical Tests:

1) Perform insulation-resistance tests, winding-to-winding and each winding-to-grounding with test voltage in accordance with Table 5. Test duration shall be for 10 minutes with resistance tabulated at 30 seconds, 1 minute, and 10 minutes.
2) Calculate polarization index.
3) Perform a turns-ratio test on no-load tap-changer positions and load tap-changer positions. Verify tap setting is as specified. Verify winding polarities are in accordance with nameplate.
4) Perform insulation power-factor/dissipation-factor tests on windings and correct to 68°F in accordance with test equipment manufacturer’s instructions.
5) Perform power-factor/dissipation-factor tests (or hot collar watts-loss tests) on bushings and correct to 68°F in accordance with test equipment manufacturer’s instructions.
6) Remove sample of insulating liquid in accordance with ASTM D923. Sample shall be tested for the following:
   a) Dielectric breakdown voltage: ASTM D877 and/or ASTM D1816.
   b) Acid neutralization number: ASTM D974.
   c) Specific gravity: ASTM D1298.
   d) Interfacial tension: ASTM D971 or ASTM D2285.
   e) Color: ASTM D1500.
   g) Measure dissipation factor or power factor in accordance with ASTM D924.
7) Remove sample of insulating liquid in accordance with ASTM D3613 and perform dissolved gas analysis (DGA) in accordance with ANSI/IEEE C57.104 or ATSM D3612.

c. Test Values:

1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
2) Insulation-resistance test values at one minute should not be less than values recommended in Table 5. Resistance values to be temperature corrected in accordance with Table 14.
3) Polarization index should be compared to manufacturer’s factory test results. If manufacturer’s data is not available, acceptance test results will serve as baseline data.

4) Turns-ratio test results shall not deviate more than 0.5% from either the adjacent coils or the calculated ratio.

5) Maximum power factor of liquid-filled transformers corrected to 68°F shall be in accordance with transformer manufacturer’s published data. Representative values are shown in Table 3. Compare with test equipment manufacturer’s published data.

6) Investigate bushing power factors and capacitances that vary from nameplate values by more than 10%. Investigate any bushing hot collar watts-loss results that exceed test equipment manufacturer’s published data.

7) Typical excitation-current test data pattern for three-legged core transformer is two similar current readings and one lower current reading.

8) Consult manufacturer if winding-resistance measurements vary more than 1% from adjacent windings.

9) Consult manufacturer if core insulation is less than one megohm at 500 VDC.

10) Insulating liquid shall comply with Table 4.

11) Evaluate results of dissolved-gas analysis in accordance with IEEE Standard C57.104. Use results as baseline for future tests.

3. Medium-Voltage Oil Switches:
   a. Visual and Mechanical Inspection:
      1) Compare equipment nameplate data with drawings and specifications.
      2) Inspect physical and mechanical condition.
      3) Inspect anchorage, alignment, grounding and required clearances.
      4) Perform mechanical operation and contact alignment tests on both the switch and its operating mechanism.
      5) Check each fuse holder for adequate support and contact.
      6) Verify fuse sizes and types correspond to drawings.
      7) Test electrical and mechanical interlock systems for correct operation and sequencing.
      8) Verify tightness of accessible bolted electrical connections and/or cable connections by calibrated torque-wrench method in accordance with manufacturer’s published data or Table 12.
      9) Perform thermographic survey of accessible bolted electrical connections in accordance with paragraph “Thermographic Survey.”
     10) Verify insulating oil level is correct.
     11) Confirm correct application of manufacturer’s recommended lubricants.
     12) Record as-found and as-left operation-counter readings.
   b. Electrical Tests:
      1) Measure contact resistance.
      2) Remove a sample of insulating liquid in accordance with ASTM D923. Sample shall be tested for the following:
         a) Dielectric breakdown voltage: ASTM D877.
         b) Color: ASTM D1500.
         c) Visual condition: ASTM D1524.
3) Perform insulation-resistance tests pole-to-pole, pole-to-ground, and across open poles. Test duration shall be one minute. Use a test voltage in accordance with Table 1 or manufacturer’s published data.

4) Perform insulation-resistance test on control wiring at 1000 VDC. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state relays. Follow manufacturer’s recommendation.

5) Perform an over-potential test on each pole with switch closed. Test each pole-to-ground with other poles grounded. Test voltage shall be in accordance with manufacturer’s published data or Table 11.

c. Test Values:
   1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
   2) Contact resistance values shall not exceed high limit of normal range as indicated in manufacturer’s published data. If manufacturer’s data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50% of lowest value.
   3) Insulating liquid shall comply with Table 4.
   4) Control wiring insulation resistance shall comply with manufacturer’s published data. In the absence of manufacturer’s published data, use Table 1. Values of insulation resistance less than this table or manufacturer’s minimum shall be investigated.

4. Thermographic Survey:
   a. Visual and Mechanical Inspection:
      1) Inspect physical, electrical, and mechanical conditions.
      2) Remove all necessary covers prior to thermographic inspection.
      3) Equipment to be inspected shall include all current-carrying devices. Provide report including the following:
         a) Discrepancies.
         b) Temperature difference between area of concern and reference area.
         c) Cause of temperature difference.
         d) Areas inspected. Identify inaccessible and unobservable areas and equipment.
         e) Identify load conditions at time of inspection.
         f) Provide photographs and thermogram of deficient area.
   b. Test Parameters:
      1) Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 2°F at 86°F.
      2) Equipment shall detect emitted radiation and convert detected radiation to visual signal.
      3) Thermographic surveys should be performed during periods of maximum possible loading but not less than 40% of rated load of the electrical equipment being inspected. Refer to NFPA 70B, Section 20.17 (Infrared Inspection).
   c. Test Results:
      1) Temperature differences of 2°F to 5°F indicate possible deficiency and warrant investigation.
      2) Temperature differences of 7°F to 27°F indicate deficiency; repair as time permits.
      3) Temperature differences of 29°F and above indicate major deficiency; repair immediately.
      4) Suggested actions based on temperature rise can be found in Table 18.

B. Test Reports:
1. Testing firm shall do the following:
   a. Prepare test report, including description of equipment tested, description of test, test results, conclusions and recommendations, retesting results, list of test equipment used and calibration date.
   b. Show test results in comparison to industry and manufacturer’s values and tolerances.
   c. Interpret test results in writing and give recommendations for acceptance or rejection upon consultation with Engineer and prior to energizing equipment.
   d. Assure electrical equipment is operational and within industry and manufacturer’s tolerances, and is installed in accordance with contract documents.
   e. Assure suitability of energization.
   f. Report to the Owner and Engineer any system, material, or workmanship that is found defective on the basis of acceptance tests.
   g. Retest equipment when required.
   h. Maintain written record of tests.
   i. Utilize safety practices during the tests in accordance with:
      1) Acceptable state and local safety operating procedures
      2) Owner’s safety practices
      3) OSHA
      4) NFPA 70E
   j. Perform tests with apparatus de-energized and grounded, except where otherwise specifically required ungrounded by test procedures.
   k. Assemble and certify final test report.
   l. Provide 4 copies of complete test report.
   m. Attach label to all tested equipment with indication of date tested and testing firm name.

2. Contractor shall do the following:
   a. Investigate, replace, or repair any fault in material or in any part of the installation revealed by the tests.
   b. Deliver one copy of each test report directly to Engineer within 30 days after completion of testing, unless directed otherwise. Insert a copy of each test report in the equipment operation and maintenance manuals.

C. Test Equipment:
   1. Test Instrument Calibration:
      a. Testing firm shall have calibration program that assures test instruments are maintained with rated accuracy.
      b. Instruments shall be calibrated in accordance with the following frequency schedule:
         1) Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
         2) Laboratory instruments: 12 months
         3) Leased specialty equipment: 12 months where accuracy is guaranteed by lessor
      c. Dated calibration labels shall be visible on test equipment.
      d. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date.
      e. Up-to-date instrument calibration instructions and procedures shall be maintained for test instrument.
      f. Equipment used for field testing shall be more accurate than instrument being tested.
      g. Calibrating standard applied to testing equipment shall be of higher accuracy than instrument tested.
SECTION 26 08 13 – POWER DISTRIBUTION ACCEPTANCE TEST TABLES

TABLE 3
Recommended Dissipation Factor/Power Factor at 20°C
Liquid Filled Transformers, Regulators, and Reactors
Acceptance Test Values

<table>
<thead>
<tr>
<th>Oil, Silicone, and Less-Flammable Hydrocarbon Maximum Value (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Power Transformers and Reactors</td>
</tr>
<tr>
<td>New Distribution Transformers and Regulators</td>
</tr>
<tr>
<td>Remanufactured Power Transformers and Reactors</td>
</tr>
<tr>
<td>Remanufactured Distribution Transformers and Regulators</td>
</tr>
</tbody>
</table>
### Table 4.1
Test Limits for New Insulating Oil Received in New Equipment

<table>
<thead>
<tr>
<th>Test</th>
<th>ASTM Method</th>
<th># 69 kV and Below</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric breakdown, kV minimum</td>
<td>D877</td>
<td>30</td>
</tr>
<tr>
<td>Dielectric breakdown, kV minimum @ 1 mm(0.04&quot;) gap</td>
<td>D1816</td>
<td>25</td>
</tr>
<tr>
<td>Dielectric breakdown, kV minimum @ 2 mm(0.08&quot;) gap</td>
<td>D1816</td>
<td>45</td>
</tr>
<tr>
<td>Interfacial tension mN/m minimum</td>
<td>D971 or D2285</td>
<td>38</td>
</tr>
<tr>
<td>Neutralization number, mg KOH/g maximum</td>
<td>D974</td>
<td>0.015</td>
</tr>
<tr>
<td>Water content, (ppm) maximum</td>
<td>D1533</td>
<td>20</td>
</tr>
<tr>
<td>Power factor at 25°C, %</td>
<td>D924</td>
<td>0.05</td>
</tr>
<tr>
<td>Power factor at 100°C, %</td>
<td>D924</td>
<td>0.40</td>
</tr>
<tr>
<td>Color</td>
<td>D1500</td>
<td>1.0</td>
</tr>
<tr>
<td>Visual condition</td>
<td>D1524</td>
<td>Bright and clear</td>
</tr>
</tbody>
</table>


### Table 4.2
Test Limits for Silicone Insulating Liquid in New Transformers

<table>
<thead>
<tr>
<th>Test</th>
<th>ASTM Method</th>
<th>Acceptable Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric breakdown, kV minimum</td>
<td>D877</td>
<td>30</td>
</tr>
<tr>
<td>Visual</td>
<td>D2129</td>
<td>clear, free of particles</td>
</tr>
<tr>
<td>Water content, (ppm) maximum</td>
<td>D1533</td>
<td>50</td>
</tr>
<tr>
<td>Dissipation/power factor, 60 Hz, % max. @ 25°C</td>
<td>D924</td>
<td>0.1</td>
</tr>
<tr>
<td>Viscosity, cSt @ 25°C</td>
<td>D445</td>
<td>47.5 – 52.5</td>
</tr>
<tr>
<td>Fire point, °C, minimum</td>
<td>D92</td>
<td>340</td>
</tr>
<tr>
<td>Neutralization number, mg KOH/g max.</td>
<td>D974</td>
<td>0.01</td>
</tr>
</tbody>
</table>

### TABLE 4 (CONT.)
### Insulating Fluid Limits

<table>
<thead>
<tr>
<th>ASTM Method</th>
<th>Test</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>D1816</td>
<td>Dielectric breakdown voltage for 2 mm (0.08&quot;) gap, kV</td>
<td>40 34.5 kV class and below  ---</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60 Desirable</td>
</tr>
<tr>
<td>D1816</td>
<td>Dielectric breakdown voltage for 1 mm (0.04&quot;) gap, kV</td>
<td>20 34.5 kV class and below  ---</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 Desirable</td>
</tr>
<tr>
<td>D974</td>
<td>Neutralization number, mg KOH/g</td>
<td>---- 0.03</td>
</tr>
<tr>
<td>D877</td>
<td>Dielectric breakdown voltage kV</td>
<td>30 ----</td>
</tr>
<tr>
<td>D924</td>
<td>AC loss characteristic (dissipation factor), % 25°C 100°C</td>
<td>---- 0.1  ---- 1</td>
</tr>
<tr>
<td>D1533B</td>
<td>Water content, (ppm)</td>
<td>---- 25</td>
</tr>
<tr>
<td>D1524</td>
<td>Condition-visual</td>
<td>Clear</td>
</tr>
<tr>
<td>D92</td>
<td>Flash point (°C)</td>
<td>275 ----</td>
</tr>
<tr>
<td>D92</td>
<td>Fire point (°C)</td>
<td>300°a ----</td>
</tr>
<tr>
<td>D971</td>
<td>Interfacial tension, mN/m, 25°C</td>
<td>38 ----</td>
</tr>
<tr>
<td>D445</td>
<td>Kinematic viscosity, mm²/s (cSt), 40°C</td>
<td>1.0 X 10²(100) 1.3 X 10²(130)</td>
</tr>
<tr>
<td>D1500</td>
<td>Color</td>
<td>---- L2.5</td>
</tr>
</tbody>
</table>

**ANSI/IEEE C57.121-1998, IEEE Guide for Acceptance and Maintenance of Less-Flammable Hydrocarbon Fluid in Transformers, Table 3.**

The test limits shown in this table apply to less-flammable hydrocarbon fluids as a class. Specific typical values for each brand of fluid should be obtained from each fluid manufacturer.

a. If the purpose of the HMWH installation is to comply with the NFPA 70 *National Electrical Code*, this value is the minimum for compliance with NEC Article 450.23.
TABLE 5
Transformer Insulation-Resistance
Acceptance Test Voltage and Minimum Results

<table>
<thead>
<tr>
<th>Transformer Coil Rating Type in Volts</th>
<th>Minimum DC Test Voltage</th>
<th>Recommended Minimum Insulation Resistance in Megohms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Liquid Filled</td>
</tr>
<tr>
<td>0 - 600</td>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td>601 - 5000</td>
<td>2500</td>
<td>1000</td>
</tr>
<tr>
<td>5001 - 15000</td>
<td>5000</td>
<td>5000</td>
</tr>
</tbody>
</table>

See Table 14 for Temperature Correction Factors.

NOTE: Since insulation resistance depends on insulation rating (kV) and winding capacity (kVA), values obtained should be compared to manufacturer's test data.
### TABLE 6
Medium-Voltage Cables
Acceptance Test Values

<table>
<thead>
<tr>
<th>Rated Voltage Phase-to-Phase kV</th>
<th>Conductor Sizes AWG or kcmil (mm)</th>
<th>Nominal Insulation Thickness mils (mm)</th>
<th>100% Insulation Level</th>
<th>133% Insulation Level</th>
<th>Maximum DC Field Test Voltages, kV During/After Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>100% Insulation Level</td>
<td>133% Insulation Level</td>
<td>100% Insulation Level</td>
</tr>
<tr>
<td>5</td>
<td>8-1000 (8.4-507) Above 1000 (507)</td>
<td>90 (2.29)</td>
<td>115 (2.92)</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>140 (3.56)</td>
<td>140 (3.56)</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>8</td>
<td>6-1000 (13.3-507) Above 1000 (507)</td>
<td>115 (2.92)</td>
<td>140 (3.56)</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>175 (4.45)</td>
<td>175 (4.45)</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>15</td>
<td>2-1000 (33.6-507) Above 1000 (507)</td>
<td>175 (4.45)</td>
<td>220 (5.59)</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>220 (5.59)</td>
<td>220 (5.59)</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>25</td>
<td>1-2000 (42.4-1013)</td>
<td>260 (6.60)</td>
<td>320 (8.13)</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>28</td>
<td>1-2000 (42.4-1013)</td>
<td>280 (7.11)</td>
<td>345 (8.76)</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>35</td>
<td>1/0-2000 (53.5-1013)</td>
<td>345 (8.76)</td>
<td>420 (10.7)</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>


The DC field test voltages listed above are intended for cable designed in accordance with ICEA specifications. When older cables or other types/classes of cables or accessories are connected to the system, voltages lower than those shown may be necessary. Consult the manufacturers of the cables and/or accessories before applying the test voltage.
### Table 6.2
**AC Test Voltages**

<table>
<thead>
<tr>
<th>Rated Voltage Phase-to-Phase kV</th>
<th>Conductor Sizes AWG or kcmil (mm)</th>
<th>Nominal Insulation Thickness mils (mm)</th>
<th>AC Test Voltage, kV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100% Insulation Level</td>
<td>133% Insulation Level</td>
</tr>
<tr>
<td>5 kV</td>
<td>8-1000</td>
<td>90 (2.29)</td>
<td>115 (2.92)</td>
</tr>
<tr>
<td></td>
<td>1001-3000</td>
<td>140 (3.56)</td>
<td>140 (3.56)</td>
</tr>
<tr>
<td>8 kV</td>
<td>6-1000</td>
<td>115 (2.92)</td>
<td>140 (3.56)</td>
</tr>
<tr>
<td></td>
<td>1001-3000</td>
<td>175 (4.45)</td>
<td>175 (4.45)</td>
</tr>
<tr>
<td>15 kV</td>
<td>2-1000</td>
<td>175 (4.45)</td>
<td>220 (5.59)</td>
</tr>
<tr>
<td></td>
<td>1001-3000</td>
<td>220 (5.59)</td>
<td>220 (5.59)</td>
</tr>
<tr>
<td>25 kV</td>
<td>1-3000</td>
<td>260 (6.60)</td>
<td>320 (8.13)</td>
</tr>
<tr>
<td>28 kV</td>
<td>1-3000</td>
<td>280 (7.11)</td>
<td>345 (8.76)</td>
</tr>
<tr>
<td>35 kV</td>
<td>1/0-3000</td>
<td>345 (8.76)</td>
<td>420 (10.7)</td>
</tr>
</tbody>
</table>


All AC voltages are RMS values.
TABLE 6 (CONT.)
Medium-Voltage Cables
Acceptance Test Values

<table>
<thead>
<tr>
<th>Rated Circuit Voltage</th>
<th>Minimum Partial Discharge Extinction Level, kV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100% Insulation Level</td>
</tr>
<tr>
<td>2001-5000</td>
<td>4</td>
</tr>
<tr>
<td>5001-8000</td>
<td>6</td>
</tr>
<tr>
<td>8001-15000</td>
<td>11</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>System Voltage</th>
<th>Phase-to-Phase (kV) (RMS)</th>
<th>Proof Phase-to-Ground (kV) (RMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>33</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>47</td>
</tr>
</tbody>
</table>
### TABLE 12

**U.S. Standard**

**Bolt Torques for Bus Connections**

Heat-Treated Steel – Cadmium or Zinc Plated

<table>
<thead>
<tr>
<th>Grade</th>
<th>SAE 1 &amp; 2</th>
<th>SAE 5</th>
<th>SAE 7</th>
<th>SAE 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Tensile (psi)</td>
<td>64K</td>
<td>105K</td>
<td>133K</td>
<td>150K</td>
</tr>
<tr>
<td>Bolt Diameter in Inches</td>
<td>Torque (Foot Pounds)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/4</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>5/16</td>
<td>7</td>
<td>11</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>3/8</td>
<td>12</td>
<td>20</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>7/16</td>
<td>19</td>
<td>32</td>
<td>44</td>
<td>48</td>
</tr>
<tr>
<td>1/2</td>
<td>30</td>
<td>48</td>
<td>68</td>
<td>74</td>
</tr>
<tr>
<td>9/16</td>
<td>42</td>
<td>70</td>
<td>96</td>
<td>105</td>
</tr>
<tr>
<td>5/8</td>
<td>59</td>
<td>96</td>
<td>135</td>
<td>145</td>
</tr>
<tr>
<td>3/4</td>
<td>96</td>
<td>160</td>
<td>225</td>
<td>235</td>
</tr>
<tr>
<td>7/8</td>
<td>150</td>
<td>240</td>
<td>350</td>
<td>380</td>
</tr>
<tr>
<td>1.0</td>
<td>225</td>
<td>370</td>
<td>530</td>
<td>570</td>
</tr>
</tbody>
</table>

**Bolt Torques for Bus Connections**

**Silicon Bronze Fasteners**

<table>
<thead>
<tr>
<th>Torque (Foot Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt Diameter in (Inches)</td>
</tr>
<tr>
<td>5/16</td>
</tr>
<tr>
<td>3/8</td>
</tr>
<tr>
<td>1/2</td>
</tr>
<tr>
<td>5/8</td>
</tr>
<tr>
<td>3/4</td>
</tr>
</tbody>
</table>

1 Bronze alloy bolts shall have a minimum tensile strength of 70,000 psi
Bolt Torques for Bus Connections
Aluminum Alloy Fasteners\(^2\)
Torque (Foot Pounds)

<table>
<thead>
<tr>
<th>Bolt Diameter in Inches</th>
<th>Lubricated</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16</td>
<td>8.0</td>
</tr>
<tr>
<td>3/8</td>
<td>11.2</td>
</tr>
<tr>
<td>1/2</td>
<td>20.0</td>
</tr>
<tr>
<td>5/8</td>
<td>32.0</td>
</tr>
<tr>
<td>3/4</td>
<td>48.0</td>
</tr>
</tbody>
</table>

\(^2\) Aluminum alloy bolts shall have a minimum tensile strength of 55,000 psi.

Bolt Torques for Bus Connections
Stainless Steel Fasteners\(^3\)
Torque (Foot Pounds)

<table>
<thead>
<tr>
<th>Bolt Diameter in Inches</th>
<th>Uncoated</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16</td>
<td>14</td>
</tr>
<tr>
<td>3/8</td>
<td>25</td>
</tr>
<tr>
<td>1/2</td>
<td>45</td>
</tr>
<tr>
<td>5/8</td>
<td>60</td>
</tr>
<tr>
<td>3/4</td>
<td>90</td>
</tr>
</tbody>
</table>

\(^3\) Bolts, cap screws, nuts, flat washers, locknuts: 18-8 alloy.
Belleville washers: 302 alloy.
### TABLE 14
Insulation Resistance Conversion Factors For Conversion of Test Temperature to 20°C

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Conversion °F</th>
<th>Apparatus Containing Immersed Oil Insulations</th>
<th>Apparatus Containing Solid Insulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>32</td>
<td>0.25</td>
<td>0.40</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
<td>0.36</td>
<td>0.45</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>15</td>
<td>59</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>20</td>
<td>68</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>25</td>
<td>77</td>
<td>1.40</td>
<td>1.25</td>
</tr>
<tr>
<td>30</td>
<td>86</td>
<td>1.98</td>
<td>1.58</td>
</tr>
<tr>
<td>35</td>
<td>95</td>
<td>2.80</td>
<td>2.00</td>
</tr>
<tr>
<td>40</td>
<td>104</td>
<td>3.95</td>
<td>2.50</td>
</tr>
<tr>
<td>45</td>
<td>113</td>
<td>5.60</td>
<td>3.15</td>
</tr>
<tr>
<td>50</td>
<td>122</td>
<td>7.85</td>
<td>3.98</td>
</tr>
<tr>
<td>55</td>
<td>131</td>
<td>11.20</td>
<td>5.00</td>
</tr>
<tr>
<td>60</td>
<td>140</td>
<td>15.85</td>
<td>6.30</td>
</tr>
<tr>
<td>65</td>
<td>149</td>
<td>22.40</td>
<td>7.90</td>
</tr>
<tr>
<td>70</td>
<td>158</td>
<td>31.75</td>
<td>10.00</td>
</tr>
<tr>
<td>75</td>
<td>167</td>
<td>44.70</td>
<td>12.60</td>
</tr>
<tr>
<td>80</td>
<td>176</td>
<td>63.50</td>
<td>15.80</td>
</tr>
</tbody>
</table>
### TABLE 18

**Thermographic Survey**

**Suggested Actions Based on Temperature Rise**

<table>
<thead>
<tr>
<th>Temperature difference (TD) based on comparisons between similar components under similar loading</th>
<th>Temperature difference (TD) based upon comparisons between component and ambient air temperatures</th>
<th>Recommended action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1°C to 3°C</td>
<td>1°C to 10°C</td>
<td>Possible deficiency; warrants investigation</td>
</tr>
<tr>
<td>4°C to 15°C</td>
<td>11°C to 20°C</td>
<td>Indicates probably deficiency; repair as time permits</td>
</tr>
<tr>
<td>-- -- --</td>
<td>21°C to 40°C</td>
<td>Monitor until corrective measures can be accomplished</td>
</tr>
<tr>
<td>&gt;15°C</td>
<td>&gt;40°C</td>
<td>Major discrepancy; repair immediately</td>
</tr>
</tbody>
</table>

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables) there are various temperature ratings. Heating is generally related to the square of the current; therefore, the load current will have a major impact on $\Delta T$. In the absence of consensus standards for TD, the values in this table will provide reasonable guidelines.


It is a necessary and valid requirement that the person performing the electrical inspection be thoroughly trained and experienced concerning the apparatus and systems being evaluated as well as knowledgeable of thermographic methodology.

END OF SECTION 26 08 13
SECTION 26 09 23 - LIGHTING CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching and dimming controls.
4. Indoor occupancy and vacancy sensors.
5. Switchbox-mounted occupancy and vacancy sensors.
7. Lighting contactors.

B. Related Requirements:

1. Section 26 27 26 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.
2. See Construction Drawings and Details for Systems and Model numbers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:
   a. Occupancy sensors.
   b. Vacancy sensors.
   c. Daylight sensors
   d. Power Packs
   e. Relay Packs
   f. Control Panels
   g. Dimmers
   h. Scene Controllers
   i. Audio/Video System inputs

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale and coordinated with each other, using input from installers of the items involved.
B. Field quality-control reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROLS

A. As Shown on Contract Documents.

2.2 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

2.3 PROGRAMMING DEVICES

A. Any Device required to program stand alone sensors or devices shall be given to MSU during training.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.
B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

C. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies. Install devices as per manufacturers written directions that will be included with every device.

D. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

E. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections[ with the assistance of a factory-authorized service representative]:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.
3.5 ADJUSTING

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

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.

3.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for five years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within five years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

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

1. There shall be (2) 4-hour training sessions per manufacturer.

END OF SECTION 26 09 23
SECTION 26 12 19 – PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED WORK
   A. Section 26 0812 - Power Distribution Acceptance Tests
   B. Section 26 0813 - Power Distribution Acceptance Test Tables

1.2 DESCRIPTION OF SYSTEM
   A. Specification covers 3-phase, liquid-filled, compartmental type, loop feed, pad-mounted transformers, including tap changers, fuses, and terminations.

1.3 REFERENCE STANDARDS
   A. ANSI C57.12.26 Standard for Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, 3-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors, H-V, 34,500 Grd/19,920 V and below; 2500 kVA and Smaller.
   B. ANSI C57.12.28 Pad-Mounted Equipment - Enclosure Integrity.
   C. IEEE C57.12.00 Standard General; Requirements for Liquid - Immersed Distribution, Power, and Regulating Transformers.
   D. UL 340 Tests for Comparative Flammability of Liquids.

1.4 SUBMITTALS
   A. Submit shop drawings for equipment provided under this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Acceptable Manufacturers: ABB, Cooper, General Electric, RTE, Square D
   B. Rating of transformer(s) shall be as shown on drawings:
      1. kVA as shown on plans
      2. Primary Voltage 12470Y/7200 Wye
      3. BIL 95 kV
      4. Secondary Voltage 480Y/277 Wye
      5. Impedance 5.75
6. Temperature Rise 65°C (over 30°C average ambient temperature)

2.2 CONSTRUCTION

A. Transformer(s) shall:
   1. Be compartmental type, self-cooled, tamper-resistant and weatherproof.
   2. Include sealed tank construction to withstand pressure of 15 psi.
   3. Include welded cover.

B. Transformer tank and high and low voltage compartments shall be assembled as integral unit.

C. High and low voltage compartments shall be located side by side, separated by a steel barrier.

D. Cooling panels will be provided on back of tank.

E. High voltage compartment shall not be accessible until low voltage door has been opened.

F. Low voltage door shall have 3-point latching mechanism with vault type handle having provisions for single padlock and pentahead locking device.

G. Access doors shall have provisions for securing doors in open position.

H. Provide lifting eyes and jacking pads.

I. Include tank grounding provisions in each compartment.

J. Provide a minimum of (2) welded, ground lug attachment points for concentric neutral termination on lower front of transformer tank. Ground lugs shall accommodate 1/0 stranded copper ground conductor.

2.3 FINISH

A. In accordance with ANSI C57.12.28 – Standard for Pad-mounted Enclosure Integrity.

B. Dark green per ANSI standards.

2.4 INSULATING FLUID

A. Coolant and insulating fluid shall be less flammable, dielectric, with fire point of not less than 300°C Liquid shall be biodegradable and nontoxic, Envirotemp FR3 or Biotemp.

2.5 CORE AND COIL CONSTRUCTION

A. Coils shall be wound with copper windings.

B. Core shall be high grade, grain oriented silicon steel laminations.

C. Core and coil assemblies shall be wound core type, 5-legged construction.
PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

D. Internal leads shall be insulated.

E. Manual Tap Changer:
   1. Provide tap changer, externally operated.
   2. Tap changer handle shall have provisions for padlocking.
   3. Tap changer shall be 4-position with four 2-1/2% full capacity taps, 2 above and 2 below rated voltage.

2.6 HIGH VOLTAGE COMPARTMENT

A. Terminations:
   1. Terminations shall be dead front construction.
   2. Provide universal 200 amp load break type bushing wells and parking stands as indicated on drawings, for loop feed and mounting accessory equipment.
   3. Bushing wells shall be externally clamped and externally removable.
   4. Provide 1 set of load break bushings and 1 load break feed-thru insert for each phase.
   5. Mount lightning arrestors to one side and phase conductor elbows to other side.

B. High Voltage Switch:
   1. Provide integral, oil immersed, 4-position, rotary, gang operated, rated for load break operation, T-Blade design with make before break option.
   2. Switches shall rotate full 360 degrees without a physical stop. Moveable index plate shall be provided that will limit accidental switch rotation.
   3. Switch operating handles shall be permanently attached, hook stick operable, and clearly marked for switch operation and circuit identification.
   4. One-line electrical diagrams of switch arrangements shall be mounted in clear view when transformer access doors are opened. Phase identification shall be clearly marked.
   5. Primary switches shall be rated 200 amp (min.) continuous current.
   6. The switch positions and required sequences are defined below. Position 1 at 12:00 and rotation listed is clockwise.

C. Position Description
   1. Source A and B connected to transformer winding
   2. Source B connected to transformer winding
   3. Source A connected to B, transformer winding disconnected
   4. Source A connected to transformer winding

   Note: Load break bayonet fuse devices shall not be considered as providing a switching function.

D. Primary Fusing:
   1. Provide Bay-O-Net type fuse combined with current limiting backup fuses.
   2. Fuses shall have continuous current ratings sized per manufacturer's recommendations for indicated kVA, impedance, and primary voltage.
   3. Primary fuse assembly shall have minimum rating of 6000 amps.
   4. Bayonet fuse units shall be oil immersed, hot stick operable, and rated for load break operation.
   5. Provide Load sensing fuse elements.
   6. Provide (1) spare fuse element for each bayonet fuse.
   7. Provide oil drip tray for each bayonet fuse.

E. Surge Arrestors:
   1. Provide 3 distribution class metal oxide varistor type surge arrestors, installed in high voltage compartment and grounded to structure. Connect to incoming load break bushings.
2.7 LOW VOLTAGE TERMINATIONS AND EQUIPMENT

A. Bushings shall be molded epoxy.

B. Externally clamped, blade type spade terminals with NEMA spacing.

C. High voltage neutral on Wye-Wye units shall be connected internally to low voltage neutral with provisions for opening this connection for testing.

D. Low voltage neutral bushing shall be fully insulated.
   1. Connect to adjacent ground pad on tank with detachable strap.

E. Accessories:
   1. Each transformer shall be equipped with the following:
      a. Dial type thermometer for indicating top liquid temperature.
      b. Globe valve to serve as drain valve, bottom filler plug connection, and liquid sampling valve.
      c. Globe valve for top filter plug connection and vacuum pump connection.
      d. Pressure vacuum gauge.
      e. Magnetic liquid-level indicator.
      f. Spare fuse pocket with 1 complete set of fuses.
   2. Pressure relief device.
   3. Stainless steel nameplate mounted in low-voltage compartment with the following information:
      a. Serial number and style number.
      b. Graphic representation of high-voltage and low-voltage connections.
      c. kVA ratings at all cooling class ratings and temperature rises.
      d. Transformer impedance at 55°C base kVA rating.
      e. Tap changer positions, voltages and full load currents at each tap setting.
      f. Low voltage rating and full load current.
      g. Gallons of liquid in tank and radiators.
      h. Maximum allowable pressure on tank.
      i. Transformer weight with and without oil.
      j. Listing as non-PCB transformer.

F. Labeling:
   1. Provide 7" x10" warning label on outside high voltage compartment door and danger label on inside low voltage compartment door.

2.8 HARDWARE

A. Provide hardware, including bolts, fasteners, caps, plugs, etc. of corrosion resistant materials or plated with corrosion resistant materials.

2.9 TESTING

A. Report of transformer tests shall be submitted for each transformer:
   1. Standard ANSI tests.
   2. Resistance measurements of windings on rated voltage tap of each transformer and at tap extremes of 1 transformer only of given rating on order.
   3. Ratio tests on rated voltage connections and on tap connections.
4. Phase-relation and polarity tests on rated voltage connections.
5. No load losses and excitation current at rated voltage on rated voltage connections.
6. Impedance and load losses at rated current on rated voltage connections of each transformer and on extremes of 1 unit only of given rating on order.
7. Applied and induced potential tests.
8. Regulation and efficiency at rated load and voltage.
9. Insulation resistance tests (high voltage to ground, low voltage to ground, high voltage to low voltage).

B. Temperature test or tests shall be made on 1 unit only of transformers covered by these specifications of given rating, provided that test data is not available from records of temperature tests on duplicate or essentially duplicate transformer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install components as indicated and in accordance with manufacturer's instructions and recommendations.

B. Install transformer level and plumb.

C. Provide means for lifting complete transformer.

D. Bearing surfaces of lifting means shall be free from sharp edges.

E. Provide facilities for guying transformer.

F. Provide lifting means for untanking transformer.

G. Base shall permit rolling (or sliding) in directions of both center lines of transformer and provision shall be made for pulling transformer in these directions.

H. Locate jacking facilities near extreme ends of junction of base segments.

I. Jack ports or lugs shall be so designed that lifting members of jack can be inserted.

J. If liquid filling of any part of transformer is required at job site, supplier shall furnish liquid and job site supervision, and shall furnish or make available suitable filter press and vacuum pump.

3.2 ACCEPTANCE TESTING

A. Testing by Testing Agency

B. Acceptance testing to be performed in accordance with Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.

END OF SECTION 26 12 19
SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
   1. Distribution transformers.
   2. Buck-boost transformers.

1.2 SUBMITTALS
A. Product Data: For each product indicated.
B. Shop Drawings: Indicate dimensions and weights.
C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
D. Field quality-control test reports.
E. Operation and maintenance data.

1.3 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ACME Electric Corporation; Power Distribution Products Division.
   2. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
   3. Controlled Power Company.
   5. Federal Pacific Transformer Company; Division of Electro-Mechanical Corp.
7. Hammond Power Solutions
9. Micron Industries Corp.
10. Myers Power Products, Inc.
13. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

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

B. Cores: Grain-oriented, non-aging silicon steel.

C. Transformers shall come with a minimum of a 20 year warranty.

D. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Aluminum or Copper as indicated on contract documents. If unstated, coil material shall be aluminum.

E. All transformers larger than 112.5 kva shall have an insulation system equal or greater than class 155 and shall be completely enclosed except for ventilation openings.

F. Transformer efficiencies – NEMA Premium High Efficiency Ratings
   1. Maximum no load losses that shall not exceed:
      a. 15kVA = 54W
      b. 30kVA = 87W
      c. 45kVA = 121W
      d. 75kVA = 165W
      e. 112.5kVA = 230W
      f. 150kVA = 290W
      g. 225kVA = 435W
      h. 300kVA = 560W
      i. 500kVA = 850W
      j. 750kVA = 1200W
   2. Efficiency at 35% nameplate shall meet or exceed DOE 10 CFR Part 431;
      a. 15kVA = 97.9%
      b. 30kVA = 98.25%
      c. 45kVA = 98.39%
      d. 75kVA = 98.6%
      e. 112.5kVA = 98.74%
      f. 150kVA = 98.81%
      g. 225kVA = 98.95%
      h. 300kVA = 99.02%
      i. 500kVA = 99.09%
      j. 750kVA = 99.16%
2.3  DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
   2. Provide weathershield for NEMA 3R rating for all transformers located outdoors.

E. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: Manufacturer’s Standard.

F. Taps for Transformers Smaller Than 3 kVA: None.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Minimum of two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

J. Energy Efficiency for Transformers Rated 15 kVA and Larger:
   1. Complying with NEMA TP 1, Class 1 efficiency levels.
   2. Tested according to NEMA TP 2.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for non-sinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.

L. Electrostatic Shielding: Transformers indicated to be shielded shall have each winding shielded with an independent, single, full-width copper electrostatic shield arranged to minimize inter-winding capacitance.

M. Wall Brackets: Manufacturer’s standard brackets.

2.4  BUCK-BOOST TRANSFORMERS

A. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.
B. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Finish Color: Manufacturer's Standard,

2.5 IDENTIFICATION DEVICES
A. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
   1. Brace wall-mounting transformers as specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Construct 4" concrete bases that extend 4" beyond the footprint of the equipment and anchor floor-mounting transformers according to manufacturer's written instructions and requirements in Division 26 Section "Hangers and Supports for Electrical Systems."

3.2 FIELD QUALITY CONTROL
A. Perform tests and inspections.
B. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3.3 ADJUSTING
A. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

END OF SECTION 26 22 00
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Transient voltage suppression devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.2 PERFORMANCE REQUIREMENTS

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

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

1.3 SUBMITTALS

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

B. Shop Drawings: For each switchboard and related equipment:

   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
   2. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
   3. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems.", if this specification is included with this project.

D. Field quality-control reports.

E. Operation and maintenance data.
1.4 QUALITY ASSURANCE

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

B. Comply with NEMA PB 2.

C. Comply with NFPA 70.

D. Comply with UL 891.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.
3. Sections front and rear aligned.

C. Nominal System Voltage: In accordance with riser diagram in contract documents.

D. Main-Bus Continuous: Per riser diagram in contract documents.

E. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

F. Enclosure: Steel, NEMA 250, Type 1.

1. Enclosure Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
2. Enclosure: Flat roof; bolt-on rear covers for each section, with provisions for padlocking.

G. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
H. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

I. Pull Box on Top of Switchboard:
   1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
   2. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
   3. Bottom shall be insulating, fire-resistant material with separate holes for cable drops into switchboard.
   4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

J. Phase and Neutral Buses and Connections: Three-phase, four-wire unless otherwise indicated. Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
   1. Ground Bus: 1/4-by-2-inch minimum size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors.
   2. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
   3. Neutral Buses: 100-percent of the ampacity of phase buses unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables.

K. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment. Extend buses the length or height of all available spaces to allow for easy addition of future circuit breakers.

2.2 SURGE PROTECTIVE DEVICES

A. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:
   1. Fuses, rated at 200-kA interrupting capacity.
   2. LED indicator lights for power and protection status.
   3. Audible alarm, with silencing switch, to indicate when protection has failed.
   4. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device.
   5. Transient-event counter set to totalize transient surges.

B. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

C. Withstand Capabilities: 5000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

D. Protection modes and UL 1449 SVR for grounded wye circuits with shall be as follows:
   1. Line to Neutral: 800 V for 480Y/277; 400 V for 208Y/120.
   2. Line to Ground: 800 V for 480Y/277; 400 V for 208Y/120.
   3. Neutral to Ground: 800 V for 480Y/277; 400 V for 208Y/120.
2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating to meet available fault currents. Provide following breakers per the riser diagram:

3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical or Compression style, suitable for number, size, trip ratings, and conductor material.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   d. Ground-Fault Protection: When indicated on the plans provide circuit breaker with integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control.", if applicable.
   g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   i. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   j. Key Interlock Kit: When indicated on plans provide externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   c. Siemens Energy & Automation, Inc.
d. Square D; a brand of Schneider Electric.

2. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
   a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
   b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

3. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.

4. Service-Rated Switches: Labeled for use as service equipment.

5. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
   a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

6. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

D. Fuses are specified in Division 26 Section "Fuses."

2.4 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.6 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install switchboards and accessories according to NECA 400.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness with 4” beyond footprint of equipment. Coordinate required dimensions with general contractor.
   1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   3. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems", if applicable.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install over-current protective devices, transient voltage suppression devices, and instrumentation.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Install spare-fuse cabinet.

H. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and over-current protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:
   1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.
B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

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

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

END OF SECTION 26 24 13
SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

1.2 PERFORMANCE REQUIREMENTS

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

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified.

1.3 SUBMITTALS

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

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

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

B. Comply with NEMA PB 1.

C. Comply with NFPA 70.
1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets as indicated on panel schedules.

1. Rated for environmental conditions at installed location.
   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R.

2. Hinged Front cover: Entire front trim hinged to box and with standard door within hinged trim cover. Standard Door-in-Door Construction Cover

   a. All circuit directories shall be typed. Hand written circuit directories are not acceptable.

C. Incoming Mains Location: Determined by Contractor unless otherwise noted on plans.

D. Phase, Neutral, and Ground Buses: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.

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

1. Material: Tin-plated copper, 98 percent conductivity.
2. Main and Neutral Lugs: Compression or Mechanical type.
3. Ground Lugs and Bus Configured Terminators: Compression or Mechanical type.
4. Feed-Through Lugs: Compression or Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Compression or Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by a NRTL. Include size and type of allowable upstream and branch devices, and listed and labeled for series-connected short-circuit rating by an NRTL.
2.2 DISTRIBUTION & SERVICE ENTRANCE PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Hinged Front Cover, standard door-in-door construction. Secured with vault-type latch with tumbler lock; keyed alike. Provide two keys for every panelboard provided. All keys keyed alike.

D. Mains: Circuit breaker or lugs only as indicated on panel schedules.


G. Fused switches are not permitted in panelboards unless specifically noted on contract documents.

H. All main service panelboards shall be rated for use as a service-entrance.

I. On all main service entrance panelboards, and on other panelboards specified on the plans, provide integral surge protective devices (SPD) with 160 kA surge current rating at 240 VAC, 320 kA at 480 VAC. SPD shall bolt onto panel bus in same fashion as circuit breaker. Device shall be equal to Square-D SurgeLogic.

J. Provide GFI protection for the main service circuit breaker for all 277/480 volt services of 1000 amperes or more in accordance with NEC 230-95.

K. Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by a NRTL. Include size and type of allowable upstream and branch devices, and listed and labeled for series-connected short-circuit rating by an NRTL.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only as indicated on panel schedules.
D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units. Plug-in style breakers are not permitted.

E. Doors: Door-in-Door Construction, Concealed hinges; secured with flush latch with tumbler lock; keyed alike. Provide two keys for every panelboard provided. All keys keyed alike.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating to meet available fault currents. Provide thermal-magnetic breakers unless otherwise indicated on contract documents.

3. Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I²t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5. Provide only when indicated on panel schedule.
5. GFCl Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (5-mA trip). Provide only when indicated on panel schedule.
7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration. Provide only when indicated on panel schedule.
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories, provide where indicated on plans:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Compression or Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
e. Communication Capability: Circuit-breaker-mounted or Integral-mounted communication module with functions and features compatible with power monitoring and control system if specified in Division 26 Section "Electrical Power Monitoring and Control."

f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at \([55 \text{ or } 75]\) percent of rated voltage.

g. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

h. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Division 26 Section "Fuses."

2.5 ACCESSORY COMPONENTS AND FEATURES

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install panelboards and accessories according to NECA 407.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Mount top of trim 72 inches above finished floor unless otherwise indicated.

D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

E. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

F. Install filler plates in unused spaces.

G. At all flush-mounted panelboards in finished spaces, stub spare ¾-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.

H. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
B. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NECA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

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

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

END OF SECTION 26 24 16
SECTION 26 27 13 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY
A. All metering equipment must be compatible with the Owner's existing Square D ION metering system by Schneider Electric and the existing software associated with that system.

1.2 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings: Dimensioned plans and sections or elevation layouts and wiring diagrams.

1.3 INFORMATIONAL SUBMITTALS
A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data:
   1. Product data.
   2. Operating instructions.

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

PART 2 - PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING BY OWNER
A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings, as manufactured by:
   1. Square D; a brand of Schneider Electric.

B. General Requirements for Owner’s Meters:
   1. Comply with UL 1244.
   2. Provide meters and accessory equipment as indicated on drawings.
3. Current-Transformers: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
4. Compatible with dry contact pulse count for flow meters and other mechanical meters.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Comply with equipment installation requirements in NECA 1.
B. Install meters in accordance with manufacturer’s recommendations and instructions.
C. Provide connections as shown on drawings.
D. Provide all programming and site licenses as required for a complete system in accordance with MSU standards.

3.2 IDENTIFICATION
A. Comply with requirements for identification specified in Section 26 05 53 “Identification for Electrical Systems.”

3.3 SYSTEM START-UP
A. Start-up services.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to configure system and bring system into operation.
   2. Service representative shall assist the Owner in interfacing new metering equipment with their existing system and the new building management system. Provide at least THREE days at the Owner’s selected location for this part of the service.

3.4 FIELD QUALITY CONTROL
A. Perform tests and inspections.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
B. Tests and Inspections:
   1. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
   2. Turn off circuits supplied by metered feeder and secure them in off condition.
   3. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
4. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.

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

D. Prepare test and inspection reports.

END OF SECTION 26 27 13
SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Wall Switches.
B. Receptacles.
C. Device Plates and Box Covers.
D. Dimmers.
E. Occupancy Sensors

1.2 RELATED WORK

A. Low-Voltage Electrical Power Conductors & Cables 26 05 19
B. Raceway & Boxes for Electrical Systems 26 05 33
C. Interior Lighting 26 51 00

1.3 REQUIREMENTS OF REGULATORY AGENCIES

A. All devices shall be UL listed.

1.4 SHOP DRAWING SUBMITTALS

A. Submit product data as required.
B. Provide product data showing configurations, finishes, dimensions, and manufacturers instructions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
B. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
D. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).
E. General Electric

F. Lithonia

2.2 COLORS
A. All device colors shall be SELECTED BY ARCHITECT. Cover plates shall be STAINLESS STEEL except as noted under DEVICE PLATES AND BOX COVERS.

B. except as noted under DEVICE PLATES AND BOX COVERS.

2.3 WALL SWITCHES
A. In all finished spaces:
1. Specification Grade AC Toggle Switch, 20 ampere, 120-277 volt, clamp type, screw terminal, side or back wired:
   a. Single Pole, 20 ampere Hubbell CS1221I
   b. Double Pole, 20 ampere Hubbell CS1222I
   c. Three-way, 20 ampere Hubbell CS1223I
   d. Four-way, 20 ampere Hubbell CS1224I

B. In mechanical/electrical equipment rooms, maintenance areas, janitor rooms, crawl spaces and other high abuse areas ONLY:
1. Specification Grade AC Toggle Switch, 20 ampere, 120-277 volt, clamp type, screw terminal, side or back wired:
   a. Single Pole, 20 ampere Hubbell CS1221I
   b. Double Pole, 20 ampere Hubbell CS1222I
   c. Three-way, 20 ampere Hubbell CS1223I
   d. Four-way, 20 ampere Hubbell CS1224I

C. Where shown on plans:
1. Pilot Light Switch, 20 ampere, light on with load on:
   a. SPST, 20 ampere, 120V, w/ pilot light Hubbell HBL1221 PL

2. Fused Switches:
   a. Box cover units with switch and plug fuse holder Bussman SSU, SSW, SSY
      Provide fuse sized for load

3. Keyed Switches:
   a. Lock-Type, chrome lock dome Leviton 1221-2KL
      Provide FOUR keys to Owner

2.4 DIMMERS
A. All dimmers shall be of same manufacturer and style and shall be identical in appearance and function regardless of load type being dimmed.
2.5 RECEPTACLES

A. In all finished spaces:
   1. Style Line, Specification Grade, 20 ampere, 120 volt, clamp type, screw terminal, side or back wired.
      a. Duplex, 20 ampere, 125V (NEMA 5-20R) Hubbell HBL 2162 Series
      b. Duplex, 20 ampere, USB charger, 125V (NEMA 5-20R) Hubbell USB20X2 Series
      c. Duplex, ground fault interrupter, 20 ampere, (NEMA 5-20R) Hubbell GF 5352 Series
      d. Isolated Ground Receptacle, 20 ampere, (NEMA 5-20R) Hubbell No IG5362 Series

B. In mechanical/electrical equipment rooms, maintenance areas, janitor rooms, crawl spaces and other high abuse areas ONLY:
   1. Duplex Receptacles, Specification Grade, Compact, Flush, Nylon Face, clamp type, screw terminal, side or back wired:
      a. Duplex, 20 ampere, 125V (NEMA 5-20R) Hubbell HBL 5352 Series

REFER TO THE DRAWINGS FOR OTHER OUTLETS REQUIRED FOR THIS PROJECT.

2.6 MISCELLANEOUS DEVICES

A. Television Outlet Leviton 80781 Series

2.7 DEVICE PLATES AND BOX COVERS

A. In all rooms with finished, painted gypboard walls:
   1. Brushed Stainless Steel Recept Plate, weatherproof "while in-use" Hubbell No. WP Series

B. Note special plates specified herein or on the drawing. Substitute materials must have sample submitted for approval.

C. Device plates for thirty ampere and larger outlets shall be No. 302 /No. 430 stainless steel and suitable for the wiring device used.

D. All plates in mechanical/electrical equipment rooms, maintenance areas, janitor rooms, crawl spaces and other high abuse areas shall be as follows:
   1. Where devices are surface-mounted and conduit is exposed use ½” deep galvanized box covers, Steel City RS Series, or equal.
   2. Where devices are flush use anodized aluminum plates, Hubbell A Series, or equal.

2.8 OCCUPANCY SENSORS

A. Ceiling Mounted
   1. Combination ultrasonic and passive infrared motion detector, ceiling-mounted, self-adjusting, available with coverage of 500, 1000 and 2000 sq-ft. Select appropriate coverage for room served. Provide power packs as required. Leviton ODC Series or equal.

B. Wall-Mounted
1. Infrared occupancy sensor, self–adjusting, 180 degree field of view, 2100 square feet of coverage. Select appropriate wattage rating for load served. Leviton Decora ODS Series, or equal.

2. Where indicated on plans provide Leviton Decora ODS0D-ID, or equal, with automatic switching for two separate lighting loads.

C. Installation
   1. Set all occupancy sensors to maximum delay (typically 30 minutes).

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS
   A. Furnish and install wiring devices as shown on the contract drawings and as specified herein.
   B. Label all Switches and Receptacle with clear self-adhesive and Black text with the Panel Name and Circuit Number.
   C. Install wiring devices plumb with walls so that device plates are tight to finish surfaces.
   D. Device plates in finished areas and on painted walls shall be smooth high-impact nylon.
   E. Device plates in mechanical and electrical rooms, mounted on exposed boxes shall be galvanized steel.
   F. Dimmers shall not be ganged, unless otherwise noted on the plans. Install with a minimum of 6 inches between dimmers. Do not remove cooling fins.
   G. Run equipment grounding wire from isolated receptacle ground terminal to main service panel ground. Isolate this conductor from all other interim grounding points.
   H. Wiring devices shall be minimum 20 ampere in all areas, unless noted otherwise herein or on the contract drawings.
   I. GFCI receptacles shall not be utilized for feed thru function to protect downstream devices. Each GFCI device as shown on plan shall dedicated to server location where shown only.

3.2 DEVICE HEIGHTS AND LOCATIONS
   A. Mount wiring devices at heights above finished floor as noted below or as shown on the contract drawings:
      1. Convenience Receptacles 18 inches to center
      2. Switches/Dimmers 48 inches to center
      3. Telephone/Data/TV 18 inches to center
      4. Telephone (wall-mounted) 48 inches to center
      5. Fire Alarm Notification Appliances Top of appliance 6” below ceiling or 80” above floor, whichever is lower
      6. Fire Alarm Pull Stations 48 inches to center
      7. Thermostats 54 inches to center
      8. Clocks As noted on drawings
B. Coordinate all device locations with architectural elevations and other plans before rough-in. Adjust device locations to accommodate casework elevations or knee-space locations or any other architectural or other trade obstruction. Contact the architect or engineer if any conflicts are present that cannot be resolved without substantially changing the layout of devices. The contractor shall be responsible to relocate any devices that are improperly coordinated.

C. Wherever receptacles are shown adjacent to tel/data, video or other low voltage locations, even if on separate plans, install boxes side-by-side with a consistent distance separating the boxes of no more than 3" between adjacent faceplates. Provide or coordinate additional framing as required.

END OF SECTION 26 27 26
SECTION 26 28 13 - FUSES

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes: Fuses rated 600-V ac and less for use in control circuits, enclosed switches, panelboards, switchboards, enclosed controllers, and motor-control centers.

1.2 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Operation and maintenance data.

1.3 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   B. Comply with NEMA FU 1 for cartridge fuses.
   C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Cooper Bussmann, Inc.
      2. Edison Fuse, Inc.
      3. Mersen, Inc.
      4. Littelfuse, Inc.

2.2 FUSES
   A. Characteristics: NEMA FU 1, nonrenewable fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 FUSE APPLICATIONS
   A. Service Entrance: Class RK1, time delay; or Class J, time delay.
B. Faders: Class RK1, time delay; Class RK5, time delay; or Class J, time delay.
C. Motor Branch Circuits: Class RK5, time delay.
D. Other Branch Circuits: Class RK1, time delay; Class RK5, time delay; or Class J, fast acting.
E. Control Circuits: Class CC, fast acting.

3.2 INSTALLATION
A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
B. Provide a spare fuse cabinet equal to Bussman SFC-FUSE-CAB (30" x 24" x 12"). Mount near main distribution panel or where majority of fused devices are located. Provide three spare fuses of each fuse type and size used in project.

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

END OF SECTION 26 28 13
SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fusible switches.
   2. Non-fusible switches.
   3. Shunt trip switches.
   4. Stand-alone molded-case circuit breakers (MCCBs).
   5. Enclosures.

1.2 DEFINITIONS

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

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: For power, signal, and control wiring.
C. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
D. Field quality-control reports.
E. Operation and maintenance data.
1.5 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.
5. Hubbell

B. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac (as required to accommodate actual voltage), 1200 A and smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Suitable for number, size, and conductor material.
5. Service-Rated Switches: Labeled for use as service equipment.

2.2 NON-FUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac to accommodate specified voltage, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Suitable for number, size, and conductor material.

2.3 SHUNT TRIP SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Bussmann, Inc.
   2. Ferraz Shawmut, Inc.
   3. Littelfuse, Inc.

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

C. Switches: Three-pole, horsepower rated, with integral shunt-trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.

E. Accessories:
   1. Oiltight key switch for key-to-test function.
   2. Oiltight ON pilot light.
   3. Isolated neutral lug.
   4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
   5. Form C alarm contacts that change state when switch is tripped.
   6. Three-pole, double-throw, fire-safety and alarm relay; confirm coil voltage with fire alarm contractor.
   7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
   8. Provide auxiliary switch on or interlocked with lockable handle. Switch to change state if handle is switched.

2.4 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   4. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

D. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and $i^2t$ response.

E. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

F. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Following items if specified on plans:
   a. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   b. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
   c. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   d. Alarm Switch: One N.O. contact that operates only when circuit breaker has tripped.

2.5 ENCLOSES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.
E. Comply with NECA 1.

3.2 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 28 16
SECTION 26 29 13 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes ac, enclosed controllers rated 600 V and less, of the following types:
      1. Across-the-line, manual and magnetic controllers.
      2. Multispeed controllers.

1.2 SUBMITTALS
   A. Product Data: For each type of enclosed controller.
   B. Shop Drawings: For each enclosed controller.
      1. Include wiring diagrams.
      2. Manufacturer Seismic Qualification Certification: Submit certification that enclosed controllers,
         accessories, and components will withstand seismic forces defined in Division 26 Section
         "Vibration and Seismic Controls for Electrical Systems."
   C. Field quality-control test reports.
   D. Operation and maintenance data.
   E. Load-current and overload-relay heater list.
   F. Load-current and list of settings of adjustable overload relays.

1.3 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,
      Article 100.
   B. Comply with NFPA 70.
   C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed
      controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other
      items. Comply with indicated maximum dimensions and clearances.

1.4 COORDINATION
   A. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits
      to which they connect.
   B. Coordinate features, accessories, and functions of each enclosed controller with ratings and
      characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electrical Company; GE Industrial Systems.
3. Siemens/Furnas Controls.
4. Square D.

2.2 ACROSS-THE-LINE ENCLOSED CONTROLLERS

A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."

1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.

B. Combination Magnetic Controller/Disconnect: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated.

1. All magnetic controllers must be packaged as combination controller & fused or circuit breaker disconnect switch. Stand alone controllers with separate disconnects are not acceptable.
2. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
3. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
4. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 20 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
5. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by an NRTL.

2.3 ENCLOSURES

A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, Type 3R, or Type 4X as specified on plans.

1. Outdoor Locations: Minimum NEMA 250, Type 3R.
2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated. All accessories shall be specified on plans.


C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.

3.2 INSTALLATION

A. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks.

B. Install freestanding equipment on concrete bases.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.
B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS, "Motor Control - Motor Starters." Certify compliance with test parameters.
2. Correct malfunctioning units and retest to demonstrate compliance; otherwise, replace with new units and retest.

END OF SECTION 26 29 13
SECTION 23 32 13 – GENERATOR SYSTEM

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The electrical contractor shall procure and install a packaged standby generator system, consisting of a generator set and generator controls, and all required accessories as specified. The equipment supplier shall be the authorized distributor for each component of the products specified herein. The work shall include furnishing of all equipment, testing, and training to provide a complete and workable power system, including generator set, generator set controls, and testing as specified herein. It is the intent of these specifications to have a single source responsibility for the generator set, generator set controls, and generator accessories.

B. Any and all exceptions to the published specifications shall be subject to the approval of the engineer.

C. The power system shall be furnished by a single manufacturer who shall be responsible for the design, coordination, and testing of the complete system. The entire system shall be provided and installed in accordance with the specifications herein.

D. The equipment shall be produced by a manufacturer who has produced this type of equipment for a period of at least 10 years and who maintains a service organization available twenty-four hours a day throughout the year.

E. The manufacturer or representative shall be on-site to assist in final check-out and commissioning of all generator system equipment.

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

G. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified.

1.2 GENERAL REQUIREMENTS

A. The equipment supplier shall provide a standby generator system that has been tested during design verification, production and at the final job site and meets the requirements of NFPA 110 for a Class X, Type 10, Level 1 system, NFPA 99 for a Type 1 system, NFPA 37, NFPA 1221 and UL 2200.

B. All furnished equipment shall be of recent commercial design and will be complete with all of the necessary accessories for complete installation as described in this specification. The equipment supplied and installed shall meet the requirements of the National Electrical Code, along with all applicable local codes and regulations.

C. Equipment shall be new and of recent production of a national firm that manufactures generator sets, controls and accessories, and assembles the generator sets as a complete and coordinated system. There shall be one source responsibility for warranty, parts, and service through a local representative with factory-trained servicemen. The service personnel shall be located within the State of Montana.
D. Weather Proof Enclosure for generator; generator shall be located in a secure enclosure capable of resisting the entrance of precipitation at the maximum wind velocities referenced in NFPA 5000

E. Diesel Source.

F. 100% Integral Load Bank

1.3 ACCEPTABLE MANUFACTURERS

A. Onan
B. Kohler
C. Caterpillar
D. Generac (TWE)

1.4 SHOP DRAWING SUBMITTALS

A. Shop drawing submittals shall include:

1. Prototype test certification and specification sheets showing all standard and optional accessories to be supplied.
2. Detailed installation diagrams including all terminal locations.
3. Dimension drawings, including weights of all components.
4. Interconnection diagrams identifying by terminal number, each required interconnection between the generator set, controllers, switchgear (if equipped), remote annunciator panel, and all other accessories.

B. See specification 260000 for additional shop drawing requirements.

1.5 WARRANTY, MAINTENANCE AND DOCUMENTATION

A. All provided equipment and materials shall be guaranteed against defective material and workmanship in accordance with the manufacturer's published warranty for one year from date of project substantial completion.

B. The equipment manufacturer and its distributor shall maintain a 24-hour parts and service organization within the State of Wyoming. This organization shall be regularly engaged in a maintenance contract program to perform preventive maintenance and service on equipment specified. A service agreement shall be available and shall include system operation under simulated operating conditions, adjustment to the generator and controls as required, and certification in the owner's maintenance log of repairs made and proper functioning of all systems.

C. At the time orders are placed for any item of equipment requiring service or operating maintenance, the supplier shall request the manufacturer furnish three (3) copies of OPERATION AND MAINTENANCE INSTRUCTIONS for each piece of equipment. These shall be original manuals, not photocopies. All manuals shall be organized into binders and presented to the Owner upon start of the warranty period. These binders shall be submitted to the Architect/Engineer and approved by him before authorization of final payment.
PART 2 - GENERATOR SET:

2.1 TESTING

A. To assure that the equipment has been designed and built to the highest reliability and quality standards, the manufacturer and/or local representative shall be responsible for three separate tests: design prototype tests, final production tests, and site tests.

1. Design Prototype Tests: Components of the emergency system such as the engine/generator set and accessories shall not be subjected to prototype tests since the tests are potentially damaging. Rather, similar design prototypes and preproduction models, which will not be sold, shall have been used for the following tests.
   a. Maximum power (kW).
   b. Maximum motor starting (kVA) at 35% instantaneous voltage dip.
   c. Alternator temperature rise by embedded thermocouple and/or by resistance method per NEMA MG1-22.40 and 16.40.
   d. Governor speed regulation under steady-state and transient conditions.
   e. Voltage regulation and generator transient response.
   f. Fuel consumption at 1/4, 1/2, 3/4, and full load.
   g. Harmonic analysis, voltage waveform deviation, and telephone influence factor.
   h. Three-phase short circuit tests.
   i. Alternator cooling air flow.
   j. Torsional analysis to verify that the generator set is free of harmful torsional stresses.
   k. Endurance testing.

2. Final Production Tests: Each generator set shall be tested under varying loads with guards and exhaust system in place. Tests shall include:
   b. Transient and steady-state governing.
   c. Safety shutdown device testing.
   d. Voltage regulation.
   e. Rated Power @ 0.8 PF
   f. Maximum Power.

3. Upon request, arrangements to either witness this test will be made, or a certified test record will be sent prior to shipment.

4. Site Tests:
   a. An installation check, start-up, and building load test shall be performed by the manufacturer's local representative. The engineer, regular operators, and the maintenance staff shall be notified of the time and date of the site test. The tests shall include:
      b. Fuel, lubricating oil, and antifreeze shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected.
      c. Accessories that normally function while the set is “standing by” shall be checked prior to cranking the engine. These shall include: battery charger, and remote annunciator.
      d. Start-up under test mode to check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage and frequency, and phase rotation.
      e. Automatic start-up by means of simulated power outage to test remote-automatic starting, transfer of the load, paralleling, operation of sequenced loading and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted for proper system coordination.
Engine coolant temperature, oil pressure, and battery charge level along with generator voltage, amperes, and frequency shall be monitored throughout the test. An external load bank shall be connected to the system if sufficient building load is unavailable to load the generator to the nameplate kW rating.

2.2 EQUIPMENT

A. The generator set shall each provide 350 kW, 438 kVA while operating at 277/480 volts, 0.8 power factor. Generator set shall be capable of this rating while operating in an ambient condition of 77°F (59.2°C) and 4900 feet above sea level.

B. The generator set shall be capable of starting motor loads of 915 kVA inrush, with a maximum voltage dip of 20%.

C. The generator set shall occupy a space no larger than 19' long by 5' wide. No equipment larger than this shall be bid without requesting prior approval and specifically identifying the larger dimensions.

D. Vibration isolators shall be provided between the engine-generator and concrete base.

E. The generator shall be located outdoors in a weather proof enclosure. Enclosure shall have sound attenuation at 75dBa@7m. Enclosure shall have a factory applied finish color as selected by the Architect.

F. Base Tank providing 24 hours of run time at full load.

G. Weather Proof Enclosure for generator; generator shall be located in a secure enclosure capable of resisting the entrance of precipitation at the maximum wind velocities referenced in NFPA 5000

H. 100% Load Bank integral to the unit.

2.3 ENGINE

A. Generator engine shall deliver approximately 530 hp at a governed speed of 1800 rpm. The engine shall be equipped with the following:

1. An isochronous governor capable of +.25% steady-state frequency regulation.
2. Positive engagement solenoid shift-starting motor.
3. Automatic battery charging alternator with solid-state voltage regulation.
4. Positive displacement, full pressure lubrication oil pump, cartridge oil filters, dipstick, and oil drain.
5. Dry-type replaceable air cleaner elements for standard-duty applications.
6. The engine shall be liquid-cooled by a unit-mounted radiator, blower fan, water pump, and thermostats.
7. Radiator duct adaptor flange.
8. Oil Heater

2.4 GENERATOR

A. The alternator shall be salient-pole, brushless, 12-lead re-connectable, self-ventilated of drip-proof construction with amortisseur rotor windings and skewed stator for smooth voltage waveform. The insulation shall meet the NEMA standard (MG1-22.40 and 16.40) for Class H and be insulated with epoxy varnish to be fungus resistant per MIL 1-24092. Temperature rise of the rotor and stator shall be
limited to NEMA Class F ratings. The excitation system shall be of brushless construction controlled by a solid-state voltage regulator capable of maintaining voltage within +/-2% at any constant load from 0% to 100% of rating. The regulator must be isolated to prevent tracking when connected to SCR loads, and provide individual adjustments for voltage range, stability and volts-per-hertz operations; and be protected from the environment by conformal coating.

B. Upon 1-step application of any load up to 100% of the rated load at 0.8 power factor, the voltage dip shall not exceed 20% and the generator shall recover to rated voltage and frequency.

C. The generator shall be capable of sustaining at least 250% of rated current for at least 10 seconds under a 3-phase symmetrical short circuit without the addition of separate current support devices.

D. The generator, having a single maintenance-free bearing, shall be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.

E. Diesel fuel type.

2.5 Accessories

A. Battery rack, and battery cables, capable of holding the manufacturer's recommended batteries, shall be supplied.

B. Block heater & coolant heater, factory installed. Each unit shall be rated 2000 watt, single phase at 208V.

C. Load Center, factory provided 208 volt, single phase with main breaker. Factory shall wire all chargers, heaters, etc. to the load center and provide a main breaker sized for that load. Electrical contractor shall ground panel per NEC. Load center shall be mounted on the generator.

D. 12-volt batteries capable of delivering the manufacturer's recommended minimum cold-cranking Amps required at 0°F, per SAE Standard J-537, shall be supplied.

E. Automatic float and equalize battery charger with +/-1% constant voltage regulation from no load to full load over +/-10% AC input line variation, current limited during engine cranking and short circuit conditions, temperature compensated for ambient temperatures from -40°C to +60°C, 5% accurate voltmeter and ammeter, fused, reverse polarity and transient protected.

F. The generator-mounted radiator shall include a mounting flange.

G. Oil Tank Heater

H. At Substantial Completion the Generate Base Tank shall be completely full by the Electrical Contractor.

I. IBC Seismic Certified/Seismic Rated Vibration Isolators

J. The engine exhaust silencer shall be constructed of carbon steel and shall be coated to be temperature and rust resistance. The silencer shall be rated for critical application and shall reduce total engine exhaust noise by 25-35 dB(A). A flanged flex connector, non-combustible ceiling thimble, and appropriate rain cap shall be provided. The silencer shall be configured with a bottom inlet and top outlet to extend exhaust piping vertically up through the ceiling of the generator room.

K. Remote annunciator panel shall be provided along with all interconnecting cabling, enabling the generator status to be viewed remotely. The remote annunciator panels shall be capable of connecting
to the system controller (SC). The panels shall be capable of flush-mounting into a standard 2x4 framed wall. *Surface-mounted annunciators are not acceptable.* The annunciator shall indicate alarm conditions through visual and audible indicators as follows, per NFPA 99 4.4.1.1.18:

1. Generator Set Supplying Power to the Load
2. Battery Charger Malfunctioning
3. Low Lube Oil Pressure
4. Low Water Temperature
5. Excessive Water Temperature
6. Low Fuel
7. Overcrank (failed to start)
8. Overspeed

2.6 INTEGRATED CONTROL SYSTEM

A. The generator set shall include a generator controller that digitally controls the engine and alternator for governor speed, voltage regulation, engine functions, auto-synchronization, load sharing and protection.

1. The controller shall announce in audible form the following minimal conditions:
   a. Over current
   b. Over/under voltage
   c. Sync check
   d. Reverse Power
   e. Over-Speed

2. The controller shall display, as a minimum:
   a. Volts and amps
   b. kW, kVAR, and power factor
   c. Engine speed and alternator frequency
   d. Oil pressure and temperature
   e. Coolant temperature
   f. Battery voltage
   g. Fuel level
   h. Run hours

3. The controller shall include a touch screen interface to navigate screens and access system parameters.

2.7 AUTOMATIC TRANSFER SWITCHES (quantity of 3)

A. Closed transition automatic transfer switches shall be provided with number of poles, amperage, and voltage as shown on the plans.

B. Transfer switch manufacturer shall be an approved manufacturer of Montana State University.

C. The switches shall have by-pass isolation

D. The switches shall be UL 1008 listed.
E. Provide a set of dry contacts for a connection to the mechanical control panel for operational sequence during normal power failure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:
   1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 Cast-in-Place Concrete.
   2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
   3. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1 inch high concrete base. Secure engine generator to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548 Seismic Controls for Electrical Systems.

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

C. Balance three-phase loads to obtain a maximum of 10 percent unbalance between any phase.

3.3 IDENTIFICATION

A. Identify system components according to Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.
3.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:
   1. Perform tests recommended by manufacturer and in "Visual and Mechanical Inspection" and "Electrical and Mechanical Tests" subparagraphs below, as specified in the NETA ATS. Certify compliance with test parameters.
      a. Visual and Mechanical Inspection:
         1) Compare equipment nameplate data with Drawings and the Specifications.
         2) Inspect physical and mechanical condition.
         3) Inspect anchorage, alignment, and grounding.
         4) Verify that the unit is clean.
      b. Electrical and Mechanical Tests:
         1) Test protective relay devices.
         2) Verify phase rotation, phasing, and synchronized operation as required by the application.
         3) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
         4) Perform vibration test for each main bearing cap.
         5) Conduct performance test according to NFPA 110.
         6) Verify correct functioning of the governor and regulator.
   2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
   3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
      a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
      b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
      c. Verify acceptance of charge for each element of the battery after discharge.
      d. Verify that measurements are within manufacturer's specifications.
   4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
   5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
   6. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
   7. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.

D. Coordinate tests with tests for transfer switches, and run them concurrently.

E. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

F. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
G. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

H. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

I. Remove and replace malfunctioning units and retest and reinspect as specified above.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component, indicating satisfactory completion of tests.

3.5 DEMONSTRATION

3.6 Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators

TESTS AND CERTIFICATION

A. The complete generator system shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that all equipment is in compliance with the specification requirements. Tests and certifications shall meet the requirements of NFPA 110 section 7.13.

3.7 TRAINING

A. The equipment manufacturer or representative shall supply on-site training at the owner's facility. The training shall continue until the owner is fully satisfied that he understands the operation of his system and shall be conducted by a full time employee of the manufacturer. The training shall cover installation, operation, maintenance, and troubleshooting of the equipment.

END OF SECTION 26 32 13
PART 1 - GENERAL

1.1 SUMMARY

A. Provide a complete, engineered lightning protection system.

1.2 SUBMITTALS

A. Product Data: For air terminals and mounting accessories indicated in specifications or contract drawings.

B. Shop Drawings: Provide plans drawings, specific to the project, using AutoCad or other similar design software. Plans shall include:

1. Details of all lightning protection system components including air-terminal locations, conductor routing and connections, and bonding and grounding provisions.
2. Details and locations of all required raceway and sleeves.
3. Information on how concealment requirements will be met.
4. Plan drawings shall clearly indicate all components and shall designate which are concealed and which are not concealed.

C. Qualification data.

D. Certification that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.

E. Field inspection reports indicating compliance with specified requirements.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who is NRTL listed or who is certified by LPI as a Master Installer/Designer.

B. Listing and Labeling: As defined in NFPA 780, “Definitions” Article.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Automatic Lightning Protection.
2. ERICO International Corporation.
3. Harger Lightning Protection, Inc.
5. Independent Protection Co.
6. Robbins Lightning Inc.
7. Thompson Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96.

B. Roof-Mounting Air Terminals: NFPA Class I, aluminum, tubular or solid, unless otherwise indicated.

C. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 26 Section "Grounding and Bonding for Electrical Systems" and with standards referenced in this section.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.

C. Conceal the following conductors:
   1. System conductors.
   2. Down conductors.
   3. Interior conductors.
   4. Conductors within normal view from exterior locations at grade within 200 feet of building.
   5. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.

D. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.

E. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

F. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

G. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.
3.2 CORROSION PROTECTION
   A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
   B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 CONCEALMENT
   A. All components of the lightning protection system, with the exception of air terminals, shall be concealed from view by a person standing at ground level anywhere within 200’ of the building.
      1. Air terminals shall not be mounted on top of parapet walls. Terminals shall be mounted to the interior vertical surface of parapet walls in such a manner so they project above the parapet.
      2. All conductors, cross-conductors, down-conductors and all other conductors shall be concealed. Particular care should be taken on shed or gabled pitched roofs where air terminals are required at the roof peak. In this case connecting conductors shall NOT be run exposed on the roof surface but shall be run below the roofing or below the roof in the space below.
      3. No visible device of any kind shall be installed on the exterior walls of the building.
      4. The building is “slab-on-grade” construction. All down conductors shall be routed through the slab to connect to the grounding electrode system so no conductor is visible from the building exterior. Provide ground rod inspection wells for access to ground rods and ground clamps. No visible, junction boxes, conduits or conductors shall be permitted to be run on the building exterior. This will require the installation of underslab conduit prior to the slab being poured.
      5. Air terminal bases located on pitched roofs shall be of a concealed design such as concealed ridge saddle assemblies.

3.4 FIELD QUALITY CONTROL
   A. UL Inspection: Provide inspections as required to obtain a UL Master Label for system.
   B. Provide an inspection by an inspector certified by LPI to obtain an LPI certification.

END OF SECTION 26 41 13
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. LED lighting fixtures, drivers, boards.
2. Interior lighting fixtures, lamps, and ballasts
3. Emergency lighting units.
4. Exit signs.
5. Lighting fixture supports.

1.2 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes.
B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
C. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.
D. Sustainable Design Submittals:

   Product Data: Indicating luminaire is certified by Design Lights Consortium.

E. Field quality-control test reports.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include manufacturers specified on Light Fixture Schedule.
2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Metal Parts: Free of burrs and sharp corners and edges.

C. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

D. Doors, Frames, and Other Internal Access: 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.

E. Plastic Diffusers, Covers, and Globes:
   1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
      a. Lens Thickness: At least 0.125 inch minimum unless different thickness is specified.
      b. UV stabilized.
   2. Glass: Annealed crystal glass, unless otherwise indicated.

2.3 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five years from date of Substantial Completion.

PART 3 - PRODUCTS

3.1 PERFORMANCE REQUIREMENTS

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

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.
   1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified.

3.2 LED LUMINAIRE REQUIREMENTS

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

B. Standards:
1. ENERGY STAR certified.
2. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
3. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
4. UL Listing: Listed for damp location.
5. Recessed luminaires shall comply with NEMA LE 4.

C. CRI of minimum 80. CCT of 4100 K.

D. Rated lamp life of 50,000 hours to L70.

E. Lamps dimmable from 100 percent to 0 percent of maximum light output.

F. Internal driver.

G. Minimum allowable efficacy of 80 lumens per watt.

H. Integral junction box with conduit fittings.

I. Nominal Operating Voltage: 120 V ac OR 277 V ac as indicated on Light Fixture Schedule.
   1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

3.3 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit 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.

C. Diffusers, and Globes:
   1. Acrylic: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   2. Glass: Annealed crystal glass unless otherwise indicated.
   3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

3.4 METAL FINISHES

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

1. Internally Lighted Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

3.6 EMERGENCY LIGHTING UNITS

A. Description: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

3.7 LED BOARDS AND DRIVERS

A. Provide LED boards and drivers as specified on Light Fixture Schedule

B. Furnish spare LED boards identical to those installed in each fixture. Quantity: 10% of total boards used or a minimum of three (3) lamps of each type, whichever is greater.

C. Furnish spare LED drivers identical to those used in each fixture. Quantity: 1 ballast or 5% of each fixture type, whichever is greater.

3.8 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 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 or equal or better by manufacturer with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes or equal or better by manufacturer with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gauge or equal or better by manufacturer.

E. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
PART 4 - EXECUTION

4.1 PROCUREMENT

A. Electrical contractor to provide all Interior Lighting from Crescent Electric, Bozeman, MT. Contact Jack Fish.

B. All lights fixtures were part of an Early Works Package and already bid and procured by Crescent Electric. No Additional Bidding of Light Fixtures shall take place.

C. Electrical contractor is responsible for a complete installation of all light fixtures.

4.2 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Comply with NFPA 70 for minimum fixture supports.

C. Suspended 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.

D. Adjust aimable lighting fixtures to satisfaction of owner.

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

F. Align luminaries and clean lenses and diffusers at completion of Project. Clean paint splatters, dirt and debris from installed luminaries. Replace any dented, scratched, soiled or cracked lens or other fixture parts.

G. Clean all Light Fixtures at Substantial completion for they are free of dirt, debris, finger prints and miscellaneous wiring scraps.

4.3 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.

END OF SECTION 26 51 00
SECTION 26 56 00 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
   2. Luminaire-mounted photoelectric relays.
   3. Poles and accessories.

B. See Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.2 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, and finishes.

B. Shop Drawings: Include anchor-bolt templates keyed to specific poles and certified by manufacturer.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: As indicated on Light Fixture Schedule or as approved through prior approval process.

2.2 LUMINAIRES, GENERAL REQUIREMENTS

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. 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. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. 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.


N. Factory-Applied Finish for Aluminum Luminaires: Color shall be as specified on Light Fixture Schedule or selected by Architect, if so specified. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
   1. Relay with locking-type receptacle shall comply with NEMA C136.10.
   2. Adjustable window slide for adjusting on-off set points.
2.4 LED LUMINAIRES

A. LED Luminaire with a minimum CRI of 70 and color temperature equal or greater than lamp specified on Light Fixture Schedule. L70 lamp life minimum of 50,000 hours

2.5 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Structural Characteristics: Comply with AASHTO LTS-4.
   1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
   2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
   1. Materials: Shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
   3. Anchor-Bolt Template: Plywood or steel.

D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

E. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.6 CONCRETE POLES

A. Poles: As specified on Light Fixture Schedule on Drawings.

PART 3 - EXECUTION

3.1 PROCUREMENT

A. Electrical contractor to provide all Exterior Lighting from Crescent Electric, Bozeman, MT. Contact Jack Fish.

B. All lights fixtures were part of an Early Works Package and already bid and procured by Crescent Electric. No Additional Bidding of Light Fixtures shall take place.

C. Electrical contractor is responsible for a complete installation of all light fixtures.
3.2 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.
   1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming to satisfaction of Owner.

3.3 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
   1. Fire Hydrants: 8'.
   2. Water, Gas, Electric, Communication, Storm Drainage and Sewer Lines: 6'.
   3. Trees: 15'.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
   1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
   2. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
   3. Install base covers, unless otherwise indicated.
   4. Use a short piece of 1/2-inch diameter PVC pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
   1. Dig holes large enough to permit use of tampers in the full depth of hole.
   2. Backfill in 6-inch (150-mm) layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
   1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
   2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days, and finish in a dome above finished grade.
   3. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

G. Raise and set poles using web fabric slings (not chain or cable).

H. All poles shall be checked after one (1) year of operation for proper vertical alignment and shall be adjusted to true plumb if necessary.

3.4 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top of base 4 inches above finished grade or surface at bollard location, unless otherwise specified on plans. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.5 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top 4 inches above finished grade or surface at luminaire location, unless otherwise specified on plans. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.6 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole, unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundations.

END OF SECTION 26 56 00
SECTION 26 60 00 - LABORATORY ELECTRICAL REQUIREMENTS

PART 1 GENERAL REQUIREMENTS

1.1 RELATED DOCUMENTS

A. The general conditions, Division 1, and Division 26 electrical requirements are part of this section and the contract for this work and apply to this section as fully as if repeated herein.

B. Reference to other sections: The applicable requirements from all other Division 26 sections shall form a part of the electrical work and each section shall be thoroughly reviewed by the Contractor for application to all other sections. For Laboratory areas only (excluding lab lighting), this section shall take precedence.

C. Provide complete electrical systems from the laboratory branch circuit panelboards to all devices and equipment as described in these specifications and shown on the Laboratory Electrical drawings. Electrical installations shall include all required hardware, fittings, boxes, mounting provisions and miscellaneous equipment to provide complete and operable systems in accordance with the standard practices of the trade. Materials utilized shall be as defined in other sections of Division 26 of these specifications and modified only as described herein.

1.2 EXPLANATION OF DRAWINGS

A. The Laboratory Electrical (LE) construction documents are intended to be diagrammatic and reflect the scope, quality, and character of the work to be performed; all miscellaneous materials and work required for a complete and operational system, though not specifically mentioned, shall be furnished and installed by the Contractor.

B. The Contractor shall confirm sizes, dimensions, weights and locations of all devices, light fixtures, and equipment prior to installation. Dimensioned architectural drawings shall take precedence over diagrammatic layouts shown on these contract documents.

C. The Contractor shall be responsible for reporting any discrepancies, errors, or omissions regarding the Laboratory Electrical drawings noted prior to bid.

D. It is the intent of the drawings to indicate schematic routing and placement of devices, fixtures, equipment and conduit. Exact locations shall be dimensioned on other trade documents (architectural, laboratory furnishings, mechanical, etc.). Offsets, elbows, or extensions shall be furnished and installed by the Contractor as necessary to avoid structure, piping, clearances and to provide a complete and workmanlike installation.
1.3 QUALITY ASSURANCE AND STANDARDS

A. All work, material or equipment shall comply with the codes, ordinances and regulations of the local government having jurisdiction, including the regulations of serving utilities and any participating government agencies having jurisdiction.

B. All electrical work shall comply with the latest edition under enforcement, including all amendments, modifications, and supplements, of the following codes and standards or other regulations which may apply:

1. American Disabilities Act (ADA)
2. American National Standards Institute (ANSI)
3. American Society for Testing and Materials (ASTM)
4. Institute of Cable Engineers Association (ICEA)
5. Institute of Electrical and Electronics Engineers (IEEE)
6. Local Code Enforcement Agency Requirements
7. National Electrical Code (NEC)
8. National Electrical Contractor's Association (NECA)
9. National Electrical Manufacturer's Association (NEMA)
10. National Electrical Testing Association (NETA)
11. National Fire Protection Association (NFPA)
12. Underwriters’ Laboratories, Inc. (UL)

No requirement of these drawings and specifications shall be construed to void any of the provisions of the above standards. Any conflicts or changes required to the contract documents in order to obtain compliance with applicable codes shall be brought to the immediate attention of the Engineer, Architect, and Owner's Representative by the Contractor.

C. All items shall be listed by Underwriter’s Laboratories and shall bear the U.L. label.

D. Equipment shown to scale is approximate only and based upon a general class of equipment specified. The Contractor shall verify all dimensions and clearances prior to commencement of work.

E. The Contractor shall verify all points of connection with the manufacturer’s requirements, instructions, or recommendations prior to installation. The actual dimensions, weights, clearance requirements and installation requirements shall be verified and coordinated by the Contractor.

1.4 SUBMITTALS

A. Shop drawings for materials, equipment, devices, fixtures, and systems shall be submitted by the Contractor for review in compliance with the requirements of Division 1 and Division 26.

B. The Contractor shall bear the responsibility for any materials installed which were not submitted for review or not installed in compliance with the review comments and the contract documents.

C. Verbal modification of submittal documents or changes to the requirements of the contract documents shall not be acceptable. All submittal material must be documented in a written format.
D. All submittal packages must be submitted at one time and in accordance with the specification section appropriate for the material. All packages must be identical and clearly labeled indicating the specification section, project name, submittal date, Contractor’s name, Engineer’s name, preparer’s name and submission version (first submission, resubmittal #1, etc.)

E. Product catalog cutsheets and descriptive literature shall be cross-referenced to the specification section by paragraph.

F. All submittal packages shall be permanently bound in brochure or booklet format. A minimum of six submittal booklets shall be provided by the Contractor; additional copies may be required if so noted.

G. Materials which bear a certification or approval of a testing agency, performance criteria, society, agency, of other organization shall be submitted with all labels identified.

H. The submittal shall be complete and with catalog data and information properly marked to show, among other things, materials, capacity and performance data to meet the specified requirements.

I. Incomplete submittals will be rejected at the discretion of the reviewing Engineer.

J. Review of the submittal is for general conformance with the contract documents. The Contractor is responsible for confirmation and coordination of dimensions, quantities, sizes, fabrication, installation methods, and for coordination of work of other trades with the electrical work.

K. Submittal brochures shall be complete and descriptive of the type, make, manufacturer, application, quantity, performance, capacity, ratings, options, dimensions, clearances, weights, nameplate data, special installation requirements, mounting method, NEMA type, NEMA class, environmental restrictions, layout requirements or other information as may be necessary for review of the material.

L. The Contractor shall be responsible for all aspects of substitutions of material including any additional cost or delay incurred as a result of the substitution. The Contractor shall coordinate all substitutions with other trades, verify code compliance, verify clearances, photometric performance, appearance, suitability, constructability, and availability of the material prior to submitting the substitution for review. The Contractor shall bear the responsibility of any increased costs to other trades which are directly related to the substitution.

M. Submittals shall include the following:

1. Raceways
2. Wire and Cable
3. Boxes
4. Wiring Devices
5. Disconnect Switches

N. Submit detailed dimensioned drawings for all multi-outlet surface raceways.
PART 2 PRODUCTS

2.1 MATERIALS

A. All materials shall be new, of prime quality, listed as suitable for the application, and bear factory-applied U.L. labels.

B. Materials shall be currently in production and shall be supported by spare parts, repair service, maintenance, and factory technical support.

2.2 RACEWAYS

A. Electrical Metallic Tubing (EMT)

1. Conduit shall be cold rolled zinc coated steel and manufactured per UL and ANSI requirements.
2. Fittings for EMT shall be watertight steel or malleable gripping ring compression type.
3. Pressure cast material for nuts of compression ring type fittings and set-screw connections are not acceptable.
4. Minimum raceway size shall be ¾”.

B. Flexible Metallic Conduit

1. Flexible conduit shall bear the UL label and be zinc-coated steel.
2. Fittings for flexible metallic conduit shall be steel or malleable iron. Fittings shall clamp to conduit securely.
3. Screw in type, sheet metal or set-screw type fittings are not acceptable.
4. Minimum raceway size shall be ¾”.

C. Liquid Tight Flexible Conduit

1. Conduit shall be manufactured in accordance with UL and ANSI requirements. Conduit shall be approved for grounding and compatible with approved fittings. Flexible steel conduit shall be hot dipped galvanized with extruded PVC covering manufactured per UL requirements.
2. Fittings shall be liquid tight type with body and gland nut of steel or malleable iron with provisions for grounding flexible conduit to fittings.
3. Minimum raceway size shall be ¾”.

D. Polyvinyl Chloride (PVC) Conduit

1. PVC shall be constructed of a virgin homopolymer PVC compound and be manufactured according to NEMA and UL specifications. PVC conduit shall be Schedule 40 or 80.
2. Minimum raceway size shall be ¾”.

E. Multi-outlet Surface Raceways

1. Multi-outlet surface raceways shall be furnished complete with bases, covers, end plates, connectors, wiring devices, receptacles, connectors, and labels as indicated on the drawings and in these specifications. The multi-outlet surface raceways may be factory or field assembled.
2. Mounting of multi-outlet surface raceways shall be according to the manufacturer’s recommendations and detailed drawings. Specific fitting of the multi-outlet surface raceways to casework, benches, or walls shall be the responsibility of the Contractor. Coordinate elevations with Laboratory Furnishings drawings and details.
3. Refer to the Laboratory Furnishings drawings and specifications for details in regard to the location, length, and quantity of multi-outlet surface raceways.

4. Multi-outlet surface raceways shall fit the intended space with no more than 1/8 inch clearance between each end of the raceway and the adjacent wall, bench, support riser, end of counter, or other laboratory finish as appropriate.

5. Final multi-outlet surface raceway cuts shall be plumb and straight and shall be finished to eliminate burrs, nicks, or sharp edges on both raceways and covers. Multi-outlet surface raceway field cuts which are not equal to the quality and appearance of the factory cuts will be rejected at the discretion of the Laboratory Engineer or Architect.

6. Provide end plates with conduit knock-outs for the conduit sizes indicated or as required by code.

7. All receptacles in multi-outlet surface raceways shall be wired for the entire length of the raceway section with properly tagged pigtails.

8. The multi-outlet surface raceways shall be U.L. listed assemblies.

9. Multi-outlet surface raceway bases, covers, and end plates shall be constructed of extruded aluminum with 0.094" minimum thickness walls and clear anodized finish. The multi-outlet surface raceway extrusion shall be rectangular in cross section and have no protrusions.
   a. Dual channel raceways shall be two compartment, factory pre-wired Wiremold AL4520 series, Monosystems SWA 4800 series, or equal. A continuous, permanently installed metallic barrier shall separate the compartments.
   b. Single channel raceways shall be one compartment, pre-wired Wiremold ALA3800 series, Monosystems SWA 3200 series, or equal.

10. Multi-outlet surface raceway covers shall be cut in 12-inch sections with one “filler” section of less than 12 inches at only one end of each run of raceway as required. Receptacle or telecommunications port locations shall only be provided on a 12-inch cover section.

11. Do not scale or dimension Laboratory Electrical drawings to determine raceway lengths. Laboratory Furnishings drawings should be used for this purpose.

12. Provide labeling with panel and circuit number at each receptacle installed in the raceway. Labels may be either engraved phenolic affixed with epoxy, or engraved directly on raceway cover plate. Phenolic labels shall be block with white lettering for normal power receptacles and red with white lettering for standby or emergency power receptacles. Engraved cover plate labels shall have black lettering for normal power receptacles or red lettering for standby or emergency power receptacles.

2.3 WIRE AND CABLE

A. Conductors shall be copper; conductors size #10AWG and smaller shall be solid, conductors size #8AWG and larger shall be stranded. Conductors shall be minimum size #12AWG for power and lighting circuits; control circuits shall use a minimum conductor size of #14AWG.

B. Insulation shall be type THW or THHN/THWN for all branch circuits up to and including size #2AWG. Insulation for conductors over size #2AWG shall be XHHW.

C. Jackets shall be nylon or PVC material.

D. All cables shall be UL listed for the application.

E. All conductors shall be installed in conduit in the field, unless specifically noted otherwise in these documents. Type AC, type NM and type MC cable are not acceptable.

F. Multi-conductor flexible cords shall be types SO, SJO, STO, or SJTO.
G. Connectors shall be UL listed and suitable for the conductor material being connected and rated appropriately. Connectors shall be solderless helical metal spring pressure type or solderless finger metal spring barb type for conductors #10AWG and smaller. Connectors shall be compression type for conductors #8AWG and larger.

2.4 BOXES

A. Boxes shall be flat rolled steel sized as required by code and as suitable for the application. Boxes shall have mounting holes and knock-outs in sides and back. Grounding shall be accommodated by means of threaded holes.

B. Provide accessories, extension rings, gaskets, supports, trim rings, hangers, straps, and other material as necessary for a complete code complying installation.

C. Boxes installed outdoors shall be weather-tight, dust-tight, and corrosion resistant. Provide gaskets and conduit hubs.

D. Provide Type FS boxes for surface mounted applications.

E. Provide additional support for boxes as necessary when mounting fixtures or devices from boxes.

F. Provide ganged boxes for multiple switches and devices; provide barriers for boxes served by separate voltages.

2.5 WIRING DEVICES

A. Receptacles

1. Wiring devices shall be UL listed and suitable for the application.
2. Devices shall be color coded per the system to which they are connected: normal power shall be white; standby or emergency power shall be red; dedicated outlets shall be grey; unless otherwise noted on the construction documents.
3. Receptacles shall be heavy duty, screw type, side wired, 120V, 20A, duplex type, unless noted otherwise on the construction documents. Verify NEMA configuration with construction documents.
4. Weathertight receptacles shall be gasketed in cast metal boxes with cast metal coverplates with spring-loaded hinged covers over each opening.
5. Ground fault interrupting receptacles shall be duplex type and capable of detecting a leaking current of 5mA.

B. Toggle Switches

1. Toggle wall switches shall be quiet AC type, rated 120/277V, 20A and UL listed for the application.
2. Switches shall be single pole, double throw with white finish unless noted otherwise.

C. Coverplates

1. Single, combination coverplates shall be used at all ganged device locations.
2. Provide stainless steel coverplates with matching screws in laboratory, process, manufacturing, and clean room areas or as noted on the construction documents.
3. Provide labeling with panel and circuit number at each receptacle coverplate. Labels may be either engraved phenolic affixed with epoxy, or direct factory engraving on the coverplate. Phenolic labels shall be block with white lettering for normal power receptacles and red with white lettering for standby or emergency power receptacles. Engraved cover plate labels shall have black lettering for normal power receptacles or red lettering for standby or emergency power receptacles.

2.6 POWER AND TELECOMMUNICATIONS PEDESTALS

A. Manufacturer
   1. Design is based on WaterSaver pedestal electrical box with 3/4” hub, single-gang catalog number E300SA, two-gang catalog number E400SA and E500SA, and four-gang catalog number E600SA.
   2. If alternate product is to be submitted, all material and functional requirements of the specified product must be demonstrated and documented to be equal.

B. Pedestals shall have aluminum base and housing, containing devices as shown on drawings. Housing finish shall be brushed.

C. Faceplates
   1. Pedestal receptacle faceplates shall be stainless steel, and shall accommodate the device types and quantities indicated on the drawings. Faceplates shall have engraved labeling with requirements as noted for raceway and coverplate labels.
   2. Pedestal telecommunication faceplates shall be stainless steel, and shall be provided with cutouts specifically designed to accommodate the type of tel/data devices to be installed by the telecommunications/data system installer. Coordinate prior to ordering faceplates.

2.7 DISCONNECT SWITCHES

A. Disconnects shall NEMA 1, indoor type, or rated for the locations in which they are installed as noted on the construction documents.

B. Disconnects shall be UL listed and suitable for the application.

C. Disconnects in exterior, wet, cold, warm, or hot environments shall be raintight, have raintight hubs, and be rated NEMA 3R.

D. Disconnects shall be heavy duty type, rated 600V with current capacity as noted on the construction documents. Verify NEMA configuration with construction documents.

E. Disconnects shall have hinged, lockable, dead-front doors with permanently marked ON/OFF indicators. Enclosures shall be baked enamel factory painted steel with conduit knockouts.

F. Disconnects shall be operated by a handle accessible from the exterior of the enclosure. Handles shall have provision to be padlocked in the OFF position.
G. All current carrying parts shall be high conductivity copper designed to carry rated load without damage from heat and plated to resist corrosion.

H. Switch mechanism shall be a quick-make, quick-break type such that the operation of the contact is restrained by the handle during the closing or opening operation.

I. Switches shall have a minimum fault current rating of 200,000A RMS.

J. All switches shall be fused unless specifically noted otherwise.

K. The disconnect door cover shall have an interlocking mechanism to prevent opening the cover when the switch is in the ON position.

L. Fuses serving motor loads shall be Class L and Class RK1, 250V and 600V, time delay, dual element unless noted otherwise on the construction documents.

M. Fuses serving non-motor loads shall be Class L and Class RK1, 250V and 600V, fast acting, dual element unless noted otherwise on the construction documents.

N. Provide built-in fuse pullers.

PART 3 EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. All laboratory electrical work shall conform to National Electrical Contractors Association standards of installation and the requirements of the manufacturer, Division 1, Division 26, and the Owner’s Representative.

B. The Contractor shall field-verify all dimensions and coordinate dimensions with equipment sizes and locations.

C. The Contractor shall coordinate and install all penetrations, openings, slots, chases, or sleeves as necessary for the routing and installation of laboratory electrical equipment. The Contractor shall provide approved fire sealant to maintain fire ratings at all penetrations.

D. The Contractor shall coordinate and cooperate with all other trades for a successful completion of the laboratory electrical work.

E. The Contractor shall install access panels in walls or ceilings in coordination with the Architect for all laboratory electrical equipment, which require access.
F. All laboratory electrical equipment shall be installed plumb, parallel, or orthogonal to structure and in a neat orderly fashion. All material shall be accessible for maintenance, inspection, servicing or replacement.

G. Verify final locations for laboratory electrical devices and equipment during the rough-in phase with dimensioned architectural drawings, fabrication drawings, or other space planning requirements included in the contract documents.

H. The Contractor shall provide adequate and qualified supervision for the work performed; no work shall be performed without the supervision of a representative of the Contractor.

3.2 GROUNDING AND BONDING

A. Special Cabinets
1. At all flammable materials storage cabinets, solvent storage cabinets, corrosive storage cabinets and gas safety cabinets, provide a (minimum) #12 AWG copper, insulated green grounding conductor from the equipment grounding conductor of the nearest available 120 volt circuit outlet box.
2. Extend cabinet bonding conductor from the nearest circuit outlet box via ½” conduit concealed in wall and stubbed out behind the respective cabinet. Conduit shall be converted to flexible metal conduit where exposed, and shall terminate with a UL listed bushing. Where indicated on the drawings, provide a flush wall box with cover plate (with grommeted hole, ½” diameter) and extend bonding conductor from wall box to equipment terminal.
3. The bonding conductor shall be secured to the bonding terminal of the cabinet. If the cabinet is not equipped with a bonding terminal, provide a UL listed screw terminal and permanently secure it to the metallic cabinet with a screw, lockwasher and bolt. Self-tapping sheet metal screws will not be accepted as the means of attachment.
4. Refer to the Lab Furnishings (LF) specifications and drawings for cabinet specs, details, quantities and locations. Bonding shall be provided at each cabinet whether or not specifically indicated at each cabinet location.

B. Grounding Bus at Storage Rooms
1. Where indicated on the drawings, provide copper bus bar assemblies, wall mounted on insulator bushings, secured to the building framing structures.
2. For each area containing a ground bus bar system, provide a dedicated conduit homerun to the respective branch circuit panel serving the area. Install an insulated copper grounding conductor (green color).
3. Provide listed fittings, nuts, bolts, connectors and miscellaneous hardware for a complete ground bus system.

3.3 COMMISSIONING

A. The Contractor shall initiate start up of all laboratory electrical equipment including operation of all devices, switches, overcurrent protection, disconnect switches, etc. to verify normal operation of all moving parts and electrical performance.

B. The Contractor shall test, adjust, align, label, clean and complete all systems prior to acceptance by the Owner’s Representative.
C. The Contractor shall demonstrate that all systems operate within the manufacturer’s recommended performance characteristics, the laboratory electrical construction documents, system requirements, and Owner requirements.

D. The Contractor shall test each laboratory electrical system per the manufacturer’s requirements and shall perform the following system tests:

1. Inspect cables for physical damage and proper connection.
2. Torque test cable connection and tighten in accordance with termination manufacturers recommendations.
3. Infrared scan all connections under loaded conditions and provide color printed images.
4. Insulation resistance test of each cable.
5. Inspect ground system connections.
6. Voltage drop tests on the main grounding electrode of system.
7. Determine the ground resistance between the main grounding system and all major electrical equipment frames, system neutral points.
8. Check rated voltage and phase balance at all equipment, motors and selected devices at full load conditions. Measure no load voltage conditions at each location.
9. Furnish all material, equipment, instruments and labor as required to complete testing.
10. Provide all test results properly bound in a three-ring binder.

3.4 CLEANING

A. Contractor shall clean all equipment, conduit interiors, fixtures, devices, etc. of all extraneous paint, drywall mud, overspray, dust, dirt, debris, trash, grease or markings. All cleaning shall be performed by the Contractor in accordance with the appropriate manufacturer’s recommendations.

3.5 RACEWAYS

A. EMT shall be run indoors concealed in drywall type construction, above suspended ceilings, or in utility chases at casework or lab benches. In unfinished indoor areas, EMT shall be run exposed no less than 8'0" above finished floor.

B. EMT shall not be installed underground or embedded in concrete.

C. Flexible conduit shall not exceed 6'0" in length.

D. Flexible conduit used for final connection to laboratory equipment shall not exceed 2'0" in length.

E. The conduit grounding system shall be continuous as recommended by the manufacturer and UL approved.

F. Liquidtight flexible conduit shall be used for final connection to machines, motors, transformers and equipment that requires vibration isolation.

G. Liquidtight flexible conduit shall be used for final connection to equipment in wet or damp locations or where exposed to grease, water, dust, dirt, pathogens, vapors, or chemicals.
3.6 WIRE AND CABLE

A. All wiring methods shall comply with the latest enforced edition of the National Electrical Code and the local authority having jurisdiction.

B. Conductors shall be installed in clean raceways using nylon cord, polypropylene cord, hemp rope, or other material, which will not damage the conductors or conduit. Do not use metal fish tape. Use lubricant when necessary for pulling.

C. Conductors shall be pulled into conduit simultaneously so as to not damage conductors during pulling.

D. Conductors installed at outlets and switches shall have a minimum of 6” pigtail left in the box for future connections. All conductors not connected to devices shall be terminated with splice caps and tape.

E. Conductors shall be terminated such that no copper material is exposed. Conductors shall be trained and labeled at terminations in a neat and workmanlike manner.

F. All terminations shall be mechanically sound, featuring helical twisting of the terminating conductors prior to the application of an electrical connector. The electrical connector shall not be used for the mechanical connection of the conductors.

G. All terminations shall comply with the manufacturer’s installation and torquing requirements.

H. Splices on conductors #10AWG and smaller shall be made with splice caps twisted onto the conductors. Tape all splices.

I. Splices on conductors #8AWG and larger shall be made with pressure connectors and terminal lugs. Where exposed to water, damp air, or moisture, splices shall be watertight.

J. Splices shall not be made in feeders; splices to branch circuits shall not be made within panelboards or similar enclosures.

K. When combining homeruns, the Contractor shall derate all conductors per code requirements including reducing the ampacity, using high temperature insulation where necessary. Conduit sizes shall be adjusted by the Contractor as suitable for the conductor revisions.

L. The Contractor shall provide a code-sized insulated ground conductor, in addition to the feeder conductors indicated on the drawings, where non-metallic conduit is used.

M. Conductors shall be color-coded as follows or as matches the building standard:

<table>
<thead>
<tr>
<th>208Y/120V</th>
<th>Phase</th>
<th>480Y/277V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>A</td>
<td>Brown</td>
</tr>
</tbody>
</table>
Red          B          Orange
Blue         C          Yellow
White        Neutral    Gray
Green        Ground     Green

N. Where tape or labels are used for color-coding, apply material at each end of the conductor, splices, boxes, and all terminations.

3.7 BOXES

A. All box installation methods shall comply with the latest enforced edition of the National Electrical Code and the authority having jurisdiction.

B. Install all boxes plumb, square, and securely fastened to structure.

C. Boxes shall be placed such that they are readily accessible.

D. Cover or plug all unused openings in boxes where knockout blanks have been removed.

E. Install boxes such that they are flush with the finished surface of the wall or surface within which they are mounted.

F. Install all boxes at mounting heights per architectural, electrical code, and ADA requirements.

G. Boxes shall not be mounted back to back in walls.

H. Boxes in sealed environments shall be sealed with an approved sealant suitable for the application.

I. Boxes penetrating fire rated walls or surfaces shall be sealed with a Fire Marshal approved fire sealant to maintain the fire rating of the wall or surface.

J. Boxes located above inaccessible ceilings shall be made accessible by means of access doors or hatches in the ceiling.

K. Install all boxes per manufacturer’s recommendations and requirements.

L. Provide for ground continuity at all boxes.
3.8 WIRING DEVICES

A. Installation methods for wiring devices shall comply with the latest enforced edition of the National Electrical Code and the local authority having jurisdiction.

B. Install all devices in accordance with the manufacturer’s recommendations and requirements.

C. Coordinate device mounting height, location and type with architectural and interior drawings. Coordinate with other trades to identify conflicts with device locations and notify the Engineer of any conflicts.

D. Install devices only in clean boxes.

E. Install all trim rings and coverplates in coordination with other trades and their installation schedules.

F. Tighten and inspect all connections prior to covering devices and reconnect or repair wiring as necessary.

G. Test all devices for voltage level, continuity, ground fault, and short circuits.

H. Install all devices plumb and square to structure and adjacent surfaces.

I. Connect and inspect all ground bonds prior to covering device.

J. Demonstrate the proper operation of all ground fault interrupting devices.

3.9 DISCONNECT SWITCHES

A. Installation methods for disconnects shall comply with the latest enforced edition of the National Electrical Code and the local authority having jurisdiction.

B. Install all disconnects in accordance with the manufacturer’s recommendations and requirements.

C. Coordinate disconnect mounting height, location and type with architectural and interior drawings. Coordinate with other trades to identify conflicts with device locations and notify the Engineer of any conflicts. Mount switches 42” above finished floor unless noted otherwise.

D. Provide suitable galvanized metal strut framework where no wall or structure is available for the mounting of disconnects.

E. Provide flexible conduit connections for disconnects mounted to strut framework, motors, or vibrating equipment.
F. Tighten and inspect all connections and reconnect or repair wiring as necessary.

G. Test all disconnects for voltage level, continuity, ground fault, and short circuits. Check switch mechanism operation under no load conditions prior to operating under load.

H. Install all disconnects plumb and square to structure and adjacent surfaces.

I. Provide and install all fuses sized per the equipment manufacturer’s recommendation.

END OF SECTION 26 60 00
PART 1 - GENERAL

1.1 PROJECT REVIEW
A. This project includes voice and data cabling at Montana State University located in Bozeman, Montana.

1.2 SUMMARY OF WORK
A. This project includes the installation, testing and certification of telephone and data networking components at Montana State University. Network media included in this project are horizontal Category 6 data and voice cabling, backbone multi-pair copper cable, and backbone singlemode fiber optic cable. The drawings listed below provide further details of the installation.

1.3 RELATED PROJECTS
A. The Contractor for this project will be required to coordinate with other contractors providing data, telephone, audio and video equipment and installation directly to the Owner.

1.4 DIVISION 27 OVERVIEW
A. Section 27 01 00 Basic Telecommunications Requirements
B. Section 27 11 00 Telecommunications Rooms
C. Section 27 12 00 Pathways, Fittings and Boxes
D. Section 27 15 00 Backbone Cabling Requirements
E. Section 27 16 00 Horizontal Cabling Requirements

1.5 DRAWING OVERVIEW
A. Associated with this Division 27 specification is a series of drawings to indicate outlet locations and types of services delivered.

<table>
<thead>
<tr>
<th>Sheet</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN1-00</td>
<td>TELECOMM. PLAN – BASEMENT</td>
</tr>
<tr>
<td>TN1-01</td>
<td>TELECOMM. PLAN – BASEMENT, ROOM B0111</td>
</tr>
<tr>
<td>TN1-11</td>
<td>TELECOMM. PLAN – LEVEL 1, OVERALL</td>
</tr>
<tr>
<td>TN1-12</td>
<td>TELECOMM. PLAN – LEVEL 1, WEST</td>
</tr>
<tr>
<td>TN1-13</td>
<td>TELECOMM. PLAN – LEVEL 1, EAST</td>
</tr>
<tr>
<td>TN1-14</td>
<td>TELECOMM. PLAN – LEVEL 1, INTRA-BUILDING BACKBONE</td>
</tr>
<tr>
<td>TN1-21</td>
<td>TELECOMM. PLAN – LEVEL 2, OVERALL</td>
</tr>
<tr>
<td>TN1-22</td>
<td>TELECOMM. PLAN – LEVEL 2, WEST</td>
</tr>
<tr>
<td>TN1-23</td>
<td>TELECOMM. PLAN – LEVEL 2, EAST</td>
</tr>
<tr>
<td>TN1-24</td>
<td>TELECOMM. PLAN – LEVEL 2, INTRA-Building BACKBONE</td>
</tr>
<tr>
<td>TN1-31</td>
<td>TELECOMM. PLAN – LEVEL 3, OVERALL</td>
</tr>
<tr>
<td>TN1-32</td>
<td>TELECOMM. PLAN – LEVEL 3, WEST</td>
</tr>
<tr>
<td>TN1-33</td>
<td>TELECOMM. PLAN – LEVEL 3, EAST</td>
</tr>
<tr>
<td>TN1-34</td>
<td>TELECOMM. PLAN – LEVEL 3, INTRA-BUILDING BACKBONE</td>
</tr>
</tbody>
</table>
1.6 CONTRACTOR QUALIFICATIONS

A. Division 27 Sub-contractor shall be a certified TE Connectivity Network Design & Installation (ND&I) Contractor and will be required to provide a TE 25-year performance warranty on parts and labor for the copper cabling system. Proof of the Sub-Contractor’s ability to provide such a warranty shall be submitted to the General Contractor at the time of bidding and to the Owner prior to the Notice To Proceed. This warranty shall cover the patch panels, horizontal cabling, and work area outlets.

B. Contractor shall employ, in conjunction with construction of the project, a capable, experienced, and reliable foreperson and such skilled workers as may be required for the various classes of work to be performed. Contractor shall be required to submit evidence of foreperson’s skilled experience on EIA/TIA certified fiber optic systems. Evidence of experience shall be submitted to Owner with submittal of bid. Minimum experience for any workman involved in cabling work shall be.

1. Cable pulling and termination work on projects for a minimum of 5 years. Provide references throughout this period.

2. Completion of training (40 hrs. minimum) which certifies the person’s work in fiber optic installations.

3. If, in the opinion of the Owner’s representative, the Contractor’s employees do not possess the necessary qualifications to install cabling and terminations, the Contractor will be required to obtain the services of workers who are certified and trained by an appropriate schooling organization. These workers, if required, shall be provided at no additional expense to the Owner.

4. Contractor shall comply with all MSU wiring standards. Standards can be found at: http://www.montana.edu/itcenter/wiringguidelines/index.html

END OF SECTION 27 00 00
SECTION 27 01 00 - BASIC TELECOMMUNICATIONS REQUIREMENTS

PART 1 – GENERAL

1.1 SCOPE OF WORK

A. Include in bid all labor, materials, tools, transportation, storage costs, training, equipment, insurance, temporary protection, permits, inspections, taxes and all necessary and related items required to provide complete and deliver operational systems shown and described.

B. References to Codes and Standards called for in the Contract Documents mean the latest edition, amendment and revisions to the Codes and Standards in effect on the date of these Contract Documents.

A. Minimum composition requirements and/or installation methods for the following materials and work are included in this Section:
   a) Miscellaneous supports
   b) Access doors and panels
   c) Fire stopping
   d) Flashing and sealing
   e) Cutting and patching
   f) Waterproofing

C. Contract shall include, but not be limited to:
   A. Copper and fiber optic cabling
   B. Routing cabling through new telecommunication pathways
   C. Telecommunication spaces

1.2 RELATED SECTION AND DOCUMENTS

B. All drawings and general provisions of Contract and Instructions to Bidders apply to this section and all other sections of Division 27.

1.3 REGULATIONS AND CODE COMPLIANCE

B. All work and materials shall conform to and be installed, inspected and tested in accordance with the governing rules and regulations of federal, state and local governmental agencies.

C. The following is a list of codes and standards that will apply to this project:
   A. Federal Occupational Safety and Health Administration - OSHA
   C. National Electrical Safety Code, 2002
   D. Underwriters Laboratory (UL)
   E. Owner’s Insurance Carrier
   F. ANSI/TIA/EIA - Building Telecommunications Standards
   G. BICSI Telecommunications Distribution Methods Manual
   H. IEEE Standards
   I. Federal Communications Commission
1.4 GLOSSARY

A. ANSI American National Standards Institute
B. ASME American Society of Mechanical Engineers
C. ASTM American Society for Testing Materials
D. BICSI Building Industry Consulting Services International
E. EIA Electronic Industries Association
F. ER Equipment Room
G. FCC Federal Communications Commission
H. FM Factory Mutual Insurance Company
I. IEEE Institute of Electrical and Electronics Engineers
J. IRI Industrial Risk Insurers
K. ISD Information Systems Division
L. ISO International Standards Organization
M. NEC National Electrical Code
N. NEMA National Electrical Manufacturers’ Association
O. NESC National Electrical Safety Code
P. NFPA National Fire Protection Association
Q. OSHA Occupational Safety and Health Administration
R. TIA Telecommunications Industry Association
S. TR Telecommunications Room
T. UFPO Underground Facilities Protective Organization
U. UL Underwriter’s Laboratories, Inc.

1.5 DEFINITIONS

A. Approved / Approval: Written permission to use a material or system.
B. As Called For: Materials, equipment including the execution Specified/shown in the contract documents.
C. Code Requirements: Minimum requirements.
D. Concealed: Work installed in pipe and duct shafts, chases or recesses, inside walls, above ceilings, in slabs or below grade.
E. Design Equipment: Refer to the article, BASIS OF DESIGN.
F. Design Make: Refer to the Article, BASIS OF DESIGN.
G. Equal or Equivalent: Equally acceptable
H. Exposed: Work not identified as concealed.
I. Final Acceptance: Owner acceptance of the project from Contractor upon certified by Consultant.
J. Furnish: Supply and deliver to installation location.
K. Furnished by Others: Receive delivery at job site or where called for and install.
L. Inspection: Visual observations by Owner’s site Representative.
M. Install: Mount and connect equipment and associated materials ready for use.
N. Labeled: Refers to classification by a standards agency.
O. Make: Refer to the article, BASIS OF DESIGN.
P. Or Approved Equal: Approved equal or equivalent as determined by Consultant.
Q. Consultant: The Prime Professional
R. Prime Professional: Architect or Engineer having a contract directly with the Owner for professional services.
S. Provide: Furnish, install and connect ready for use.
T. Relocate: Disassemble, disconnect, and transport equipment to new locations, then clean, test, and install ready for use
U. Replace: Remove and provide new item.
V. Review: A general contractual conformance check of specified products.
W. Roughing: Pipe, duct, conduit, equipment layout and installation.
X. Satisfactory: As specified in contract documents.
Y. Site Representative: Construction Manager or Owner’s Inspector at the work site.
Z. Refer to General Conditions of the Contract for additional definitions.

1.6 INTENT OF DRAWINGS
A. The drawings are diagrammatic, unless detailed dimensioned drawings are included. Drawings show approximate locations of equipment, and fixtures. Exact locations are subject to the approval of the Consultant.
B. Anything mentioned in the Specifications and not shown in the Drawings, or shown in the Drawings and not mentioned in the Specifications, shall be of like effect as if shown and mentioned in both. In case of differences between the Drawings and the Specifications, the stricter provision as determined by the Consultant shall govern. Omissions from the Drawings or Specifications, or the incorrect description of details of Work which are evidently necessary to carry out the intent of the Drawings and Specifications, or which are customarily performed, shall not relieve the Contractor from performing such omitted or incorrectly described details of the Work, but they shall be performed as if correctly described in the Contract Documents. Acceptance of this project by the Contractor acknowledges that they have verified all field measurements, field construction criteria, materials, catalog numbers and similar data, or will do so, and that they will check and coordinate each shop drawing and sample with the requirements of the Work and of the Contract Documents.

1.7 REVIEW OF THE CONTRACT DOCUMENTS
A. The contractor shall carefully study and compare the Contract Documents and shall at once report to the Consultant any error, inconsistency or omission he or she may discover. If
contractor performs any construction activity knowing it involves a recognized error, inconsistency or omission in the contract documents without such notice to the Consultant or Owner, the contractor shall assume appropriate responsibility for such performance and shall bear an appropriate amount of the attributable cost for correction.

B. The contractor must verify all dimensions locating the work and its relation to existing work, all existing conditions and their relation to the work and all man made obstructions and conditions, etc. affecting the completion and proper execution of the work as indicated in the Contract Documents.

1.8 EXAMINATION OF THE PREMISES

A. Contractor shall visit Site to familiarize themselves with the local conditions under which the work is to be performed and correlate their observations with the requirements of the Contract Documents. No allowance will be made for claims for concealed conditions, which Contractor, in exercise of reasonable diligence in its observations of the Site and review of the local conditions under which the work is to be performed, learned or should have learned of, unless otherwise specifically agreed by Owner and Consultant in writing.

B. Before ordering any materials or doing any work, the contractor shall verify all measurements and be responsible for correctness of same. No extra charge or compensation will be allowed for duplicate work or material required because of an unverified difference between an actual dimension and the measurement indicated in the drawings. Any discrepancies found shall be submitted in writing to the Project Manager and Consultant for consideration before proceeding with the work.

PART 2 – PRODUCTS

2.1 EQUIPMENT AND MATERIALS MINIMUM REQUIREMENTS

A. Materials shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less, in accordance with NFPA 255.

B. Provide materials that meet the following minimum requirements:

1. All equipment and material for which there is a listing service shall bear a National Recognized Testing Laboratory (NRTL) label.

2. Electrical equipment and systems shall meet UL Standards and requirements of the NESC. This listing requirement applies to the entire assembly. Any modifications to equipment to suit the intent of the specifications shall be performed in accordance with these requirements.

3. Equipment shall meet all applicable FCC Regulations

4. All materials, unless otherwise specified, shall be new and be the standard products of the manufacturer. Used equipment or damaged material will be rejected.

5. The listing of a manufacturer as “acceptable” does not indicate acceptance of a standard or cataloged item of equipment. All equipment and systems must conform to the Specifications and meet the quality of the design make.

6. The Contractor shall furnish and file with the proper Authorities all drawings required by them in connection with this work. The Contractor, if required, shall obtain all official permits, licenses and inspections and shall pay all legal and proper fees and charges.
7. The Contractor shall at inception of the work provide the Project Coordinator with copies of all required building and trade permits, if said are required.

8. The Contractor shall be responsible for arranging all inspections and for securing all required signatures. Upon completion of the work, properly completed permits shall be returned to the Project Coordinator, if any are required.

2.2 WORKMANSHIP, SUBSTITUTIONS AND WARRANTY

A. Materials and workmanship shall meet or exceed industry standards. Horizontal cabling and all related passive equipment shall be fully guaranteed by TE for a minimum of twenty-five years from final acceptance. All non TE components shall carry a one-year warranty. Cable integrity and associated terminations shall be thoroughly inspected, fully tested and guaranteed as free from defects, transpositions, opens-shorts, tight kinks, damaged jacket insulation, etc.

1. All labor must be thoroughly competent and skilled, and all work shall be executed in strict accordance with the best practice of the trades.

2. Contractor shall be responsible for and make good, without expense to the Owner, any and all defects arising during this warranty period that are due to imperfect materials, appliances, improper installation or poor workmanship.

3. No substitution will be considered unless written request has been submitted by the Bidder to the Consultant and has been approved by the MSU IT representative at least seven (7) days prior to the date for receipt of bids. Each request shall include the name of the material or equipment for which it is to be substituted and a complete description of the proposed substitution. Provide original product data (no copies will be accepted) with performance and test data and any other information necessary for an evaluation. See Division 1 for further information.

4. After a Contract is awarded, requests to substitute for previously approved materials shall be submitted by the Contractor to the Consultant and has been approved by MSU IT representative within seven (7) days, complete with reasons for substitution and savings, which accrue to Owner if substitutes are approved. Substitutes, after Contract award, will be considered only if equal or superior to that specified.

5. Approval of alternate or substitute equipment or material in no way voids Contract document requirements.

6. Under no circumstances shall the Owner be required to prove that an item proposed for substitution is not equal to the specified item. It shall be mandatory that the Contractor submit to the Owner all evidence to support his contention that the item proposed for substitution is equal to the contract specified item. The Owner’s decision as to the equality of substitution shall be final and without further recourse.

2.3 CABLES

A. Any cable associated with this Contract shall be suitable, listed and marked for use in a riser or plenum application unless noted otherwise. For example, riser cable shall minimally be CMR rated for riser spaces and CMP for plenum spaces per the 2014 National Electrical Code and shall meet all local and state codes.

2.4 FACTORY ASSEMBLED PRODUCTS

A. Provide maximum standardization of components to reduce spare part requirements.

B. Manufacturers of equipment assemblies that include components made by others shall assume
complete responsibility for final assembled unit.

1. All components of an assembled unit need not be products of same manufacturer, but the completed system shall supply the Owner with a minimum manufacturer’s 25-year performance warranty.

2. Constituent parts, which are alike, shall be product of a single manufacturer.

3. Components shall be compatible with each other and with the total assembly for intended service.

4. Contractor shall guarantee for the minimum of twenty-five years, the assemblies of components, and shall repair or replace elements of the assemblies as required to deliver complete assembly.

C. Components of equipment shall bear manufacturer's name or trademark, model number and serial number on a nameplate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

D. Major items of equipment that serve the same function must be the same make and model. Exception will be permitted if performance requirements cannot be met.

2.5 COMPATIBILITY OF RELATED EQUIPMENT

A. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that a complete and fully operational system will result.

B. Provide maximum standardization of components to reduce spare part requirements.

C. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.

1. Constituent parts that are alike shall be product of a single manufacturer.

2. Contractor shall guarantee assemblies of components, and shall repair or replace elements of the assemblies as required to deliver the complete assembly.

3. Components of equipment shall bear manufacturer’s name or trademark, model number and serial number on a nameplate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

2.6 SPECIAL TOOLS

A. If any part of equipment requires a special tool for assembly, adjustment or maintenance thereof and such tool is not readily available on commercial tool market, it shall be furnished by the Contractor.

2.7 LIFTING ATTACHMENTS

A. Provide equipment with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered without bending or distortion of shape, such as rapid lowering and braking of load.
2.8 MISCELLANEOUS SUPPORTS
   A. Metal bars, plates, tubing, etc. shall conform to ASTM standards:
      1. Steel plates, shapes, bars, and grating - ASTM A 36
      2. Cold-Formed Steel Tubing - ASTM A 500
      3. Hot - Rolled Steel Tubing - ASTM A 501
      4. Steel Pipe - ASTM A 53, Schedule 40, welded
   B. Metal Fasteners shall be Zinc-coated (type, grade and class as required)

2.9 FIRESTOPPING
   A. Fire stopping for Openings through Fire and Smoke Rated Walls and Floor Assemblies shall be listed or classified by an approved independent testing laboratory for “Through-Penetration Fire-Stop Systems.” The system shall meet the requirements of “Fire Tests of Through-Penetration Fire-Stops” designated ASTM E814.
   B. Inside of all conduits, the fire-stop system shall consist of a dielectric, water resistant, non-hardening, permanently pliable/re-enterable putty along with the appropriate damming or backer materials (where required). The sealant must be capable of being removed and reinstalled and must adhere to all penetrants and common construction materials and shall be capable of allowing normal wire/cable movement without being displaced.
   C. The Contractor shall patch all openings remaining around and inside all conduit, sleeves and cable penetrations to maintain the integrity of any fire rated wall, ceiling, floor, etc. The fire-stop system shall consist of a dielectric, water resistant, non-hardening, permanently pliable/re-enterable putty along with the appropriate damming materials (where required). The sealant must be capable of being removed and reinstalled and must adhere to all penetrants and common construction materials and shall be capable of allowing normal wire/cable movement without being displaced.
   D. All building conduits and sleeves installed and/or used under this contract shall be fire-stopped, or re-fire-stopped, upon cable placement through such passageways.
   E. Manufacturer's recommended installation standards must be closely followed (i.e. minimum depth of material, use of ceramic fiber and installation procedures).

PART 3 – EXECUTION

3.1 ROUGH-IN
   A. Before construction work commences, the Contractor shall visit the site and identify the exact routing for all horizontal pathways.
   B. Due to small scale of Drawings, it is not possible to indicate all offsets, fittings, changes in elevation, etc. Verify final locations for installation with field measurements and with the equipment being connected. Verify exact location and elevations at work site prior to any rough in work. If field conditions, details, changes in equipment or shop drawing information require a significant change to the original documents, contact the owners’ representative for approval before proceeding.
   C. All equipment locations shall be coordinated with other trades, other renovation projects, and existing conditions to eliminate interference with required clearances for equipment maintenance and inspections.
1. Coordinate work with other trades, other renovation projects, and existing conditions to determine exact routing of all cable tray, hangers, conduit, etc., before fabrication and installation. Verify with Consultant exact location and mounting height of all equipment in finished areas, such as equipment racks, communication and electrical devices. Coordinate all work with existing Architecture.

2. Where more than one trade is involved in an area, space or chase, all shall cooperate and install their own work to utilize the space equally between them in proportion to their individual requirements. There will be no priority schedule for trades. If, after installation of any equipment, piping, ducts, conduit, and boxes, it is determined that ample maintenance and passage space has not been provided, rearrange work and/or furnish other equipment as required for ample maintenance space. Any changes in the size or location of the material or equipment supplied or proposed, which may be necessary in order to meet field conditions or in order to avoid conflicts between trades, shall be brought to the immediate attention of the Consultant and approval received before such alterations are made.

D. Provide easy, safe, and code mandated clearances at equipment racks and enclosures, and other equipment requiring maintenance and operation.

E. The Contractor shall be responsible for all required locations, cutting, patching, coring and associated work for the complete cabling system at no additional cost to the Owner.

3.2 CUTTING AND PATCHING

A. Contractor shall include the required cutting and patching work to perform work. Cut and drill from both sides of walls and/or floors to eliminate splaying. Patch adjacent existing work disturbed by installation of new work including insulation, walls and wall covering, ceiling and floor covering, other finished surfaces. Patch and/or paint openings and damaged areas equal to existing surface finish. Cut openings in prefabricated construction units in accordance with manufacturer's instructions.

3.3 CHASES

A. General:

1. Assume responsibility for correct and final location and size of such pathways.

2. Rectify improperly sized, improperly located or omitted conduit due to faulty or late information or failure to check final location.

3. Correct, by drilling, omitted or improperly located sleeves. Assume responsibility for all work and equipment damaged during course of drilling. Cap or fire stop all unused conduits and sleeves.

4. Seal voids in fire rated assemblies with a fire-stopping seal system to maintain the fire resistance of the assembly. Provide 18 gauge-galvanized sleeves at fire rated assemblies. Extend sleeves a minimum 2” above floors.

5. In wall openings, drill or cut holes to suit. Provide 18 gauge-galvanized sleeves at shafts and fire rated assemblies. Provide fire-stopping seal between sleeves and wall in drywall construction. Provide fire stopping similar to that for floor openings.
3.4 SUPPORTS
   A. Provide required supports, beams, angles, hangers, rods, bases, braces, straps, struts, and other items to properly support contract work. Supports shall meet the approval of the Consultant. Modify studs, add studs, add framing, or otherwise reinforce studs in metal stud walls and partitions as required to suit contract work. If necessary, in stud walls, provide special supports from floor to structure above. For precast Panels/Planks and Metal Decks, support communication work as determined by manufacturer and Consultant. Provide heavy gauge steel mounting plates for mounting contract work. Mounting plates shall span two or more studs. Size, gauge, and strength of mounting plates shall be sufficient for equipment size, weight, and desired rigidity.

3.5 GENERAL INSTALLATION REQUIREMENTS
   A. Coordinate ordering and installation of all equipment with long lead times or having a major impact on work by other trades so as not to delay the job or impact the schedule.
   B. Where mounting heights are not detailed or dimensioned, install systems, materials and equipment to provide the maximum headroom possible.
   C. Set all equipment to accurate line and grade, level all equipment and align all equipment components.
   D. Provide all scaffolding, rigging, hoisting and services necessary for erection and delivery of equipment and apparatus furnished into the premises. These items shall be removed from premises when no longer required.
   E. No equipment shall be hidden or covered up prior to inspection by the Consultant and MSU IT representative. All work that is determined to be unsatisfactory shall be corrected immediately.
   F. All work shall be installed level and plumb, parallel and perpendicular to other building systems and components.
   G. Contractor shall replace/repair all ceiling tiles or plaster damaged by work performed as part of Division 27 contract.

3.6 PAINTING
   A. Contract includes the following:
      1. Painting for all cut and patch work performed as part of Division 27 contract.
      2. Painting for junction boxes and conduits per Owner’s standards or Division 27 standards.
      3. Painting for damage to existing wall and ceiling surfaces.
      4. Under no circumstances shall any of the cabling be painted.

3.7 ADDITIONAL ENGINEERING SERVICES
   A. In the event that the Consultant is required to provide additional engineering services as a result of substitution of equivalent materials or equipment by the Contractor, or changes by the Contractor in dimension, weight, power requirements, etc., of the equipment and accessories furnished, or if the Consultant is required to examine and evaluate any changes proposed by the Contractor for the convenience of the Contractor, then the Consultant’s expenses in connection with such additional services shall be paid by the Contractor and may be deducted from any moneys owed to the Contractor.
   B. In the event that the Consultant is required to provide additional engineering services as a
result of Contractor's errors, omissions or failure to conform to the requirements of the Contract Documents, or if the Consultant is required to examine and evaluate any changes proposed by the Contractor solely for the convenience of the Contractor, then the Consultant's expense in connection with such additional services shall be paid by the Contractor and may be deducted from any monies owed to the Contractor.

3.8 FIRE-STOPPING

A. Fire-stopping for Openings through Fire and Smoke Rated Wall and Floor Assemblies:

1. Provide materials and products listed. The system shall meet the requirements of "Fire Tests of Through-Penetration Fire-Stops" designated ASTM E814. To be used inside all conduits and sleeves. Caulk on exterior of conduit penetration.

2. Provide fire-stop system seals at all locations where conduit, fiber, cable trays, cables/wires, and similar utilities pass through or penetrate fire rated wall or floor assembly. Provide fire-stop seal between sleeve and wall for drywall construction.

3. The minimum required fire resistance ratings of the wall or floor assembly shall be maintained by the fire-stop system. The installation shall provide an air and watertight seal.

4. The methods used shall incorporate qualities that permit the easy removal or addition of conduits or cables without drilling or use of special tools. The product shall adhere to itself to allow repairs to be made with the same material and permit the vibration, expansion and/or contraction of any items passing through the penetration without cracking, crumbling and resulting reduction in fire rating. Typical rating:

   a) Floors - 3 hours
   b) Corridor walls - 2 hours
   c) Offices - ¾ hour
   d) Smoke partitions - ¾ - 1 hour

END OF SECTION 27 01 00
PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, tools, and equipment required for the complete installation of work called for in the Contract Documents.

1.2 SCOPE

A. This Section includes the minimum requirements for equipment and cable installations in the Telecommunications Room.

B. Minimum composition requirements and installation methods for the following:
   1. 19” Racks
   2. Cable management
   3. Fiber optic patch panels and accessories
   4. Category 6 patch panels
   5. Building Entrance Terminal
   6. Voice patch panels
   7. 110 Blocks

1.3 QUALITY ASSURANCE

A. All telecommunication room hardware shall be installed in a neat and workmanlike manner in meeting the requirements of the National Electrical Code (NEC). All methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the Owner’s representative. Materials that are specified in this Section shall be of the quality and manufacture indicated. Where “approved equal” is stated, the materials shall be equivalent in every way to that of the material specified, and subject to written approval.

B. Materials and work specified herein shall comply with the latest applicable requirements of:
   1. ANSI/TIA-568-C.0 Generic Telecommunications Cabling for Customer Premises
   2. ANSI/TIA-568-C.1 Commercial Building Telecommunications Standard
   3. ANSI/TIA-568-C.2 Balanced Twisted-Pair Telecommunications Cabling and Components Standard
   4. ANSI/TIA-568-C.3 Optical Fiber Cabling Components Standard
   5. ANSI/TIA/-569-B, Commercial Building Standard for Telecommunications Pathways and Spaces
   6. ANSI/TIA–606-B, Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   7. ANSI/TIA-J-STD-607-B, Commercial Building Grounding and Bonding Requirements for Telecommunications
   8. Underwriters Laboratory (UL)
   10. National Electrical Code (NEC)
1.4 SUBMITTALS

A. Provide product data for the following:
1. 19” racks
2. Cable management
3. Fiber optic patch panels
4. Category 6 patch panels
5. Building Entrance Terminal
6. Voice patch panels
7. 110 Blocks

PART 2 – PRODUCTS

2.1 19” RACKS

A. Use racks conforming to EIA Standard 310-D. Refer to drawings for details.

B. Racks shall include horizontal wire management features between all components as well as vertical wire management on all sides of the racks.

C. Design Make:
   1. CHATSWORTH, Universal Rack (Part # 46353-5-03).

2.2 CABLE MANAGEMENT

A. Provide wire management between each component (patch panel, active components, etc.) in all racks as well as vertical management on all sides of racks.

B. Design make:
   1. TE, Horizontal wire manager (Part # 558331-1).
   2. SIEMON, Rear wire minders (Part # WM-BK).
   3. CHATSWORTH, Vertical wire management unit (Part # 40100-703).

2.3 FIBER OPTIC PATCH PANELS AND ACCESSORIES

A. Provide fiber optic patch panels as indicated on the drawings.

B. Design make:
   1. CORNING, 2U fiber panel (Part # CCH-02U). Required in 0110, 0210, 0310, 0123, 0301A & EPS 289A.
   2. CORNING, 4U fiber panel (Part # CCH-04U). Required in 0164B, 0266, & 0364.
   3. CORNING, Fiber optic adapter plate duplex, APC, 12 F, singlemode (OS2) (Part # CCH-CP12-B3). As required. Blank all unused panels (Part # CCH-BLNK).
   5. CORNING, Splice Cassette (Part # CCH-CS). As required.
   6. CORNING, Buffer tube fan out kit (Part # FAN-BT36-12). As required.
   7. CORNING, 12-fiber LC APC singlemode pigtail (Part # 002212R5120001M). As required.
   8. CORNING, 12-fiber LC multimode pigtail (Part # 000312T5120001M). As required.
   9. CORNING, LC APC singlemode Unicam connector for tight buffered AV cables. See TN1-12 key note 4 and TN1-13 key note 5 (Part # 95-200-99). As required.
2.4 CATEGORY 6 PATCH PANELS

A. Provide category 6 patch panels as indicated on the drawings.

B. Design make:
   1. TE, 48-port Category 6 patch panel (Part # 1375015-2).

2.5 Building Entrance Terminal

A. Provide building entrance terminal as indicated on the drawings.

B. Design make:
   1. TII, 100-pair building entrance terminal (Part # 24100-110-M110C). Two Required. NAH side.
   2. TII, 5-pin gas-tube protector modules (Part # 175BCXN-230). 400 required. NAH side.
   3. TII, 100 Pair Wire-Wrap & Quick Clip Connector Block, (Part # P399-QC-24-50). Two required. Renne side. Contractor provided and installed by MSU ITC.
   4. TII, 5-Pin Solid State Protector Modules (Part # 115-6C1FSC-N). 400 required. Renne side. Contractor provided and installed by MSU ITC.
   5. TE, 100 Pair 110Connect XC Category 5e Kits, (Part # 569440-1). Two required. Renne side.

2.6 Voice Patch Panels

A. Provide voice patch panels as indicated on the drawings.

B. Design make:
   1. TE, 48-port voice patch panel (Part # 557411-1).

2.7 110 Blocks

A. Provide 110 blocks as indicated on the drawings.

B. Design make:
   1. TE, 300 pair 110Connect XC Category 5e Kits, (Part # 569446-1). Two required. Located in 0164B.
   2. TE, 100 pair 110Connect XC Category 5e Kits, (Part # 569440-1). 5 required. Located in 0110, 0266, 0210, 0364, and 0310.

PART 3 - EXECUTION

3.1 EQUIPMENT RACK

A. The equipment rack shall be constructed using approved methods and materials. Install horizontal wire management between all patch panels and equipment.

B. Provide all miscellaneous installation hardware such as screws, brackets, hangers, equipment trays, etc., which may not be called out on the drawings, but are required
for installation which is acceptable to MSU IT representative.

3.2 GROUNDING AND BONDING

A. Grounding shall be accomplished by common single-point termination of all ground conductors.

B. Bond metallic equipment rack to the ground bar with #6 ground wire.

C. All connectors and clamps shall be UL Listed, mechanical type, made of silicon bronze.

D. Terminals shall be solderless compression type, copper long-barrel NEMA two bolt.

END OF SECTION 27 11 00
PART 1 - GENERAL

1.1 WORK INCLUDED

A. The work in this Section includes conduit and cable support systems required for telecommunications systems. See drawings for additional details.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Rigid conduit shall be galvanized rigid steel conforming to Federal Specification No. WW-C-581. Install bushings to protect cabling.

B. Intermediate metal conduit may be used only as permitted by the National Electric Code.

C. EMT shall be galvanized steel conforming to Federal Specification No. WW-C-563. May only be used where rigid steel is not called for or required by Code.
   1. Connectors and fittings up through 2" size to be steel compression type (cast metal is not acceptable). Setscrew type is not acceptable up through 2" size.
   2. Conduit runs shall be limited to 100 feet, with no more than two 90-degree bends between pull points or boxes.

D. Insulated bushings shall be O-Z/Gedney or equal Type B, SB or SBT and are required on all conduits.

E. Surface raceway systems shall be Wiremold (size 4000 with associated extra deep outlet boxes) or EMT unless otherwise noted and/or approved by the Consultant. Factory finish or field paint to match surface it is mounted on.

F. Cable tray to be Flextray by Cooper B-Line. Install per manufacturer’s recommendations. Where possible wall mount with 8 L BRKTEG “L” brackets. Use WB6CH hangers for ceiling mounted applications. Provide FTA2DO dropouts where cable leaves tray. Tray coating shall be electroplated zinc. Size shall be 4”x8”. Provide cable roller at all 90 degree turns.

G. Outlet boxes used with conduit shall be metal 4-inch square boxes with a minimum depth of 2 1/8" inches with a single gang mud ring unless noted otherwise. Refer to electrical.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Raceways shall be used throughout construction for all cables unless otherwise specifically indicated.

B. All conduits shall be provided with lock nuts, insulated throat connectors, and insulated bushings.
C. Conduit shall be concealed in finished spaces, unless otherwise indicated.

D. Installation of raceways to be coordinated with installation of other trades, in particular, ductwork and piping. The location of mechanical equipment and systems shall take precedence over raceway location. Installation shall not restrict equipment maintenance space or access thereto.

E. Hanging of raceways done in first-class manner using conduit clamps, Unistrut brackets, racks, etc., or other approved methods. Hanging off ductwork, suspended ceiling support wires or resting on ceiling support system or ceiling material is not permitted. Installation shall not interfere with removable ceiling panels or access openings.

F. Exposed conduit shall be run parallel and/or perpendicular with walls. Use appropriate factory fittings for changes in direction, terminations and connections.

G. Annular openings around conduit penetrating fire barriers such as floors, fire rated walls and fire rated ceilings shall be fire-stopped as specified in Section 27 01 00.

H. Conduit or raceway shall not be run through ductwork.

I. All conduits, regardless of the phase of the project, shall be kept closed so as to prevent the introduction of water, soil or vermin into the conduits or buildings.

J. Conduit shall be used for all locations where cabling penetrates a wall.

K. Conduits shall not exceed 40% fill ratio.

3.2 GROUNDING RACEWAY SYSTEM

A. All non-current carrying metallic parts of electrical equipment and all raceway systems shall be grounded.

B. Ground raceway systems and cabinets for auxiliary systems by bonding or by conduit interconnection with the electrical system or as otherwise specifically indicated on the drawings.
SECTION 27 15 00 - BACKBONE CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, tools, and equipment required for the complete installation of work called for in the Contract Documents.

1.2 SCOPE

A. This section includes the installation of multiple fiber optic cable and multiple category 3 cables. Refer to drawings for additional details. The MSU ITC representative requires 24 hour notice when access to telecommunications rooms in EPS and Renne is required.

1.3 QUALITY ASSURANCE

A. All cable shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner's Representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based upon the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Materials and work specified herein shall comply with the applicable requirements of:

1. ANSI/TIA-455-A, Standard Test Procedures for Fiber Optic Fibers, Cables and Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components

2. ANSI/ICEA S-80-576, Communications Wire and Cable for Wiring Premises

3. ANSI/ICEA S-83-596, Fiber Optic Premises Distribution Cable

4. ANSI/ICEA S-87-640, Fiber Optic Outside Plant Communications Cable

5. ANSI/TIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant OFSTP-14A

6. ANSI/TIA-598-A, Optical Fiber Cable Color Coding


8. ANSI/TIA–568-C

9. ANSI/TIA–569-B

10. ANSI/TIA-758-B

11. NFPA 70

12. BICSI Telecommunications Distribution Methods Manual

13. FCC 47 CFR 68

14. NEMA – 250

15. NEC - Articles 725, 760 770 and 800 (2011 or newer addition)

16. TSB-72

17. ISO/IEC 11801
1.4 SUBMITTALS

A. Manufacturer’s catalog sheets, specifications and installation instructions for all products to be installed within the scope of work included under this contract.

PART 2 - PRODUCTS

2.1 BACKBONE CABLES

A. An I/O riser rated 48-strand singlemode fiber optic cable shall be used for connectivity between the NAH and EPS. I/O plenum rated 24-strand singlemode and 12-strand multimode fiber optic cables shall be used for connectivity between Telecommunications Rooms. A 200-pair Category 3 cable shall be used for connectivity between the NAH and Renne Library. 50 Pair cables shall be used for connectivity between Telecommunications Rooms. See drawings for additional details.

2.2 FIBER OPTIC CABLE

A. Design Make: CORNING, I/O OS2 singlemode loose tube 48-strand riser rated fiber optic cable (Part # 048EUF-T4101D20). Run between EPS 289A and NAH 0164B.

B. Design Make: CORNING, I/O OS2 singlemode loose tube 12-strand riser rated fiber optic cable (Part # 012ESF-T4101D20). Run between NAH Parking garage TR and NAH 0164B.

C. Design Make: CORNING, I/O OS2 singlemode loose tube 12-strand plenum rated fiber optic cable (Part # 024ESP-T4101D20). Run between 0164B and 0110, 0266, and 0364. Also, run between 0266 and 0210 and between 0364 and 0310.

D. Design Make: CORNING I/O OM3 multimode loose tube 12-strand plenum rated fiber optic cable (Part # 012TSP-T4180D20). Run between 0164B and 0110, 0266, and 0364. Also, run between 0266 and 0210 and between 0364 and 0310.

E. Design Make: CORNING, OS2 singlemode tight buffered 6-strand plenum rated fiber optic cable (Part # 006E8P-31131-29) (For A/V, see TN1-12 key note 4 & TN1-13 key note 5). For key note 4, in room 0165 provide faceplate (TE, 4-port single gang, Part # 558088-1), 3 fiber optic couplers (TE, LC duplex coupler, Part # 1933286-3) and in room 0301A provide fiber optic patch panel (CORNING, CCH-2U) and LC 6 fiber adapter plate. For key note 5, in room 0123 provide fiber optic patch panel (CORNING, CCH-2U) and LC 6 fiber adapter plate. In room 0301A provide LC 6 fiber adapter plate. Install adapter plate in patch panel provided in key note 4.

2.3 CATEGORY 3 CABLE

A. Design Make: SUPERIOR ESSEX, AR Series 200-pair Category 3 OSP riser cable (Part # 02-108-03). Run between Renne 018D and NAH 0164B.

B. Design Make: SUPERIOR ESSEX, 200-pair Category 3 plenum rated cable (Part # 18-A99-36). Run between telephone switch room, Renne 73 and Renne 018D. MSU ITC will terminate this cable in Renne 73.
C. Design Make: SUPERIOR ESSEX, 50-pair Category 3 plenum rated cable (Part # 18-579-36). Run between 0164B and each TR.

D. Design Make: SUPERIOR ESSEX, 100-pair Category 3 riser rated cable (Part # 18-789-33). Run between Building Entrance Terminal and 110 block on telephone backboard in 0164B.

E. Design Make: SUPERIOR ESSEX, 50-pair Category 3 riser rated cable (Part # 18-579-33). Run between 110 block in 0164B and 110 block in each TR and between 110 block in each TR to voice patch panel in each TR.

PART 3 - EXECUTION

3.1 OPTICAL FIBER CABLE

A. Cable shall be pulled through MSU tunnel system. See TN4-01 for additional details.

B. Fiber optic cable not installed in conduit shall be run in 1” orange innerduct. Plenum rated innerduct is required within NAH. Innerduct shall be labeled every 200’ in the tunnel. Innerduct shall be labeled every 50’ within the building.

C. Maintain polarization for entire system as described in ANSI/EIA/TIA-568-A section 12.7.1.

D. Cable shall be continuous from source to destination.

E. For the fiber, leave a 15’ service loop at each end of the cable.

F. The contractor shall be responsible for verifying the actual footage’s and distances identified on the drawings (i.e. source to destination).

G. The contractor shall be responsible for verifying that conduits and raceways are “ready for occupancy” before cable placement.

H. The contractor shall assume the responsibility for any difficulties or damage to the cable during placement.

I. Cable shall be supported every 48” on center.

J. Test, label, and document.

3.2 CATEGORY 3 CABLE

A. Cable shall be pulled through MSU tunnel system. See TN4-01 for additional details.

B. Cable installation shall conform to industry standards with regard to anchoring, cable support and separation from other facilities.

C. Cable shall not sag or droop but should be installed so as to maintain a flat plane with smooth transitions from one level or direction to another.

D. Cable shall be sufficiently racked and supported in order to eliminate stress on the cable.
E. Cable shall be supported every 48" on center.

F. Cable shall not be allowed to lie on floors, ceiling or ceiling support structure. Cable must be secured in such a way as to not interfere with other services or space access.

G. The contractor shall be responsible for verifying the actual footage’s and distances identified on the drawings (i.e. source to destination).

H. The contractor shall be responsible for verifying that conduits and raceways are "ready for occupancy" before cable placement.

I. The contractor shall assume the responsibility for any difficulties or damage to the cable during placement.

J. Test, label, and document. Wiremap testing shall be performed on all pairs. Test results shall be delivered to MSU ITC representative and Engineer.

PART 4 - INSPECTION, TESTING, AND ACCEPTANCE OF FIBER OPTIC CABLING

4.1 WORK INCLUDED

A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.

B. In order to conform to the overall project event schedule, the cabling contractor shall survey the work areas and coordinate cabling testing with other applicable trades.

C. In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner’s representative of any additional tests that are deemed necessary to guarantee a fully functional system. The contractor shall carry out and record any additional measurement results at no additional charge.

4.2 SCOPE

A. This Section includes the minimum requirements for the test certification, identification and administration of backbone optical fiber cabling.

B. This Section includes minimum requirements for:
   1. Fiber optic test instruments
   2. Fiber optic testing
   3. Identification
   4. Labels and labeling
   5. Administration
   6. Test results documentation
   7. As-built drawings

C. Testing shall be carried out in accordance with this document. This includes testing the attenuation and polarity of the installed cable plant with an optical loss test set (OLTS) and the installed condition of the cabling system and its components with an optical time domain reflectometer (OTDR). The condition of the fiber endfaces shall also be verified.

D. Testing shall be performed on each cabling link (connector to connector).
E. Testing shall be performed on each cabling channel (equipment to equipment) that is identified by the owner.

1. Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

F. All tests shall be documented including OLTS dual wavelength attenuation measurements for multimode and singlemode links and channels and OTDR traces and event tables for multimode and singlemode links and channels. A copy of the tests shall be sent to both the Engineer and MSU IT representative.

1. Optionally documentation shall also include optical length measurements and pictures of the connector endface.

4.3 QUALITY ASSURANCE

A. All testing procedures and field-test instruments shall comply with applicable requirements of:

1. ANSI Z136.2, ANS For Safe Use Of Optical Fiber Communication Systems Utilizing Laser Diode And LED Sources


3. ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR.

4. ANSI/TIA/EIA-455-60A, Measurement of Fiber or Cable Length Using an OTDR.

5. ANSI/TIA/EIA-455-61A, Measurement of Fiber or Cable Attenuation Using an OTDR.


10. ANSI/TIA/EIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements.

11. The Owner or the Owner’s representative shall be notified of the start date of the testing phase five (5) business days before testing commences.

12. The Owner or the Owner’s representative will select a random sample of 5% of the installed links. The Owner or the Owner’s representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

4.4 SUBMITTALS

A. Manufacturers catalog sheets and specifications for fiber optic field-test instruments including optical loss test sets (OLTS; power meter and source), optical time domain reflectometer (OTDR) and inspection scope.

B. A schedule (list) of all optical fibers to be tested.
C. Sample test reports.

4.5 ACCEPTANCE OF TEST RESULTS

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in compliance with the following test limits:

1. Optical loss testing
   a) Multimode and singlemode links
      
      1) The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA/EIA-568-C.1:

      (i) Link Attenuation (dB) = Cable_Attn (dB) + Connector_Attn (dB) + Splice_Attn (dB)

      (ii) Cable_Attn (dB) = Attenuation_Coefficient (dB/km) * Length (Km)

      (iii) Connector_Attn (dB) = number_of_connector_pairs * connector_loss (dB)

      (iv) Maximum allowable connector_loss = 0.75 dB

      (v) Splice_Attn (dB) = number_of_splices * splice_loss (dB)

      (vi) Maximum allowable splice_loss = 0.3 dB

      (vii) The values for the Attenuation_Coefficient (dB/km) are listed in the table below:

      | Type of Optical Fiber     | Wavelength (nm) | Attenuation coefficient (dB/km) | Wavelength (nm) | Attenuation coefficient (dB/km) |
      |---------------------------|-----------------|---------------------------------|-----------------|---------------------------------|
      | Multimode 62.5/125 µm     | 850             | 3.5                             | 1300            | 1.5                             |
      | Multimode 50/125 µm       | 850             | 3.5                             | 1300            | 1.5                             |
      | Single-mode (Inside plant)| 1310            | 1.0                             | 1550            | 1.0                             |
      | Single-mode (Outside plant)| 1310           | 0.5                             | 1550            | 0.5                             |
      | Single-mode (Outside plant)| 1310           | 0.5                             | 1550            | 0.5                             |

2. OTDR testing
   a) Reflective events (connections) shall not exceed 0.75 dB.
   b) Non-reflective events (splices) shall not exceed 0.3 dB.

3. Magnified endface inspection
   a) Fiber connections shall be visually inspected for endface quality.
   b) Scratched, pitted or dirty connectors shall be diagnosed and corrected.

B. All installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described in Part 6. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation in accordance with Part 6.
C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Engineer and MSU IT representative.

PART 5 - PRODUCTS

5.1 OPTICAL FIBER CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer.

B. Optical loss test set (OLTS)

1. Optical fiber light source
   a) Provide dual laser light sources with central wavelengths of 1310 nm (±20 nm) and 1550 nm (±20 nm) and 850 nm (±20 nm) and 1300 nm (±20 nm).
   b) Output power of –10 dBm minimum.

2. Power Meter
   a) Provide 1310 nm and 1550 nm and 850 nm and 1300 nm wavelength test capability.
   b) Power measurement uncertainty of ± 0.25 dB.
   c) Store reference power measurement.
   d) Save at least 100 results in internal memory.
   e) PC interface (serial or USB).

3. Optional length measurement
   a) It is preferable to use an OLTS that is capable of measuring the optical length of the fiber using time-of-flight techniques.

C. Optical Time Domain Reflectometer (OTDR)

1. Shall have a bright, color transmissive LCD display with backlight.
2. Shall have rechargeable Li-Ion battery for 8 hours of normal operation.
3. Weight with battery and module of not more than 4.5 lb and volume of not more 200 in³.
4. Internal non-volatile memory and removable memory device with at least 16 MB capacity for results storage.
5. Serial and USB ports to transfer data to a PC.
6. Singlemode OTDR
   a) Wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm) and 850 nm (± 20 nm) and 1300 nm (± 20 nm).
   b) Event deadzones of 2 m maximum at 850, 1300, 1310, and 1550 nm.
   c) Attenuation deadzones of 15 m maximum at 850, 1300, 1310, and 1550 nm
   d) Distance range not less than 10000 m.
   e) Dynamic range at least 10 dB at 850, 1300, 1310, and 1550 nm

D. Fiber Microscope

1. Magnification of 250X or 400X for endface inspection
2. Optional requirements
   a) Video camera systems are preferred.
   b) Camera probe tips that permit inspection through adapters are preferred.
   c) It is preferable to use test equipment capable of saving and reporting the endface image.

E. Integrated OLTS, OTDR and fiber microscope
   1. Test equipment that combines into one instrument an OLTS, an OTDR and a fiber microscope may be used.

5.2 IDENTIFICATION
   A. Labels
      1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.
      2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).
      3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.
      4. Where insert type labels are used provide clear plastic cover over label.

5.3 ADMINISTRATION
   A. Administration of the documentation shall include test results of each fiber link and channel.
   B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
   C. The test result records saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records.

PART 6 – EXECUTION

6.1 GENERAL
   A. All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.
   B. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

6.2 OPTICAL FIBER CABLE TESTING
   A. Field-test instruments shall have the latest software and firmware installed.
   B. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
   C. Fiber endfaces shall be inspected at 250X or 400X magnification. 250X magnification is suitable for inspecting singlemode fibers. 400X magnification may be used for detailed examination of singlemode fibers. Scratched, pitted or dirty connectors shall be diagnosed and corrected.
   D. Testing shall be performed on each cabling segment (connector to connector).
E. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner’s instructions.

F. Testing of the cabling shall be performed using high-quality test cords of the same fiber type as the cabling under test. The test cords for OLTS testing shall be between 1 m and 5 m in length. The test cords for OTDR testing shall be approximately 100 m for the launch cable and at least 25 m for the receive cable.

G. Optical loss testing
   1. Backbone link
      a) Backbone links shall be tested at 850 nm, 1300 nm, 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper or the equivalent method.
      b) Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
      c) Use the One Reference Jumper Method specified by ANSI/TIA/EIA-526-14A, Method B and ANSI/TIA/EIA-526-7, Method A.1 or the equivalent method. The user shall follow the procedures established by these standards or application notes to accurately conduct performance testing.

H. OTDR Testing
   1. Backbone, horizontal and centralized links shall be tested at the appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.
   2. Each fiber link and channel shall be tested in one direction.
   3. A launch cable shall be installed between the OTDR and the first link connection.
   4. A receive cable shall be installed after the last link connection.

I. Magnified Endface Inspection
   1. Fibers shall be inspected at 250X or 400X magnification. 250X magnification is suitable for inspecting singlemode fibers. 400X magnification may be used for detailed examination of singlemode fibers.

J. Length Measurement
   1. The length of each fiber shall be recorded.
   2. It is preferable that the optical length be measured using an OLTS or OTDR.

K. Polarity Testing
   1. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with subclause 10.3 of ANSI/TIA/EIA-568-B.1. The polarity of the paired duplex fibers shall be verified using an OLTS.

6.3 IDENTIFICATION
   A. Labeling
      1. Labeling shall conform to the requirements specified within ANSI/TIA/EIA-606-B or to the requirements specified by the Owner or the Owner’s representative.

6.4 ADMINISTRATION
   A. Test results documentation
1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., “as saved in the field-test instrument”. The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.

2. The test results documentation shall be available for inspection by the MSU IT representative during the installation period and shall be passed to the MSU IT representative within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as-built information.

3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD-ROM prior to MSU IT representative acceptance of the building. This CD-ROM shall include the software tools required to view, inspect, and print any selection of the test reports.

4. Circuit IDs reported by the test instrument should match the specified label ID (see 6.3 of this Section).

5. The detailed test results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the following information
   a) The identification of the customer site as specified by the end-user
   b) The name of the test limit selected to execute the stored test results
   c) The name of the personnel performing the test
   d) The date and time the test results were saved in the memory of the tester
   e) The manufacturer, model and serial number of the field-test instrument
   f) The version of the test software and the version of the test limit database held within the test instrument
   g) The fiber identification number
   h) Test results to include OLTS attenuation link and channel measurements at the appropriate wavelength(s) and the margin (difference between the measured attenuation and the test limit value).
   i) Test results to include OTDR link and channel traces and event tables at the appropriate wavelength(s).
   j) The length for each optical fiber as calculated by the OTDR.
   k) The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements
   l) Optional
      1) A picture or image of each fiber end-face
      2) A pass/fail status of the end-face based upon visual inspection.

B. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the MSU IT representative, and at end of the project on CD-ROM. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. CAD drawings are to incorporate test data imported from the test instruments.
2. The as-built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as-builts shall include all field changes made up to construction completion:

a) Field directed changes to pull schedule.
b) Field directed changes to cross connect and patching schedule.
c) Horizontal cable routing changes.
d) Backbone cable routing or location changes.
e) Associated detail drawings.
PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, tools, and equipment required for the complete installation of work called for in the Contract Documents.

1.2 SCOPE OF WORK

A. Horizontal cabling is the portion of the cabling system that extends from the work area to the patch panels. The horizontal cabling shall be configured in a star topology. The horizontal cabling includes the horizontal cables, the mechanically terminated jacks/inserts and the faceplates that the jacks/inserts snap into in the work area.

B. This section includes minimum requirements for the following:
   1. Category 6 and UTP Cable from TR to Work area
   2. Faceplates and Jacks
   3. Installation and Termination Methods
   4. Testing

1.3 QUALITY ASSURANCE

A. All cable shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of MSU IT representative. Equipment and materials shall be of the quality and manufacturer indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Strictly adhere to all Category 6 installation practices when installing UTP cabling.

C. Materials and work specified herein shall comply with the latest applicable requirements of:
   1. ANSI/ICEA S-80-576-1988, Communications Wire and Cable for Wiring Premises
   2. NFPA 70, 1996, National Electrical Code
   3. ANSI/TIA/EIA – 568-C Telecommunications Cabling Standard
   4. ANSI/TIA/EIA – 569-A Pathway and Spaces
   5. BICSI Telecommunications Distribution Methods Manual
   6. FCC 47 CFR 68
   7. NEMA – 250
   8. NEC - Articles 770 and 800
   9. ADA - Americans with Disabilities Act

1.4 SUBMITTALS

A. Manufacturers catalog sheets, specifications and installation instructions for all products in this section.
PART 2 - PRODUCTS

2.1 COPPER TELECOMMUNICATIONS HORIZONTAL CABLE
A. 4-pair, 23 gauge, Category 6 UTP copper telecommunications horizontal cable shall be used for connectivity between the telecommunications closets and work area outlets. Cable will be placed in conduit, J-Hooks, and/or cable tray spaced no greater than 48” O.C.
B. The cable shall conform to requirements of ANSI/TIA/EIA-568-C and applicable specifications of 4-pair cable within ANSI/ICEA S-80-576.
C. Design Make:
   1. TE, Category 6, Gray, Plenum (Part #: TE620P-GYXX).

2.2 OUTLETS
A. All Category 6 and outlets shall conform to ANSI/TIA/EIA-568-C.
B. All outlets shall be wired to T568B as specified in ANSI/TIA/EIA-568-C.
C. Design Make:
   1. TE, Category 6 Modular Insert, (Part # 1375055-x) (Color to be determined at time of submittal).
   2. TE, SL Series Blank Insert, (Part # 1116412-x). (Color to be determined at time of submittal).

2.3 OUTLET HOUSINGS AND FACEPLATES
A. Provide faceplates for each outlet indicated on the drawings. Provide blanks for any unused ports.
B. Design Make:
   1. TE, 6-port single gang, (Part # 2111012-x) (Color to be determined at time of submittal).
   2. TE, 2-port single gang, (Part # 2111009-x) (Color to be determined at time of submittal).
   3. TE, 4-port single gang, (Part # 2111011-x) (Color to be determined at time of submittal).
   4. TE, 2-port Modular Jack Boxes, (Part # 1-1116697-1) (Color to be determined at time of submittal).

PART 3 - EXECUTION

3.1 INSTALLATION
A. The maximum pulling tensions specified by the cable manufacturers shall not be exceeded. Contractor shall use tools and equipment specifically designed for the pulling of cable. The contractor shall implement installation practices that ensure the highest quality installation. Contractor shall make all cutting, splicing, pulling and termination of cables using equipment specifically designed for that purpose.
B. Contractor shall install tie wraps so that they spin freely on cable bundles. Tie wraps and other securing hardware shall be rated as required for the installation environment (i.e., tie wraps will
be approved for use in a plenum area when installed in a return air space). Contractor shall fill cable tray or conduit with cables using the following guidelines:

1. Where cable trays or conduits are stacked, the contractor shall fill the top raceway to its maximum fill ratio first and then move to the next raceway below it and so on.

2. Where multiple conduits are being used, the contractor shall fill one conduit to its maximum fill ratio before going on to the next conduit. Wherever possible, the contractor shall leave as many spare conduits available as possible. The maximum fill ratios for some typical raceway using telecommunications cabling are as follows:
   a. Ladder type cable tray 40%.
   b. Solid bottom cable tray 40%.
   c. EMT type conduit 40%.

3. The contractor shall not exceed the maximum fill ratio, per the NEC, for any reason. All spare conduits or conduits filled with less than the maximum allowed fill ratio shall have a pull string installed and left for future pulling in of cable. Clearly label as "pulling line" indicating To/From.

4. Contractor shall support cables running overhead that are not installed in raceway by J-hooks spaced no more than 4 feet on center. Openings around electrical raceway penetrations shall maintain the fire resistance rating required. See NEC 300-21. Install cable trays in accordance with NEC Article 318 and manufacturers’ recommendations.

C. Install all connectors in conformance with manufacturer recommended procedures. Use tools designed for this purpose. Each outlet and patch panel pair of ports shall be clearly labeled in both the telecommunications room and the workstation location with the workstation room number. If there are multiple jacks in a room, the numbering shall include a hyphen suffix designation, such as 232-1, 232-2, and will begin at the closest jack to the left of the main doorway (standing in the doorway, looking in), and proceed clockwise around the room. Single jacks in a room shall be labeled with just the room number and will not have a hyphen suffix designation (e.g., 233, 234). If there are jacks located in the center of the room, after going around the exterior of the room, go up the middle from the main doorway. The label at the outlet will be placed on either the top of the faceplate (if difficult to see the front of the faceplate), or on the top label indentation on the front of the faceplate. Four-plex or greater density jack plates will be labeled as two (or more) jacks rather than one, such as 101-1, 101-2. Each jack consists of 2 cables. Contractor shall maintain one set of drawings on site to continually maintain an accurate record of the as-constructed work. The mark-up drawings shall accurately indicate location of equipment, pull-boxes, conduits, cable types and labeling. Provide the marked up drawings to the Consultant prior to final walkthrough with completed project checklist.

D. All wiring concealed in walls or soffits shall be installed in metal conduits.

E. All exposed wiring shall be installed in surface raceway or cable tray.

F. All wiring above ceilings shall be installed in cable tray, J-Hooks, and conduit NO GREATER THAN 48” O.C.

G. Cable above accessible ceilings shall be supported at no more than 48” on center by approved cable support attached to building structure.

H. Do not untwist cable pairs more than 0.5 in. when terminating.

I. The Contractor shall be responsible for replacing all cables that do not pass Category 6 requirements.

J. Maximum length of cable between the telecommunications closet and the work area outlet shall be 76 meters.
K. Cable shall have no physical defects such as cuts, tears or bulges in the outer jacket. Cables with defects shall be replaced.

L. Install cable in neat and workmanlike manner. Neatly bundle and tie all cable in closets. Leave sufficient cable for 90-degree sweeps at all vertical drops.

M. Maintain the following clearances from EMI sources for all Category 6 wiring.
   1. Power cable - 6 in.
   2. Fluorescent Lights - 12 in.
   3. Transformers - 36 in.

N. Do not install cable in common cable hangers with audio cable.

O. Do not install Category 6 cable with more than 110N (25 lbs) pull force, as specified in EIA/TIA and BICSI TDDM practices. Utilize appropriate cable lubricant in sufficient quantity to reduce pulling friction to acceptable levels on: long pulls inside conduit, pulls of multiple cables into a single small bore conduit, on conduit runs greater than 100 lineal feet with bends of opposing directions, and in conduit runs that exceed 180 degrees of accumulated bends. Use of tensile rated cords (i.e. fishing line) should be used for difficult or questionable pulls - to judge go/no-go condition of the conduit and pulling setup.

P. Cable jackets that are chaffed or burned exposing internal conductor insulation or have any bare copper (“shiners”) shall be replaced.

Q. Firestop all openings where cable is installed through a fire barrier.

R. Provide a minimum 12” of cable slack above each communications outlet and 24” of slack in each telecommunications room.

S. Prior to terminating any cabling contact MSU IT representatives to inspect cabling rough-in.

3.2 INSERTS AND FACEPLATES

A. Outlet boxes shall be secured to building with mechanical fasteners. Adhesive fasteners are not allowed.

B. All extra openings to be filled with blank inserts.

C. Terminate cable per TIA/EIA T568A standard pin assignments.

PART 4 - INSPECTION, TESTING, AND ACCEPTANCE OF COPPER CABLING

4.1 REQUIREMENTS

A. Visually inspect all cables, cable reels, and shipping cartons to detect possible cable damage incurred during shipping and transport. Visibly damaged goods are to be returned to the supplier and replaced at no additional cost to the Owner.

B. If the manufacturer of cables or connecting hardware has supplied post-manufacture performance data, copies of such data are to be kept for inclusion in the Documentation and
made available to the Owner upon request. All materials are to be new and unused.

C. Contractor is responsible for supplying all of the required test equipment used to conduct acceptance tests.

4.2 TEST PROCEDURES

A. Owner reserves the right to be present during any or all testing. Contractor shall notify Owner of their intent to test 48 hours before beginning said tests.

B. Testing shall be of the Permanent Link. However, Contractor shall warrant performance based on Channel performance and provide patch cords that meet channel performance.

C. All cabling not tested strictly in accordance with these procedures shall be re-tested at no additional cost to the Owner.

D. 100% of the installed cabling shall be tested.

4.3 STANDARDS COMPLIANCE AND TEST REQUIREMENTS

A. Cabling must meet TIA 568C.2 Category 6 performance specifications for horizontal cabling.

B. Test reports shall include the following information for each cabling element tested:

C. Wiremap results that indicate the cabling has no shorts, opens, miswires, split, reversed, or crossed pairs, and end-to-end connectivity is achieved.

D. For Category 6 cabling: Length, NEXT, PSNEXT, Return Loss, Insertion Loss, ACR (near & far), ELFEXT, and PSELFEXT, data that indicate the worst case result, the frequency at which it occurs, the limit at that point, and the margin. Information shall be provided for all pairs or pair combinations and in both directions when required by the appropriate standards. Any additional tests required by the cable Manufacturer for warranty purposes shall be run. Any individual test that fails the relevant performance specification shall be marked as a FAIL.

E. Length, propagation delay, and delay skew relative to the relevant limit. Any individual test that fails the relevant performance specification shall be marked as a FAIL.

F. Cable manufacturer, cable model number/type, and NVP.

G. Tester manufacturer, model, serial number, hardware version, and software version.

H. Circuit ID number and project name.

I. Autotest specification used.

J. Overall pass/fail indication.

K. Date of test.

L. Test reports shall be submitted within 7 business days of completion of testing.
4.4 STANDARDS COMPLIANCE AND TEST REQUIREMENTS

A. Test reports may be submitted in hardcopy or electronic format. Hand-written test reports are not acceptable.

B. Hardcopy reports are to be submitted in labeled 3 ring binders with an attached affidavit verifying passing execution of all tests. For large installations electronic reports with hardcopy summaries are preferred. Hardcopy summary reports shall contain the following information on each row of the report: circuit ID, test specification used, length, date of test, and pass/fail result.

C. Electronic reports are to be submitted or CD format. If proprietary software is used, disk or CD shall contain any necessary software required to view test results. Electronic reports must be accompanied by a Certificate signed by an authorized representative of the Contractor warranting the truth and accuracy of the electronic report. Certificate must reference traceable circuit numbers that match the electronic record.

4.5 TEST EQUIPMENT

A. Test equipment used under this contract shall be from manufacturers that have a minimum of 5 years experience in producing field test equipment. Manufacturers must be ISO 9001 certified. Tester must be an approved tester of the cabling Manufacturer being used on this project.

B. All test tools of a given type shall be from the same manufacturer, and have compatible electronic results output.

C. The manufacturer of the test equipment must approve test adapter cables. Adapters from other sources are not acceptable.

D. Baseline accuracy of the test equipment must meet or exceed TIA Level III, as indicated by independent laboratory testing.

E. Test equipment must be capable of certifying Category 6 links.

F. Test equipment must have a dynamic range of at least 100 dB to minimize measurement uncertainty.

G. Test equipment must be capable of storing full frequency sweep data for all tests and printing color graphical reports for all swept measurements.

H. Test equipment must include S-Band time domain diagnostics for NEXT and return loss (TDNXT and TDRL) for accurate and efficient troubleshooting.

I. Test equipment must be capable of running individual NEXT, return loss, etc measurements in addition to autotests. Individual tests increase productivity when diagnosing faults.

J. Test equipment must include a library of cable types, sorted by major manufacturer.

K. Test equipment must store at least 1000 Category 6 autotests in internal memory.

L. Test equipment must be able to internally group autotests and cables in project folders for good records management.

M. Test equipment must include DSP technology for support of advanced measurements.
N. Test equipment must make swept frequency measurements in compliance with TIA standards.

O. The measurement reference plane of the test equipment shall start immediately at the output of the test equipment interface connector. There shall not be a time domain dead zone of any distance that excludes any part of the link from the measurement.

4.6 ACCEPTANCE

A. Once all work has been completed, test documentation has been submitted, and MSU IT representative is satisfied that all work is in accordance with contract documents, the MSU IT representative shall notify Contractor in writing of formal acceptance of the system.

B. Acceptance shall be subject to completion of all work and successful post-installation testing which yields 100% PASS rating.

END OF SECTION 27 16 00
PART 1 - GENERAL

1.1 SCOPE

A. The electrical contractor, through subcontract with an authorized fire alarm supplier, shall furnish and install, complete and ready for operation, an intelligent, addressable, digital Voice Evacuation Fire Alarm System, including panel, local operating consoles, detectors, pull stations, door holders, local alarms, wiring, remote booster power supplies, signal appliances, and any and all other equipment necessary for a complete operational system, as shown on the drawings and indicated herein.

B. The Fire Alarm Supplier shall be licensed by the State of Montana. All fire alarm equipment shall be installed exclusively by installers and workmen that are employees of the fire alarm system supplier. All installers and workmen shall be National Institute for Certification in Engineering Technologies (NICET) certified for fire alarm systems at level two or greater. All submittal preparers shall be resident NICET level four in fire alarm and shall be state licensed. Contractors and workmen not complying with this specification shall not be allowed to perform this work.

C. The Fire Alarm Supplier shall prepare plans and calculations required by the authority having jurisdiction (AHJ), shall submit all required documents to the AHJ for approval, and shall obtain all necessary permits or approvals from the AHJ including anything required prior to installation and/or after completion and testing.

D. The electrical contractor shall provide for all rough-in (including supply and installation of electrical boxes and raceways) and wire pulling. The fire alarm supplier shall supply wiring and any specialty back-boxes required for the fire alarm suppliers equipment. The electrical contractor shall NOT install any fire alarm system components beyond rough-in and wire pulling. The fire alarm supplier shall coordinate all requirements with the electrical contractor prior to bidding.

E. All portions of the systems shall be installed in accordance with the drawings, details, and specifications or as required by jurisdictional authorities and codes. Jurisdictional authorities and codes shall take precedence over plans, details and specifications in the event of a dispute between the requirements of contract documents and jurisdictional authorities or codes.

F. The position is taken that the Owner is entitled to a project which meets or exceeds the minimum requirements of nationally recognized fire protection standards. All efforts and installations shall be directed toward this end. All deficiencies as noted by fire rating bureaus, insurance service offices or jurisdictional authorities shall be corrected. No extra charges will be allowed on this account.

G. The fire alarm supplier shall coordinate all requirements with the electrical contractor. Any additional requirements or detail not shown on the drawings, but required for a complete working integrated system will be the responsibility of the fire alarm supplier.

H. Work to be performed under this section shall include, but not be limited to the following:

1. Fire Alarm System
   a. Control Panel
   b. Programming
   c. Audible/Visual Alarm Devices
d. Pull Stations
e. Smoke/Heat Detectors
f. Duct Smoke Detectors
g. Installation of Auto-Dialer
h. Very Early Smoke Detection System (VESDA)

1.2 RELATED WORK

A. All work performed under this section of the specifications shall be subject to the requirements of both the General and Special Conditions and the Electrical Specification.

1.3 REGULATORY AGENCIES

A. The term jurisdictional authority used in this section of the specification shall include, as applicable, but not be limited to the following:

1. Local Building Department and Fire Department.
3. Insurance Services Office or Insuring Authority having jurisdiction.
4. Owner.

B. The design and installation of all systems of fire protection shall conform to all requirements of applicable codes and publications herein defined:

1. International Building Code 2015
2. International Fire Code 2015
3. NFPA #72
4. NFPA #70
5. All State and local ordinances
6. Underwriters Laboratories.
7. Factory Mutual.
10. Occupational Safety and Health Administration.

1.4 SUBMITTALS

A. The successful Supplier shall provide submittal data as required under other portions of these specifications. Submittals shall conform to the instructions set forth in the General and Special Conditions of these specifications entitled Shop Drawings and Submittals.

B. Submittals shall include, at a minimum, the following:

1. Cut sheets of all equipment and wiring.
2. AUTOCAD-based floor plans, with location of control panel, batteries, annunciators, primary power supplies, detectors, notification appliances, and each alarm initiating devices. Show single-line fire alarm/voice notification systems riser diagram, device and zone schedules. Each device on the riser should be identified by type and location, with device number. Indicate connection of equipment by circuit runs, or
3. Summary of battery calculations (with new code required annunciation of 24 hours plus 15 minutes).
4. Summary of Voltage Drop calculations.

C. Electronic submittals are acceptable however one hard-copy binder of all materials, including drawings shall be prepared and submitted to the engineer along with electronic submittals.

D. The supplier shall submit to the authority having jurisdiction (AHJ) all necessary documents, plans, calculations and any other details required by NFPA and the AHJ necessary to receive approval and permitting from the AHJ for the work required. Should the AHJ require Professional Engineering stamping of plans, it shall be the suppliers responsibility to obtain stamping at suppliers cost.

1.5 JOB CONDITIONS

A. The Supplier shall determine, and be responsible for, the proper locations and character of inserts for hangers, chases, sleeves, and other openings in the construction required for fire alarm system work, and shall obtain this information well in advance of the construction progress to avoid delay of the work.

B. All fees and permits specifically required for fire alarm work, not obtained by others as specified elsewhere shall be applied for and paid for by the fire alarm supplier.

1.6 OPERATION AND MAINTENANCE MANUALS

A. Three (3) sets of operating and maintenance instructions shall be provided the Owner upon completion.

1.7 TRAINING

A. The fire alarm supplier shall supply on-site training at the owner's facility to familiarize the Owner with the basic operation of the system.

1.8 GUARANTEES AND WARRANTIES

A. The Fire Alarm Supplier shall guarantee to the Owner in writing, all equipment and workmanship for a period of THREE (3) years after the fire alarm system has been placed in continuous service and has been accepted by all authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Approved Manufacturers/Installers, subject to compliance with specifications:

1. Notifier, by API
2. Edwards Systems Technologies, by Montana Wyoming Systems
3. Notifier, by Systems Northwest
4. Simplex Grinnell, by Simplex of Helena
5. Others by prior approval only as accepted by owner with service contracts outlined.

2.2 FIRE ALARM CONTROL PANEL (FACP)

A. A master control panel having the features of a fire alarm and voice evacuation control unit and fire alarm and voice evacuation control. The panel shall have central processing, memory, input and output terminals, LCD display units and shall comply with UL 864 and listed and labeled by an NRTL. Provide panel capable of including DVC inside panel. Provide sealed lead-acid batteries.

B. A button strip shall be supplied with 6 groups of switches.
   1. Buttons are programmed by the Fire Alarm Contractor from the input of the owner. Buttons shall be used to control notification and auxiliary equipment during testing. Coordinate programming and control with owner.
   2. Two Buttons shall turn the smoke exhaust system on and off.

C. An RS232 interface port shall be installed for programming, testing and reporting.

2.3 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.4 LOCAL OPERATING CONSOLE (LOC)

A. The LOC shall consist of a firefighter’s microphone or telephone and associated controls to allow emergency responders and/or building occupants to operate the VEFAS including delivery of recorded and/or live messages. The LOC shall also include an integral remote annunciator. A separate remote annunciator may be provided and installed adjacent to the LOC. Remote annunciator shall be backlit LCD, 80-character, with system status LED’s for power, alarm, trouble, supervisory and alarm silenced. Provide control switches for system acknowledge, signal silence, drill, and reset.

1. The LOC and remote annunciator housing(s) shall be recessed, NEMA 250, type 1 and shall be suitable for installation in block wall and contain a lockable door.

B. Remote Annunciator: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

C. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.
2.5 DIGITAL VOICE COMMAND (DVC)

A. Digital audio processor and event driven audio message generator connected directly to fire alarm control panel.
   1. Up to 32 minutes of standard quality digital audio storage of user-selected/created messages and tones.
   2. Capable of supporting remote microphones.
   3. Auxiliary inputs for low-level audio sources and external audio sources such as telephone paging or background music.

2.6 DETECTORS

A. SMOKE & HEAT DETECTORS: Intelligent, photelectric, low-profile (less than 2-1/4" high). Equal to Notifier FSP or FST series.

B. Smoke detectors shall not be installed until the project has undergone FINAL cleaning in accordance with NFPA 72. In the event detectors are installed prior to final cleaning, the supplier shall clean or replace all detectors at no additional cost to the Owner. Installation of protective plastic covers does not meet the intent of this requirement.

C. Duct Smoke detectors shall be 24 volt DC, intelligent, photelectric with tube and keyed remote test switch.
   1. Keyed Remote Test switches shall be accessible and installed at 72” AFF.
   2. Location of test switches shall be concealed in non-public locations to the greatest extent possible.

D. See 283111.15 for Aspirating Smoke Detection system.

2.7 MANUAL PULL STATIONS

A. Dual action push-in pull-down style, addressable, surface mounted and red. Equal to Notifier NBG-12LX.

2.8 NOTIFICATION APPLIANCES

A. SPEAKER/STROBES – White with “Fire Markings”, clear lensed, surface-mounted device box, field-selectable candela ratings, rotary switch for speaker voltage and power settings (1/4, 1/2, 1 and 2 watts), suitable for indoors.

B. SPEAKER – White with “Fire Markings”, surface-mounted device box, rotary switch for speaker voltage and power settings (1/4, 1/2, 1 and 2 watts), suitable for indoors.

2.9 REMOTE NAC POWER SUPPLIES

A. Where remote power supplies are required for notification appliance circuits, they shall be located the central mechanical room and stacked per floor.

B. Provide 2 hour rated service paths as required by current code. These locations shall be clearly indicated on shop drawings.
2.10 MAGNETIC DOOR HOLDER

A. Low profile, semi-flush wall mounted holder with catch plate assembly. Equal to Simplex RSG series with chrome finish and multi voltage capable (24VDC). Provide with proper length catch plate extender rod to facilitate door location swing in relation to holder.

1. Where noted in plan holder shall be floor mounted model in surface box, same model as wall unit.

2. Door Holders shall be powered from the Fire Alarm System and shall have battery backup.

2.11 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for three years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within three years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

2.12 WIRE AND CONDUIT

A. All wiring shall be installed in accordance with NFPA #70 (NEC).

B. Fire Alarm system circuits shall be run 100% in EMT conduit or surface mounted steel wiremold.

C. EMT conduit shall have a factory RED finish.

D. All EMT conduit shall be a minimum of ¾" conduit.

E. Wiring shall be routed in conduit and steel wiremold and must be run in a neat and orderly manner. Conceal conduit to the greatest extent possible.

PART 3 - EXECUTION

3.1 DESIGN CRITERIA

A. Approximate fire alarm devices, alarm panel, notification appliances, and detector arrangement is indicated on the drawings. Supplier is responsible for all required devices and locations.

1. **Final Speaker Quantity & Locations:** Quantity and location of speakers on the plan is approximate. The required quantity and location of speakers may vary depending on the characteristics and capabilities of different manufacturer's speakers. Therefore it is the
responsibility of the VEFAS supplier to determine the final quantity and location of speakers in order to meet the requirements for sound levels and intelligibility in NFPA 72 and acceptance by the authority-having-jurisdiction. This shall be done using supplier's software and other engineering resources. In the event the installed system is not accepted by the AHJ, it is the responsibility of the VEFAS supplier to make whatever corrections, including installation of additional speakers, removal of speakers, or relocation of speakers to satisfy the AHJ. This shall be done at no additional cost to the Owner or Engineer.

B. The entire fire alarm system is not shown on plans. The intent is to provide complete fire alarm systems including all necessary manufacturer's components to provide a complete, functional system. The Supplier shall be responsible for preparing working drawings for the total system. Supplier shall provide additional devices as required.

C. The FACP shall provide power, annunciation, supervision, and control for the system. Addressable systems shall be microcomputer based with a minimum word size of eight bits with sufficient memory to perform as specified.

D. Provide notification appliance circuits. The visual alarm notification appliances shall have the flash rates synchronized as required by NFPA 72.

E. Provide electrical supervision of the primary power (AC) supply, presence of the battery, battery voltage, and placement of system modules within the control panel.

F. Provide an audible and visual trouble signal to activate upon a single break or open condition, or ground fault. The trouble signal shall also operate upon loss of primary power (AC) supply, absence of a battery supply, low battery voltage, or removal of alarm or supervisory panel modules. Provide a trouble alarm silence feature at both the FACP and Annunciator that shall silence the audible trouble signal, without affecting the visual indicator. After the system returns to normal operating conditions, the trouble signal shall again sound until the trouble is acknowledged. A smoke sensor in the process of being verified for the actual presence of smoke shall not initiate a trouble condition.

G. Alarm, supervisory, and/or trouble signals shall be automatically transmitted to a UL-listed central station. As part of this contract, include the cost of 5 years of subscription service to the call center. The Call center shall be the same center for all the Montana State University Fire alarm systems report to.

H. Alarm functions shall override trouble or supervisory functions. Supervisory functions shall override trouble functions.

I. The system shall be capable of operating, supervising, and/or monitoring both addressable and non-addressable alarms and supervisory devices.

J. There shall be no limit, other than maximum system capacity, as to the number of addressable devices that may be in alarm simultaneously.

K. Where the fire alarm/voice evacuation system is responsible for initiating an action in another emergency control device or system, the addressable fire alarm relay shall be in the vicinity of the emergency control device.

L. The supplier shall provide a smoke detector at the fire alarm control panel as shown on the plans. The supplier shall provide additional detectors at any other control units or sub-panels required by their system design if required by the Authority Having Jurisdiction.
3.2 SYSTEM OPERATION

A. An alarm signal shall automatically initiate the following functions:
   1. Transmission of an alarm signal to a UL-listed central station
   2. Visual indication of the device operated on the control panel, and on remote annunciators.
   3. Continuous actuation of all alarm notification appliances.
   4. Announcement over system speakers of a pre-recorded fire announcement.
   5. Recording of the event electronically in the history log of the fire control system unit.
   6. All control relays shall change state.

B. A supervisory signal shall automatically initiate the following functions:
   1. Visual indication of the device operated on the FACP, and on the remote annunciator, and sounds the audible alarm at the respective panel.
   2. Transmission of a supervisory signal to a UL-listed central station.
   3. Recording of the event electronically in the history log of the control unit.

C. A trouble condition shall automatically initiate the following functions:
   1. Visual indication of the system trouble on the FACP, on the remote annunciator, and sound the audible alarm at the respective panel.
   2. Transmission of a trouble signal to a UL-listed central station.
   3. Recording of the event in the history log of the control unit.

D. The system shall continuously check for malfunctions or troubles. Upon detecting any fault the following shall occur.
   1. Activate a reporting signal tone at main panel.
   2. Indicate the point location on the main F.A. panel as to the location and type of the fault.
   3. Add all information to the history log of the panel.

3.3 VOICE EVACUATION SYSTEM FUNCTIONS

A. Notification Appliance Network - The audible notification appliance network shall consist of speakers located to provide intelligible instructions at all locations in the building. The Voice Evacuation System announcements shall take priority over all other audible announcements of the system including the output of the fire alarm system in a normal or alarm state. When a Voice Evacuation announcement is activated during a fire alarm, all fire alarm system functions shall continue in an alarm state except for the output signals of the fire alarm audible and visual notification appliances.

B. Voice Notification - An autonomous voice notification control unit is used to monitor and control the notification appliance network and provide consoles for local operation. Using a console, personnel in the building can initiate delivery of pre-recorded voice messages, and provide live voice messages and instructions. The autonomous voice notification control unit will temporarily override audible fire alarm notification while delivering Voice Notification messages to ensure they are intelligible.

C. Voice Notification Messages
   1. Voice notification messages shall utilize a female voice at 1000 Hz tones or as otherwise required by NFPA 72 and shall be similar to the following:
a. "May I have your attention please. May I have your attention please. A fire emergency has been reported in the building. Please leave the building by the nearest exit." (Provide a 3 second pause.) "May I have your attention please, (repeat the message)."

b. Up to an additional four messages shall be recorded at the Owner’s discretion. The fire alarm supplier shall consult with the owner and provide messages as directed.

2. The LOC shall incorporate a Push-To-Talk (PTT) microphone, redundant controls and system status indicators for the system. The LOC shall incorporate microphone override of any tone generation or prerecorded messages. The unit shall be fully supervised from the control panel.

3. Auxiliary microphone locations shall incorporate a Push-To-Talk (PTT) microphone, to allow Public Address paging in the facility. The Public Address paging function shall not override any alarm or notification functions and shall be disabled by such signals.

3.4 INSTALLATION

A. Final connections between all fire alarm equipment and the wiring system shall be made only by or under the supervision of an authorized representative of the system manufacturer.

B. The fire alarm contractor shall provide red labels:
   1. On the fire alarm control panel indicating the panel and circuit supplying power to the panel.
   2. Next to the circuit breaker inside the panel supplying power to the fire alarm control panel stating “FIRE ALARM CIRCUIT CONTROL”.

C. Duct Detectors shall be supplied by the Fire Alarm contractor, install by the Mechanical Contractor and wired by the electrical contractor.

D. All Test Switches shall be accessible and located at 72” AFF.

E. The Mechanical Temperature Controls Contractor shall wire from Mechanical Equipment to the Fire Alarm Field Devices or interfaces. The Fire Alarm contractor is responsible for all coordination between the Mechanical contractor.

3.5 IDENTIFICATION

A. Provide Labels on all Fire Alarm Devices with address.

B. Labels shall use 24 font.

C. All cover plates on raceway boxes shall be RED. Many exposed spaces will have all boxes and conduit painted, the Fire Alarm System contractor to replace all cover plates after painting with a RED cover.

D. Fire Alarm Devices above lay-in ceilings shall also be labeled on the ceiling grid runner.

3.6 FINAL TESTS AND REPORT

A. Upon completion of the installation and system tests, the certified test technician shall submit to the Engineer three copies of a written report on forms provided by the manufacturer, to indicate the system has been fully tested in supervision, trouble and alarm modes and is fully operational conforming to the letter of these Specifications.
3.7 SYSTEM INSPECTIONS

The contractor shall provide TWO inspections of each system under this Contract during the ONE (1) year warranty period. The first inspection shall be at the six month interval after system acceptance and the second at the 12 month interval. Inspections shall include confirmation that the system is in proper working order. Inspections shall also include a complete checkout of the control and alarm system. Documents certifying satisfactory system conditions shall be submitted to the Owner's technical representative upon completion of each inspection.

END OF SECTION 28 31 11
SECTION 28 31 11.15 - ASPIRATING SMOKE DETECTION SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. This document provides Basis of Design specification details for Fire Alarm Aspiration Sensing Technology (FAAST) detectors and approved equals are acceptable. All items under this specification shall comply with all applicable code requirements and manufacturer’s recommendations.

1.2 APPROVALS

A. The Aspirating Smoke Detector shall be tested, approved and/or listed by:

1. Underwriters Laboratories (UL) S911
2. Underwriters Laboratories Canada (ULC)
3. Factory Mutual (FM)
4. California State Fire Marshal (CSFM) 7259-1653:0215
5. Maryland State Fire Marshal (MSFM) 2244
6. VdS Approved (Europe)
7. CSIRO (ACTIVFIRE)
8. KFI (Korea)

1.3 CODE, STANDARDS, AND REGULATION

A. The aspirating smoke detector shall be installed per manufacturer’s instructions, including pipe network, programming, and power requirements, and shall comply with one or more of the following codes and standards:

1. National Fire Protection Association (NFPA)
2. British Fire Protection Association (EN-54)
3. National Electrical Code (NEC)
4. UL 268: Standard for Smoke Detectors for Open Areas
5. UL 268A: Standard for Smoke Detectors for Duct Application
6. Local codes and standards

1.4 SYSTEM REQUIREMENTS

A. The Aspirating Smoke Detector (ASD) shall offer various classifications to include Very Early Warning Smoke Detection (VEWFD), Early Warning Smoke Detection (EWFD), and Standard Smoke Detection (SFD) settings as identified per the requirements of NFPA.

B. The ASD shall be self-contained and monitored by a display featuring LEDs and/or LCD to include a control system utilizing microprocessor-based technology with all functions fully programmable, LED displays, alarm indications, airflow and detector faults.
C. The system shall constantly sample air from the environment. In operation, air shall be drawn from the air sampling piping network, through a particle separator and a 30 micron filter assembly being pulled through the detection chamber by the aspirator. The system shall not rely on air currents to bring smoke to the detector. Inside the smoke detection chamber, air shall be exposed to a blue LED and infrared laser light source. Light scattered by smoke particles shall flow through the chamber and be detected by solid state receivers, which shall convert the light to an electronic signal.

D. The ASD shall incorporate a dual light source technology system for the automatic discrimination of signals from non-fire related sources, such as dust. The system shall automatically compensate for changes in environmental conditions and the negative effect of filter contamination.

E. The ASD shall display a series of LEDs or be visible via an interactive LCD. The ASD shall include a Reset, Isolate, and Test functions on the front of the panel. The system shall be configured by a programmer that is PC based via PipeIQ software.

F. The program shall allow the following detector parameters to be configured:

1. Up to five threshold alarm levels (Alert, Action 1, Action 2, Fire 1, and Fire 2).
2. Test, reset, and isolate functions from remote locations.
3. Design pipe network and ability to calculate obscurations levels, transport times, sample hole diameters, flow and pressure levels.
4. Shall allow the ability to program the detector to three different settings: day, night, and weekend mode.
5. Acclimate mode shall automatically adjust alarm levels within user-specified parameters to reduce nuisance alarms.

G. The program shall allow the ASD firmware to be updated in the field by system installers and maintainers.

H. The ASD shall have the capability to connect to the building automation/management system via Modbus Protocol utilizing a TCP server or serial connection using RS-485.

I. Provide local networking capability and monitoring through the onboard Ethernet connection allowing for up to six email addresses. Each address shall be configured to notify the recipient of a specific alarm level, fault level, or isolate condition.

J. Detector Performance Requirements

1. Detectors shall be tested and approved to cover up to (5,000 sq. ft /464 sq. m) (8,000 sq. ft /744 sq. m) (28,800 sq. ft / 2,680 sq. m).
2. Detectors shall be approved to monitor up to five alarm levels. Each level shall be programmable and able to select desired sensitivity, ranging from 0.00029%/ft – 6.0%/ft. UL approval compliance recognizes sensitivity ranges from 0.00029%/ft – 4.0%/ft.
3. Detectors shall report alarms and faults using fault relays or direct connection via the SLC loop, if applicable.
4. Detectors shall include a field-replaceable filter and an internal particle separator to reduce the amount of non-combustible materials reaching the detection chamber.
5. The software shall provide pipe design, system configuration, and system monitoring in a single software program. It shall store up to 18,000 events. Events shall include smoke levels, alarm conditions, operator actions, and faults. The date and time of each event shall be recorded.
6. The front panel of the detector shall indicate flow faults, configuration, external monitor, time, communication, trouble, filter, isolation, voltage, and high flow faults via dedicated LEDs or an LCD display.
7. The ASD shall use ultrasonic sensors to confirm proper air flow through the pipe network and produce a fault when there is a change of a user-settable percentage from nominal air flow.
8. The ASD shall store vital statistics including airflow, obscuration signal level, alarm levels, fan speed, and temperature. The frequency with which these statistics are stored shall be adjustable.

1.5 SUBMITTALS

A. System shall be complete in all ways and shall include all engineering and electrical installation, all detection and control equipment, auxiliary devices and controls, alarm interfaces, functional testing, training, and all other operations necessary for a functional, UL Listed, and FM Approved system.

B. Prepare product data and site drawings indicating the system layout, including location of modules, detection/aspiration unit, air intake ports, flow calculations, transport times, power requirements, and sample hole obscuration sensitivity level calculations.

C. Show method and spacing of hanger supports on aspirating tube to the building structure.

D. System commissioning data shall be supplied as recommended per manufacturer's instructions within 30 days of installation.

E. As-Built Drawings:

   1. Upon completion of the installation, the Contractor shall revise aspirating detection system design files, calculations, manuals, and operating instructions to agree with on-site conditions.
   2. Submit a copy of the manufacturer's installation, operation, and maintenance manuals.
   3. Final construction drawings shall be stamped/sealed by a licensed Professional Engineer in the state where the work is being constructed, or a NICET level III or higher certified fire alarm technician.

1.6 QUALITY ASSURANCE

A. Manufacturer

   1. The manufacturer shall have a minimum of 30 years of production experience in the manufacturing and design of smoke detection devices.

B. Detector Requirements

   1. The ASD shall have dual source (blue LED and infrared laser) optical smoke detection for a wide range of fire detection, with enhanced immunity to nuisance particulates. The ASD shall operate in air flows from 0-4000 ft/min (0-1,219 m/min). The system software shall provide pipe design, system configuration, and system monitoring in a single software program.
   
   2. The ASD shall offer Very Early Warning Smoke Detection, Early Warning Smoke Detection, and Standard Smoke Detection settings. The ASD shall offer a wide range of sensitivity settings from 0.00029%/ft – 4.0%/ft. The detector shall be capable of operating in temperatures from 32°F (0°C) to 100°F (38°C). Sampled air temperatures shall range from –4°F (~20°C) to 140°F (60°C). Operating humidity shall range from 10-95% non-condensing.

C. Installer

   1. The equipment installer shall be authorized and trained by the manufacturer and shall have the ability to design a system based on code requirements. The installer shall be capable of providing calculations, design, and testing documents upon request.
PART 2 - PRODUCT

2.1 MANUFACTURER

   A. Approved aspirating smoke detection manufacturer:
      1. System Sensor – Fire Alarm Aspirating Sensing Technology (FAAST)
      2. Prior Approved Equal

   B. System Sensor (Headquarters)
   C. 3825 Ohio Avenue
   D. St. Charles, IL 60174

   E. Manufacturer Approved Units:
      1. FAAST XS  Detector coverage area up to 5,000 sq. ft. (464 sq. m)
      2. FAAST XM  Detector coverage area up to 8,000 sq. ft. (744 sq. m)
      3. FAAST XT  Detector coverage area up to 28,800 sq. ft. (2,680 sq. m)

2.2 ASPIRATING SMOKE DETECTOR

   A. The ASD shall allow up to 5 programmable alarm levels with time delays, including Alert, Action 1, Action 2, Fire 1, and Fire 2. The ASD shall allow for Acclimate or Day/Night/Weekend settings to accommodate environmental changes. The Acclimate mode shall automatically adjust alarm levels within user-specified parameters to reduce nuisance alarms. It shall continually adapt to current environmental conditions when activated. Day/Night/Weekend settings shall allow the user to create specific thresholds and delays during the day, night, or weekend.

   B. The ASD shall provide up to 8 form C, programmable, latching or non-latching relays or the ability to connect directly to the FACP via the SLC. It shall include a field-replaceable filter and an internal particle separator to reduce the amount of non-combustible materials reaching the detection chamber. It shall be tested and approved for coverage up to (5,000 sq. ft. /464 sq. m) (8,000 sq. ft. /744 sq. m) (28,800 sq. ft. / 2,680 sq. m). The unit shall use ultrasonic sensors to confirm proper air flow through the pipe network and store up to 18,000 events. Events shall include smoke levels, alarm conditions, operator actions, and faults. The date and time of each event shall be recorded.

2.3 DESIGN PARAMETERS

   A. The ASD design shall comply with all national and local code requirements and UL and FM approved listings. The ASD shall be designed with the following parameters:

      1. NFPA Classifications:
         a. VEWFD: Very Early Warning Fire Detection. The sample port spacing shall not exceed 200 sq. ft. (18.5 sq. m) and shall initiate an alarm/alert in less than 60 seconds from the furthest sample port. The detector shall be programmed to pre-alarm at .2% obscuration per foot and alarm at 1% obscuration per foot at the sample port.
b. EWFD: Early Warning Fire Detection. The sample port spacing shall not exceed 400 sq. ft. (37.1 sq. m) and shall initiate an alarm/alert in less than 90 seconds from the furthest sample port. The detector shall be programmed to alarm at 1.5% obscuration per foot at the sample port.

c. SFD: Standard Fire Detection. The sample port spacing shall not exceed 900 sq. ft. (83.7 sq. m) and shall initiate an alarm/alert in less than 120 seconds from the furthest sample port. The detector shall be programmed to alarm at 3.2% obscuration per foot at the sample port.

2. Return Air Monitoring:

a. Sampling of return air grills shall comply with the requirements of NFPA-76 and manufacturer’s recommendations. The sample port spacing shall not exceed more than 4 sq. ft. (0.37 sq. m) per return air grill. The sample ports must be aligned at an angle between 20 to 45 degrees in the direction of the airflow. The sample pipe shall stand-off between 2”-8” (.05 - .2 m) from the return air grill.

3. In-Duct Sampling:

a. The ASD monitoring in-duct applications shall be installed and designed based on the manufacturer’s recommendations and verified via PipeIQ software calculations.

4. Sampling point flow and pressure requirements:

a. Minimum Flow: 2 L/min.

b. Minimum Pressure: 25 Pa

B. A test port shall be provided at each pipe run located at 18” above the finished floor for under floor systems, or 5ft above the finished floor when pipe network is above the ceiling. The test port shall be constructed using a vented end cap. Provide a decal indicating the install date, detector zone, pipe number, test point ID, transport time and suction pressure (Pa).

2.4 INTELLIGENT FIRE ALARM CONTROL PANEL CONNECTIVITY

(FAAST XS & XT MODELS ONLY)

A. The ASD shall be capable of connection to an Intelligent Fire Alarm Control Panel (FACP) via a Signaling Line Circuit (SLC) using the communications protocol native to the system, without the use of any additional hardware. The FACP shall be capable of monitoring and annunciating up to five smoke event thresholds on the ASD and ten trouble conditions. Each event threshold shall be capable of being assigned a discrete type ID at the FACP, including Aspiration Alarm, Aspiration Pre-Alarm, Aspiration Supervisory, Aspiration Non-Fire, and Aspiration Air Reference, which will determine how the event will be annunciated at the FACP. The FACP shall support flexible system programming for all event levels, and shall be capable of simultaneous activation of multiple event levels.

B. The following operations shall be able to be performed on the ASD via the FACP:

1. Disable/enable reset airflow baseline,

2. Reset.

B. Trouble conditions annunciated at the FACP shall include indications for: Low air flow, configuration (programming) fault, device in service mode, communications loss, time lost or not set, aspiration fault, filter fault, high air flow fault, detector fault, detector initializing warning, and power fault.
2.5 MONITORING:

A. The ASD shall provide up to three Fault types to indicate the priority of faults generated in the system. Fault indication shall be provided for the following:

1. Low flow – If the device has decreased in air flow, a Fault shall be generated at a user-settable decrease in air flow.
2. High flow – If the device has increased in air flow, a Fault shall be generated at a user-settable increase in air flow.
3. Configuration – Device configuration failure. A Fault shall be generated if a configuration update did not transfer.
4. Sensor – If the particulate sensor is not operating properly and needs immediate replacement, a Fault shall be generated.
5. External Monitor – If the external monitor detects an open Fault shall be generated.
6. Time – If the internal time base needs to be updated, a Fault shall be generated.
7. Communication – If the device fails to communicate to one of its peripherals and cannot function properly, a Fault shall be generated.
8. Aspiration – If the aspirator is not working and requires immediate attention, an Fault shall be generated.
9. Filter – As the filter approaches a pre-set threshold, an initial warning shall be given to change the filter and a Fault shall be generated.
10. Isolate – If the device is put into the Isolate mode, an Isolation fault shall be generated.

2.6 DISPLAYS

A. The system shall provide a user interface at the front of the detector with the following displays:

1. Air Flow/Fault Display – The air flow/fault display shall consist of 10 bicolor LEDs and operate in one of two modes: air flow or fault indication. Green segments shall indicate how close the current air flow is to the high or low air flow threshold. The default threshold for a fault condition is + or – 20% from the airflow baseline. During normal operation two adjacent indicators shall be green and correspond to the current airflow entering the detector. When airflow is at a balanced level, the two green segments shall be centered on the graph. As airflow rises and falls, the green segments shall move right and left accordingly. If a fault is activated on the device, the corresponding LEDs shall illuminate in amber and an additional “fault” LED shall be triggered to signal a fault has been generated. All 10 faults shall be indicated on the User Interface.
2. 10 particulate levels – The particulate level display shall consist of ten amber LEDs that correspond to the current level of the particulate detected. The LEDs shall illuminate in order from Level 1 to Level 10, starting from the bottom of the display and moving up as the particulate level increases. Each LED shall represent a 10% increase in the particulate level necessary to reach the Alert Alarm level.
3. (3) 5 alarm levels – All (3) 5 Alarm levels shall be indicated on the User Interface. The Alarm Level Display shall consist of (3) 5 red LEDs that correspond to the current alarm level. These LEDs shall be located directly above the Particulate Level LEDs. They shall illuminate sequentially upward as the severity of the alarm increases.
4. On/Off indication
5. Low Voltage indication

B. The user interface shall offer an interactive panel. The panel shall have a security passcode system to prevent unauthorized access if chosen. The panel shall allow the following features to be activated at the device:

1. Test
2. Reset
3. Isolate
4. Information Generation – the detector shall provide the local device address and the IP address of the device through a coded sequence or via the LCD interactive function.
5. Password input if required to activate detector.

C. Liquid Crystal Display for FAAST XS and XT models shall provide detailed information of the device status and configuration. The LCD will enter a sleep state if the screen has remained unchanged for a period of 30 seconds. The home screen shall display the device’s current state which includes local address, date, time, current percent of smoke, and the highest priority state. The LCD shall support multiple languages. Navigation through the menus shall be done with the keypad located on the right hand side and shall be able to perform the following functions:

1. Isolate
2. Disable
3. Reset Baseline
4. Monitor Airflow per pipe
5. Test
6. Sounder Test
7. Reset IP Network
8. Password input if required to activate detector.

2.7 SOFTWARE

A. The software shall be based on a single program, PipeIQ, which provides pipe network design, ASD configuration, and system monitoring. The software shall provide the ability to remotely monitor the system and provide the following functions:

1. Test, reset, and isolate functions from remote locations
2. Bill of Materials for the pipe network
3. Pipe layout of the pipe network
4. Generate transportation time from the sampling holes to the detector and sampling hole pressure
5. Live event monitoring
6. Historic event retrieval
7. Custom message function to input messages about a device or site
8. Configuration settings
9. Network settings
10. Trend graph reflecting obscuration over time
11. Shall support up to 255 devices.

2.8 NETWORK CONNECTIVITY

A. The ASD shall include an onboard Web server interface to enable remote monitoring. Connection to the device shall be through an RJ45 Ethernet jack. A password shall be required to access the Web server. The software shall include the ability to enter up to six (6) e-mail addresses to send automatic updates for alarms and/or faults. Each e-mail address shall have the ability to select the type of notification desired.

B. The ASD shall communicate Modbus protocol using the onboard Ethernet connection. The device shall be able to receive remote configuration, as well as be monitored remotely, when the Modbus function is employed.
C. The Modbus/TCP communications shall be enabled through port 502 without inhibiting the functions of the PipeIQ server, the e-mail service (port 25), or the device’s integral web server. Each of these communication capabilities shall be available simultaneously.

D. Modbus communications shall be enabled without inhibiting the functions of the PipeIQ server or the device’s integral web server. Each of these communication capabilities shall be available simultaneously.

2.9 SAMPLE PIPE NETWORK

A. The ASD shall consist of a pipe network to transport air to the detection system supported by calculations from a computer-based design modeling tool.

1. The internal pipe diameter of the network may range from 0.59 inches to 1.03 inches (15-26 mm) with a smooth bore internal surface.
2. The ASD shall accept both nominal 3/4 inch and 25 mm pipe diameters.
3. Inflow and Exhaust pipes shall enter the device from either the top or the bottom of the unit so that the unit does not have to be inverted.
4. The system exhaust must be located back into the room being monitored. If the ASD is located within the same room being monitored, no exhaust pipe is required to be connected to the ASD.
5. Material for pipe and fittings shall be orange chlorinated polyvinyl chloride (CPVC) PIPE. The pipe shall be UL Listed as an accessory for plenum use as per IL 1887 standard.
6. The pipe shall be identified as “Smoke Detector Sampling Tube” along its entire length, in requirements per local codes and standards and manufacturer’s recommendations.
7. Pipe material substitution may be acceptable to accommodate environments where pipe network will be installed but must be approved by the specifying engineer and authority having jurisdiction, and if applicable, insurance underwriters.
8. The substitution pipe must comply with both inner and outer pipe diameter requirements.
9. All joints and sampling pipes must be glued and connected, free of any air gaps using solving cement throughout the pipe network, with the exception of the pipe connected to detector.

B. FAAST XS

1. The pipe network shall be designed based on a multi-branch system from a single pipe inlet. The system shall have the ability to cover up to 5,000 sq. ft. (464 sq. m) per detector. Final square footage shall be based on classification requirements per NFPA.
2. A single pipe network cannot exceed a maximum of 180 linear ft (54.8 m) on a single run and 225 ft (68.5 m) on an aggregate pipe network. Final pipe lengths shall be verified with PipeIQ software and comply with NFPA classifications.

C. FAAST XM

1. The pipe network shall be designed based on a multi-branch system from a single pipe inlet. The system shall have the ability to cover up to 8,000 sq. ft. (744 sq. m) per detector. Final square footage shall be based on classification requirements per NFPA.
2. A single pipe network cannot exceed a maximum of 262 linear ft (80 m) on a single run and 328 ft (100 m) on an aggregate pipe network. Final pipe lengths shall be verified with PipeIQ software and comply with NFPA classifications.

D. FAAST XT

1. The pipe network shall be designed based on a four (4) pipe multi-port system from a single detector. The system shall have the ability to cover up to 28,800 sq. ft. (2,000 sq. m) per detector. Final square footage shall be based on classification requirements per NFPA.
2. A single pipe network cannot exceed a maximum of 400 linear ft. (123 m) on a single run and 1,050 feet (320 m) on an aggregate pipe network. Final pipe lengths shall be verified with PipeIQ software and comply with NFPA classifications.

2.10 SAMPLING PORT

A. Sample port spacing shall comply with the requirements of NFPA classifications and manufacturer’s recommendations.

B. The minimum sample port diameter must not be less than 5/64” and shall not exceed a diameter larger than 1/4”.

C. All sample ports must be identified in accordance with NFPA.

D. In areas with a suspended ceiling the pipe network shall be installed above the ceiling utilizing a 3/8 inch diameter, flexible capillary tubing attached to an approved manufacturer’s capillary sample port supported by the ceiling.

E. The size of sample ports shall be verified and confirmed with PipeIQ calculations software.

2.11 SYSTEM OPERATING POWER

A. Provide power supply/charger to convert 115 VAC/60 Hz input into a single 12 VDC or 24 VDC Class 2 Rated power limited output, with UL listing UL294.

B. Power supply shall be provided with appropriately sized batteries to accommodate the system’s power requirements in the event main AC power is interrupted.

C. Upon loss of AC power, the external battery shall have sufficient capacity to power the fire alarm system for not less than 24 hours plus 5 minutes of alarm.

2.12 FILTER ASSEMBLY

A. Internal non-replaceable particle separator shall remove larger contaminates before entering the detection chamber and filter.

B. Multi-stage 30 micron field replaceable filter. A fault shall be generated when the filter needs replacement.

2.13 WIRING

A. Wire gauge shall range from 24 to 12 AWG (0.5-2.05 mm). Wire or conduit shall enter the detector from either the top or the bottom of the device. Pluggable terminals shall be used to wire the detector.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION
A. The entire system shall be installed in accordance with national and local codes and per the manufacturer’s installation manual.

B. Aspirating Smoke Detector Installation
1. ASD shall be mounted on a secured wall at a height of approximately 36 to 60 inches (0.9-1.5 m) above the finished floor.
2. ASD shall be located in an unobstructed location and shall maintain 36 inches (0.9 m) clearance in front of the unit.
3. All pipes and fittings shall be glued using solvent cement, except at entry of the ASD.

C. Sampling Pipe Network
1. Sampling pipe network shall be installed and designed so that the transport times from the most remote sample port location complies with the classifications of NFPA; (VEWFD) (EWFD) (SFD).
2. Sampling pipe shall be installed within 4 to 12 inches (0.1-0.3 m) from the ceiling in smooth ceiling applications.
3. All pipes shall be supported by mechanical hangers attached to the structure of the building, at no greater than five foot centers.
4. All pipes must be labeled throughout its entire length, as required per NFPA.
5. Piping network(s) shall be installed/design to provide detection points and spacing as indicated on the drawings (or as required). All changes to the direction of the pipe shall be made with standard elbows or tees. Piping shall be verified per manufacturer’s modeling software.

D. Sampling Port
6. Sample port spacing shall comply with the requirements of NFPA classifications and manufacturer’s recommendations.
7. All sample ports shall be drilled directly at the bottom of the pipe and equal the diameter as indicated per the PipeIQ reports.
8. In high air flow environments being used as plenums the sample ports must be aligned at angle between 20 to 45 degrees in the direction of the airflow, as per manufacturer’s recommendations.

3.2 SYSTEM INSPECTION:

A. Perform a visual inspection of the physical installation, checking adequate size batteries are used, piping is securely connected and installed, and all sample ports comply with the design.

B. Verify ASD communicates to fire alarm control, and if applicable, has the ability to network via a dedicated IP address and Modbus protocol.

C. Check the controller to ensure the following functions are operational and programmed in accordance with the specification:
1. Alarm Levels and Indicators
2. Time Delays
3. Particulate Level Display
4. Detector Fault Test Indicator
5. Detector Test and Indicator
6. Isolate/Reset Function
7. Air Flow Fault Indicators
8. Configuration Fault
9. Sensor Fault
10. External Monitor Fault
11. Time Fault
12. Communication Fault
13. Aspirator Fault
14. Filter Fault

3.3 COMMISSIONING

A. The system shall be commissioned in the presence of the manufacturer or installing contractor representative and client representative. The contractor shall provide the following necessary instrumentation, equipment, materials, and labor for the test:

1. PipeIQ Pipe Layout Report
2. Aerosol smoke (Home Safeguard Industries Model 25S or equivalent)
3. Stopwatch capable of measuring 1 second intervals
4. A total of two (2) qualified personals when testing is being performed

B. Acceptance testing shall be conducted in front of specifying engineer or client representative, and if required, in front of the Authority Having Jurisdiction using the following testing methods:

1. Introduce canned smoke (Home Safeguard Industries Model 25S or equivalent) directly into the sampling hole into farthest sample hole for a duration of 2 seconds at a distance of 6 inches from the sample hole. Start the timer once the smoke has been introduced.
2. Stop the timer once the first particulate bar is illuminated on the front of the device, above what was displayed during normal device operation. The device need not go into alarm to verify the transport time – an increase on the particulate meter is a successful measurement of transport time.
3. Compare the observed transport time with the results on the Pipe Layout report from PipeIQ. If there is more than a 20% discrepancy, verify the sample hole quantity, sizes, location, and the integrity of pipe and that the installed pipe network is identical to the PipeIQ Pipe Layout report.
4. Once transport times for the farthest sample points are verified, test the remaining holes for airflow by introducing smoke into each hole and verifying a response at the device or panel. Transport times are not required on each of the remaining holes, only a verification that air is flowing.
5. Document test results as required per NFPA to include the client’s contact information, transport times, and sensitivity levels.
6. Upon completion of a successful test, installer shall so certify the system in writing to Owner’s Representative.

3.4 WARRANTY

A. The manufacturer shall guarantee the product by warranty for a period of three years. All components of the detector shall be replaced with the exception of regular maintenance accessories: replaceable micron filter. Any damage to the ASD due to poor handling or operating outside of the listed criteria will void any such warranty. The installation and programming of the ASD shall be completed by factory-trained installer.

3.5 TRAINING

A. The contractor shall provide complete training to the Owner by factory-trained technicians.