Riverside County
Perris, California

SPECIFICATION NO. 1347S

WINCHESTER LIFT STATION ODOR CONTROL FACILITY

Work Order # 414377

A PUBLIC WORKS PROJECT

Volume 2 of 2

Contents:
Special Conditions | Specifications | Appendices

Paul D. Jones, II, P.E. - General Manager

Safety is of paramount and overriding importance to
Eastern Municipal Water District

Visit our website at www.emwd.org to view currently advertised projects
Navigate to Construction ➔ Construction Bid Opportunities
# TABLE OF CONTENTS

## VOLUME 1

### BIDDING REQUIREMENTS

<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000</td>
<td>Title Page</td>
</tr>
<tr>
<td>00010</td>
<td>Table of Contents</td>
</tr>
<tr>
<td>00012</td>
<td>Notice Inviting Bids (NIB-1 thru NIB-6)</td>
</tr>
<tr>
<td>00014</td>
<td>Bid Opening Map</td>
</tr>
<tr>
<td>00016</td>
<td>Bid Walk-thru map/directions</td>
</tr>
<tr>
<td>00018</td>
<td>Instructions to Bidders (B-1 thru -6)</td>
</tr>
<tr>
<td>00020</td>
<td>Bidding Sheets &amp; Equipment &amp; Material List <em>(submit with bid)</em> (BS-1 thru -6)</td>
</tr>
<tr>
<td>00024</td>
<td>Proposal (7 day) <em>(submit with bid)</em> (C3-1 thru -2)</td>
</tr>
<tr>
<td>00027</td>
<td>Bidder’s Experience Record &amp; Resumes <em>(submit with bid)</em> (BR-1 thru -2)</td>
</tr>
<tr>
<td>00028</td>
<td>Designation of Subcontractors <em>(submit with bid)</em> (C5a thru e)</td>
</tr>
<tr>
<td>00030</td>
<td>Contractor’s Licensing Statement <em>(submit with bid)</em> (C6-1 thru -2)</td>
</tr>
<tr>
<td>00032</td>
<td>Non-Collusion Declaration <em>(submit with bid)</em> (C7-1 thru -2)</td>
</tr>
<tr>
<td>00034</td>
<td>Agreement (C8a thru d)</td>
</tr>
<tr>
<td>00036</td>
<td>Performance Bond (C9-1 thru -4)</td>
</tr>
<tr>
<td>00038</td>
<td>Payment Bond (C10-1 thru -4)</td>
</tr>
<tr>
<td>00040</td>
<td>Bid Bond <em>(submit with bid)</em> (BB-1)</td>
</tr>
<tr>
<td>00042</td>
<td>Worker’s Compensation Insurance Certificate (C11-1 thru -2)</td>
</tr>
<tr>
<td>00044</td>
<td>Certificate of Insurance (C12)</td>
</tr>
<tr>
<td>00046</td>
<td>Iran Contracting Act Certification (C13-1 thru -4)</td>
</tr>
<tr>
<td>00050</td>
<td>Cal-Osha form 300A <em>(submit with bid)</em> (C16-1 thru -2)</td>
</tr>
<tr>
<td>00052</td>
<td>Contractor’s Cal Osha Compliance History and SIC Code <em>(submit with bid)</em> (C17-1 thru -2)</td>
</tr>
<tr>
<td>00056</td>
<td>Employee Safety &amp; Health Training Records (C19-1 thru -2)</td>
</tr>
<tr>
<td>00057</td>
<td>Contractor Registration Extract(s) <em>(submit with bid)</em> (C22-1 thru -2)</td>
</tr>
</tbody>
</table>

### GENERAL CONDITIONS

<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00062</td>
<td>Section E, Inspection &amp; Tests (E-1 thru -2)</td>
</tr>
</tbody>
</table>
| 00064 | Section F, Labor & Construction (F-1 thru -58)  
  *Includes Exhibit A – Escrow Agreement* |
| 00066 | Section H Permits (H-1 thru -2) |

### SPECIAL CONDITIONS

<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00100</td>
<td>Special Conditions (SC-1 thru SC-20)</td>
</tr>
</tbody>
</table>

### CONTRACT DRAWINGS

<table>
<thead>
<tr>
<th>Page</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00200</td>
<td>Section P Standard &amp; Construction Drawings (list) (P-1 thru P-2)</td>
</tr>
</tbody>
</table>
**EMWD DETAILED PROVISIONS**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>01000</td>
<td>General Safety Requirements</td>
<td>1 thru 8</td>
</tr>
<tr>
<td>01026</td>
<td>Schedule of Values</td>
<td>1 thru 6</td>
</tr>
<tr>
<td>01381</td>
<td>Pre-Const. Audio Video Taping Above Ground Facilities</td>
<td>1 thru 4</td>
</tr>
<tr>
<td>01430</td>
<td>Operation and Maintenance Data</td>
<td>1 thru 10</td>
</tr>
<tr>
<td>01610</td>
<td>General Equipment Stipulations <em>(Custom)</em></td>
<td>1 thru 6</td>
</tr>
<tr>
<td>01611</td>
<td>Meteorological and Seismic Design Criteria <em>(Custom)</em></td>
<td>1 thru 8</td>
</tr>
<tr>
<td>01612</td>
<td>Product Delivery Requirements <em>(Custom)</em></td>
<td>1 thru 2</td>
</tr>
<tr>
<td>01614</td>
<td>Product Storage and Handling Requirements <em>(Custom)</em></td>
<td>1 thru 2</td>
</tr>
<tr>
<td>01650</td>
<td>Commissioning <em>(Custom)</em></td>
<td>1 thru 16</td>
</tr>
<tr>
<td>01820</td>
<td>Demonstration and Training <em>(Custom)</em></td>
<td>1 thru 4</td>
</tr>
<tr>
<td>02050</td>
<td>Demolition and Salvage</td>
<td>1 thru 2</td>
</tr>
<tr>
<td>02201</td>
<td>Construction Methods and Earthwork</td>
<td>1 thru 26</td>
</tr>
<tr>
<td>02210</td>
<td>Site Grading</td>
<td>1 thru 8</td>
</tr>
<tr>
<td>02221</td>
<td>Trenching, Backfilling, and Compacting</td>
<td>1 thru 10</td>
</tr>
<tr>
<td>02252</td>
<td>Control Density Fill</td>
<td>1 thru 4</td>
</tr>
<tr>
<td>02303</td>
<td>Bypass Pumping <em>(Custom)</em></td>
<td>1 thru 4</td>
</tr>
<tr>
<td>02444</td>
<td>Chain Link Fencing</td>
<td>1 thru 6</td>
</tr>
<tr>
<td>02513</td>
<td>Asphalt Concrete Paving</td>
<td>1 thru 4</td>
</tr>
<tr>
<td>02704</td>
<td>Pipeline Pressure and Leakage Testing <em>(Custom)</em></td>
<td>1 thru 4</td>
</tr>
<tr>
<td>02718</td>
<td>Installation of Water Pipeline</td>
<td>1 thru 22</td>
</tr>
<tr>
<td>03150</td>
<td>Formwork</td>
<td>1 thru 6</td>
</tr>
<tr>
<td>03200</td>
<td>Reinforcing</td>
<td>1 thru 6</td>
</tr>
<tr>
<td>03300</td>
<td>Cast-in-Place Concrete</td>
<td>1 thru 38</td>
</tr>
<tr>
<td>03600</td>
<td>Grouting <em>(Custom)</em></td>
<td>1 thru 2</td>
</tr>
<tr>
<td>04220</td>
<td>Concrete Masonry Unit</td>
<td>1 thru 12</td>
</tr>
<tr>
<td>05100</td>
<td>Structural Metals</td>
<td>1 thru 6</td>
</tr>
<tr>
<td>05550</td>
<td>Anchorage in Concrete and Masonry <em>(Custom)</em></td>
<td>1 thru 8</td>
</tr>
<tr>
<td>07920</td>
<td>Sealants and Caulking</td>
<td>1 thru 6</td>
</tr>
</tbody>
</table>
VOLUME 2

EMWD DETAILED PROVISIONS (Continued)

09900  Painting and Protective Coatings 1 thru 48
11005  General Mechanical and Equipment 1 thru 18
11354  Activated Carbon Unit (Custom) 1 thru 20
11356  Odor Control Fans (Custom) 1 thru 12
11357  Odor Control Dampers and Valves (Custom) 1 thru 6
15020  Misc. Piping and Accessories Installation (Custom) 1 thru 12
15066  Fiberglass Reinforced Plastic Pipe (Air Service) (Custom) 1 thru 10
15067  Miscellaneous Plastic Pipe, Tubing, and Accessories (Custom) 1 thru 6
15081  Gaskets 1 thru 2
15089  Nuts and Bolts 1 thru 2
15094  Backflow Preventer (Custom) 1 thru 2
15104  Ball Valves 1 thru 4
15140  Pipe Supports (Custom) 1 thru 12
15400  Plumbing (Custom) 1 thru 18
15430  Emergency Eyewash/Shower Units 1 thru 4
15990  Testing, Adjusting, and Balancing (Custom) 1 thru 6
16010  General Electrical Requirements 1 thru 28
16040  Short Circuit Arc Flash Study 1 thru 26
16050  Basic Electrical Materials and Methods (Custom) 1 thru 20
16150  Induction Motors 1 thru 22
16160  Variable Frequency Drives 1 thru 30
16950  Custom Control Panels 1 thru 30
17005  General I&C Components 1 thru 32
17010  Programmable Logic Controller 1 thru 32
17550  Software Control Block Descriptions (Custom) 1 thru 8
17561  Panel Mounted Instruments (Custom) 1 thru 10
17564  Process Analytical Instruments (Custom) 1 thru 6

APPENDICES

Appendix A  Approved Materials List
Appendix B  Geotechnical Investigation Report
### CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.01</td>
<td>SCOPE</td>
</tr>
<tr>
<td>1.02</td>
<td>Warranty</td>
</tr>
<tr>
<td>1.03</td>
<td>CONTRACTOR</td>
</tr>
<tr>
<td>1.04</td>
<td>DEFINITIONS</td>
</tr>
<tr>
<td>1.05</td>
<td>HOURS OF WORK</td>
</tr>
<tr>
<td>1.06</td>
<td>PRE-JOB CONFERENCE</td>
</tr>
<tr>
<td>1.07</td>
<td>QUALITY ASSURANCE</td>
</tr>
<tr>
<td>1.08</td>
<td>SAFETY AND HEALTH REQUIREMENTS</td>
</tr>
<tr>
<td>1.09</td>
<td>REFERENCE SPECIFICATIONS AND STANDARDS</td>
</tr>
<tr>
<td>1.10</td>
<td>COMPLIANCE WITH ENVIRONMENTAL REGULATORY REQUIREMENTS</td>
</tr>
<tr>
<td>1.11</td>
<td>SUBMITTALS</td>
</tr>
<tr>
<td>1.12</td>
<td>PROTECTION OF WORK</td>
</tr>
<tr>
<td>2.01</td>
<td>GENERAL</td>
</tr>
<tr>
<td>2.02</td>
<td>PAINT AND COATING MATERIALS</td>
</tr>
<tr>
<td>2.03</td>
<td>SERVICE CONDITION A</td>
</tr>
<tr>
<td>2.04</td>
<td>SERVICE CONDITION B</td>
</tr>
<tr>
<td>2.05</td>
<td>SERVICE CONDITION C</td>
</tr>
<tr>
<td>2.06</td>
<td>SERVICE CONDITION D</td>
</tr>
<tr>
<td>2.07</td>
<td>SERVICE CONDITION E</td>
</tr>
<tr>
<td>2.08</td>
<td>SERVICE CONDITION F</td>
</tr>
<tr>
<td>2.09</td>
<td>SERVICE CONDITION G</td>
</tr>
<tr>
<td>2.10</td>
<td>SERVICE CONDITION H</td>
</tr>
<tr>
<td>2.11</td>
<td>SERVICE CONDITION I</td>
</tr>
<tr>
<td>2.12</td>
<td>ARCHITECTURAL PAINT FINISHES</td>
</tr>
<tr>
<td>2.13</td>
<td>MISCELLANEOUS COATINGS</td>
</tr>
<tr>
<td>3.01</td>
<td>GENERAL</td>
</tr>
<tr>
<td>3.02</td>
<td>QUALITY CONTROL</td>
</tr>
<tr>
<td>3.03</td>
<td>SURFACE PREPARATION, GENERAL - INDUSTRIAL</td>
</tr>
<tr>
<td>3.04</td>
<td>SURFACE PREPARATION, GENERAL - ARCHITECTURAL</td>
</tr>
<tr>
<td>3.05</td>
<td>APPLICATION, GENERAL</td>
</tr>
<tr>
<td>3.06</td>
<td>APPLICATION, SPECIFIC - ARCHITECTURAL</td>
</tr>
<tr>
<td>3.07</td>
<td>COLOR IDENTIFICATION</td>
</tr>
<tr>
<td>3.08</td>
<td>STENCIL IDENTIFICATION</td>
</tr>
<tr>
<td>3.09</td>
<td>APPLICATION, SPECIFIC - INDUSTRIAL</td>
</tr>
<tr>
<td>3.10</td>
<td>FINAL TESTING OF INDUSTRIAL COATING</td>
</tr>
<tr>
<td>3.11</td>
<td>CLEAN-UP</td>
</tr>
<tr>
<td>3.12</td>
<td>OMISSIONS</td>
</tr>
<tr>
<td>3.13</td>
<td>COLOR CODE SCHEDULE</td>
</tr>
</tbody>
</table>

Rev: 04/16/14
PART 1 - GENERAL

1.01 SCOPE

A. Requirements of Conditions of Contract and Division 1 apply to this Section. Provide all labor, materials, apparatus, scaffolding, and all appurtenant work in connection with painting and protective coatings, complete as indicated, specified and required.

B. Work included in this section. Principal items include:

1. All exposed piping, conduits, ducts and other metal surfaces, interior and exterior, except as hereinafter specifically excluded.

2. All submerged and intermittently submerged metal surfaces, except stainless steel.

3. All structural and miscellaneous steel, including tanks.

4. The interior of wet wells, headworks, manholes, junction structures, transition stations and similar structures.

5. Exterior above-ground concrete and concrete block as specified and shown on the Drawings.

6. The interior and exterior of structures as specified in the Painting Schedule and shown on the Drawings.

7. Equipment furnished with and without factory finished surfaces.

8. Equipment on which factory applied finishes have been marred, abraded, scratched, nicked, or otherwise damaged.

9. Exterior and interior concrete, concrete unit masonry, cement plaster, doors, frames, sheet metal surfaces and other architectural work as specified and shown on the Drawings.

10. Protective coating of submerged and intermittently submerged concrete and masonry surfaces, except portion of such surfaces designated to receive waterproofing.
11. Recoating of existing interior and exterior painted surfaces from architectural break where damaged or altered in performance of Work of this General Contract.

C. **Related Work Not Included in This Section.** The following surfaces, in general, shall not be painted:

1. Concrete surfaces subject to pedestrian or vehicular traffic except as herein specified.

2. Plastic surfaces and fiberglass reinforced plastic (FRP) surfaces, except as specified for identification purposes.

3. Nonferrous metals and stainless steel unless otherwise noted or indicated. Galvanized metal shall not be coated unless specified otherwise.

4. Mechanical equipment with factory finish as specified herein.

5. Electrical and instrumentation equipment with approved factory finish as indicated herein.

6. Waterproofing, damp proofing and roof covering Work.

7. Pavement stripping and marking as specified elsewhere in these Specifications.

8. Existing painted surfaces which are not within areas of alterations performed under this General Contract unless such surfaces are damaged in performance of Work of this General Contract.

D. In no case shall any concrete, wood, metal, or any other surface requiring protection be left unpainted or uncoated even though not specifically defined herein.

### 1.02 WARRANTY

A. A two (2) year guarantee which commences on the date of acceptance against any failure of coatings shall be provided. Defective coating shall be any of those defined by SSPC’s Visual Comparison Manual and include isolated failures. Failure of any coating during the guarantee period shall be repaired by the Contractor who shall absorb all costs related to the repair of the coating.

B. All personnel present at the Pre-Job Conference should attend a warranty inspection. All defective work shall be repaired in strict accordance with this Specification and to the satisfaction of the Engineer.
1. **Notification:** The Owner shall establish the date for the inspection and shall notify the Contractor at least 30 days in advance. The Contractor shall provide, at his own expense, suitable access equipment, lighting, and ventilation for the inspection.

C. **Inspection:** All surfaces of the coating systems shall be visually inspected. All defective coatings, as well as damaged or rusting spots, shall be satisfactorily repaired by and at the sole expense of the Contractor. Defective coating shall be any of those defined by SSPC’s Visual Comparison Manual.

1. **Inspection Report:** The Engineer shall prepare and deliver to the Contractor an inspection report covering the warranty inspection. The report shall set forth the number and type of failures observed, and the names of the persons making the inspection.

2. **Schedule:** Upon completion of the inspection and receipt of Inspection Report as noted herein, Owner shall establish a date for Contractor to proceed with remedial work. Any delay on part of Contractor to meet schedule established by Owner shall constitute breach of this Contract and Owner may proceed to have defects remedied through other means, and these costs may be charged to the Contractor.

3. **Remedial Work:** Any location where coating or paint is defined as defective shall be considered to be a failure of the system at that location. The Contractor shall make repairs at all points where failures are observed by removing the deteriorated coating, cleaning the surface, and recoating or repainting with the same system specified herein. Any spot repairs to defective areas will require feathering at least 3 inches into sound adjacent coating. If an area of failure exceeds 25 percent of a specific coated surface, the entire coating system from that specific area may be required to be removed and recoated in accordance with the original Specification.

1.03 **CONTRACTOR**

A. The Contractor shall hold a valid State of California Contractor’s Class C-33, Painting and Decorating license for performing surface preparation, cleaning and coating/painting work. The Contractor shall have a minimum of five years’ experience and successful history in the application of the specified products to similar surfaces. The Contractor shall demonstrate said experience by submitting qualifications to the Owner for approval.

B. All coating and surface preparation work shall be performed by skilled personnel demonstrating experience, as listed above. Continuity of personnel shall be maintained
throughout the duration of the cleaning and coating work and any changes in key personnel shall be subject to the approval of the Owner.

C. Applicator Training: Application of coating is considered specialized work. Personnel performing this work shall be trained in proper methods of application.

D. Subcontractor Qualifications: Where the coating is to be applied by a Subcontractor, the Contractor shall provide 5 references, which show that the Subcontractor has previous successful experience with the indicated coating systems in similar applications. Include the name, address, and the telephone number for the owner of each installation for which the Subcontractor provided the coating.

1.04 DEFINITIONS

A. "Lining" refers to protective materials used or applied to interior surfaces, "Paint" refers to protective materials used or applied on exterior surfaces, and "Coating" refers to protective materials used or applied on interior surfaces, or any protective material in general.

B. "Owner" refers to Eastern Municipal Water District. "Engineer" refers to the Inspector, Owner, or the Owner’s designated representative.

1.05 HOURS OF WORK

A. Work areas will be available for performance of the Contract work between 7:00 A.M. and 5:00 P.M. excluding Saturdays, Sundays and holidays. No work shall be accomplished during hours or on days other than specified above, unless approved in advance by the Owner.

B. Inspections requested by or made necessary as a result of actions of the Contractor on Saturdays, Sundays or holidays must be scheduled and approved in writing by Engineer. The contractor shall bear all additional fees or expenses of Owner's personnel and Inspection services created by extraordinary work hours including standby time or overtime.

1.06 PRE-JOB CONFERENCE

A. A Pre-Job Conference shall be scheduled prior to start of project. The Owner, Contractor and Engineer shall be present. A schedule of work to be accomplished and a list of labor, material and equipment rates for additional work will be established and maintained throughout the project. Contractor shall furnish a complete set of submittal data for use by Engineer.
1.07 QUALITY ASSURANCE

A. Quality assurance procedures and practices shall be used to monitor all phases of surface preparation, application and quality control inspection throughout the duration of the project. Procedures or practices not specifically defined herein may be used provided they meet recognized and acceptable professional standards and are approved by the Engineer.

B. All materials furnished and all work accomplished under the Contract shall be subject to fulltime continuous inspection by the Engineer. The Contractor shall be held strictly to the true intent of the Specifications in regard to quality of materials, workmanship, and diligent execution of the Contract.

C. Work accomplished in the absence of prescribed inspection may be required to be removed and replaced under the proper inspection. The entire cost of removal and replacement, including the cost of all materials which may be furnished by the Owner and used in the work thus removed, shall be borne by the Contractor regardless of whether the work removed is found to be defective or not. Work covered up without the authority of the Engineer, shall upon order of the Engineer, be uncovered to the extent required. The Contractor shall similarly bear the entire cost of performing all the work and furnishing all the materials necessary for the removal of the covering and its subsequent replacement, as directed and approved by the Engineer.

D. The Engineer will make, or have made, such tests as deemed necessary to assure the work is being accomplished in accordance with the requirements of the Contract. Unless otherwise specified, the cost of such testing will be borne by the Owner. In the event such tests reveal non-compliance with the requirements of the Contract, the Contractor shall bear the cost of such corrective measures deemed necessary by the Engineer, as well as the cost of subsequent retesting. It is understood and agreed the making of tests shall not constitute an acceptance of any portion of the work, nor relieve the Contractor from compliance with the terms of the Contract.

1.08 SAFETY AND HEALTH REQUIREMENTS

A. General: ventilation, electrical grounding, and care in handling coatings, paints, solvents and equipment are important safety precautions during coating and painting projects. Contractor shall conform with safety requirements set forth by regulatory agencies applicable to the construction industry and manufacturer's printed instructions and appropriate technical bulletins and manuals. The Contractor shall provide and require use of personal protective life saving equipment for all persons working in or about the project site.

B. Access Facilities: all ladders, scaffolding and rigging shall be designed for their intended uses. Ladders and scaffolding shall be erected where requested by Engineer to facilitate
inspection and be moved by the Contractor to locations requested by the Engineer.

C. Ventilation: where ventilation is used to control hazardous exposure, all equipment shall be explosion-proof, of industrial design and shall be approved by the Engineer. Ventilation shall reduce the concentration of air contaminant to the degree a hazard does not exist by educting air, vapors, etc. from the confined space. Air circulation and exhausting of solvent vapors shall be continued until coatings have fully cured. Forced air eduction during blast cleaning and coating application operations is mandatory 24 hours per day until coatings have fully cured. If dehumidification equipment is used, equipment must be operated on a continuous basis during all blasting and coating operations, including shifts during which no work is being accomplished. Only ventilation, not dehumidification is required during final curing phases.

1. Ventilation system shall be furnished and installed by the Contractor in accordance with these specifications. The Contractor shall make modifications to the ventilation system as directed by the Engineer to insure a safe working environment and complete removal of all solvent vapors. Upon completion of the final curing period, as determined by the Engineer, the Contractor shall remove the ventilation system.

2. The exhaust blower capacity shall be sufficient to maintain air changes within tank interiors in accordance with OSHA, the coating manufacturer's recommendations, and the local air quality management district's regulations.

3. If Contractor uses dehumidification equipment, or any other alternative ventilation systems, Contractor must submit, in advance, for approval by the Engineer, a complete list of equipment and procedures for its use.

4. Where applicable, upon completion of applied coating system, Contractor shall furnish an approved exhaust fan or blower of sufficient capacity to insure removal of solvent vapors during curing process. The fan or blower shall be installed as approved by the Engineer and shall remain in continuous operation until coating is completely cured as determined by the manufacturer of the coating system.

D. Head and Face Protection and Respiratory Devices: equipment shall include protective helmets, which shall be worn by all persons while in the vicinity of the work. During abrasive blasting operations, nozzle-men shall wear U.S. Bureau of Mines approved air-supplied helmets and all other persons who are exposed to blasting dust shall wear approved filter-type respirators and safety goggles. When coatings are applied in confined areas all persons exposed to toxic vapors shall wear approved respiratory protection.

E. Grounding: blasting, spray, and air hoses shall be grounded to prevent accumulation of charges of static electricity.
F. Illumination: spark proof artificial lighting shall be provided for all work in confined spaces. Light bulbs shall be guarded to prevent breakage. Lighting fixtures and flexible cords shall comply with the requirements of NFPA 70 "National Electric Code" for the atmosphere in which they will be used. Whenever required by the Engineer, the Contractor shall provide additional illumination per SSPC Guide 12 and necessary supports to cover all areas to be inspected. The Engineer shall determine the level of illumination required for inspection.

G. Toxicity and Explosiveness: the solvents used with specified protective coatings are explosive at low concentrations and are highly toxic. The maximum allowable concentration of vapor shall be kept below the maximum safe concentration for eight-hour exposure, plus Lower Explosive Limit must be strictly adhered to. If coatings or paints contain lead or other hazardous materials, all regulations related to safety of personnel and handling of such materials shall be strictly adhered to.

H. Protective Clothing: coating and paint materials may be irritating to the skin and eyes. When handling and mixing coatings and paints workmen shall wear appropriate covering gloves and eye shields.

I. Fire: during mixing and application of coatings and paints, all flames, welding and smoking shall be prohibited in the vicinity. Appropriate type fire extinguishers shall be provided by Contractor and kept at the jobsite during all operations.

J. Sound Levels: whenever the occupational noise exposure exceeds the maximum allowable sound levels, the Contractor shall provide and require the use of approved ear protective devices. General sound levels for project shall be those that will not affect routine facility or neighborhood activities. Whenever any levels are objectionable, they shall be adjusted as directed by the Engineer. Adjustments to noise levels required may include the relocation of equipment or the installation of a sound barrier, as required by the Engineer.

K. Compliance with California Code of Regulations: Contractor shall submit a notarized letter signed by a principal officer of the Corporation certifying the Contractor fully complies with California Code of Regulations pertaining to the work including, but not limited to, the following:

1. Illness Injury Prevention Program CSO/G ISO 1508/3203
2. Confined Space Plan G ISO 5156/5159
3. Respiratory CSO/G ISO 1531/5144
4. Hazard Communication G ISO 5194
5. Rolling Scaffolds CSO 1646
6. Employee Safety Instruction CSO 1510
7. Emergency Medical Service CSO 5112
8. Dusts, Fumes, Mists, Vapors & Gases CSO 1528
L. Protective Coverings, Containment, and Ventilation Materials/Equipment: The Contractor shall provide all protective coverings needed to protect those surfaces that are not designated to be prepared or coated. Provide all materials needed for the implementation of a containment/ventilation system around the operation to control emissions and exposures in accordance with the provisions of this Section. This includes, but is not limited to, rigging, scaffolding, planking, tarpaulins, dust collectors and vacuums. Verify that all materials are free of lead, chromium, loose dust and debris when brought onto the Owner’s property and upon removal from the site.

1.09 REFERENCE SPECIFICATIONS AND STANDARDS

A. Without limiting the generality of other requirements of these Specifications, all cleaning, surface preparation, and coating work shall conform to the applicable requirements of the referenced portions of the standards specified herein to the extent that the requirements therein specified are not in conflict with the provisions of this Section.

B. Unless otherwise specified, all work and materials for the preparation and coating of all metal surfaces shall conform to the applicable requirements specified in the Steel Structures Painting Manual, Volume 2, Systems and Specifications, latest edition, published by SSPC: The Society for Protective Coatings.

C. The Engineer’s decision shall be final as to interpretation and/or conflict between any of the referenced codes, laws, ordinances, specifications and standards contained herein.

D. The latest edition of standards and regulations herein form a part of this specification.

E. American Society for Testing and Materials (ASTM)

1. ASTM E337, Standard Test Method for Measuring Humidity with a Psychrometer

2. ASTM D1186, Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base

3. ASTM D2240, Standard Test Method for Rubber Property-Durometer Hardness


6. ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
7. ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air
8. ASTM D4414, Standard Practice for Measurement of Wet Film Thickness by Notch Gages
9. ASTM D4417, Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
11. ASTM D4562, Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces

F. International Concrete Repair Institute (ICRI)
1. Guideline No. 03732, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.
2. ICRI, Concrete Surface Profile Standards

G. NACE International (NACE)
1. NACE SP 0188-06, Standard Recommended Practice for Discontinuity (Holiday) Testing of Protective Coatings
2. NACE SP 0178-89, Standard Recommended Practice for Fabrication Details, Surface Finish Requirements, and Proper Design Considerations for Tanks and Vessels to be Lined for Immersion Service.
H. Painting Decorators and Contractors of America (PDCA)

1. PDCA P2 - Third Party Inspections: Qualifications, Responsibilities, and Procedures

2. PDCA P4 - Responsibility for Inspection and Acceptance of Surfaces Prior to Painting and Decorating

3. PDCA P13 - The Inspection and Acceptance of Architectural Paints on the Interior Surfaces of Structures When Dry Film Thickness is Specified

4. PDCA P22 - Cleaning Surfaces Using Pressurized Water

I. SSPC: The Society for Protective Coatings (SSPC)

1. **SSPC-SP5 White Metal Blast Cleaning**, removal of all visible rust, mill scale, paint, and foreign matter by blast cleaning by wheel or nozzle (dry) using sand, grit, or shot (Typically for very corrosive atmosphere).

2. **SSPC-SP10 Near-White Blast Cleaning**, blast cleaning until at least 95 percent of each element of surface area is free of all visible residues. (For high humidity, chemical atmosphere, marine or other corrosive environment.)

3. **SSPC-SP6 Commercial Blast**, blast cleaning until at least 66 percent of each element of surface area is free of all visible residues.

4. **SSPC-SP7 Brush-Off Blast Cleaning**, blast cleaning to remove loose rust, loose mill scale, and other detrimental foreign matter present to the degree specified. Loose materials are those that can be removed with a dull putty knife.

5. **SSPC-SP 2/3 Hand/Power Tool Cleaning**, hand or powertool cleaning of all loose materials. Loose materials are those that can be removed with a dull putty knife.

6. **SSPC-SP1 Solvent Cleaning**, removal of oil, grease, dirt, soil, visible salts, and contaminants by cleaning with solvent, vapor, alkali, emulsion or steam.

7. **Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating (SSPC-SP12)**

8. **Surface Preparation of Concrete (SSPC-SP13)**

9. **SSPC-PA1**, Shop, Field, and Maintenance Painting of Steel

10. **SSPC-PA 2**, Measurement of Dry Film Thickness with Magnetic Gages
11. **SSPC-VIS 1**, Visual Standard for Abrasive Blast Cleaned Steel

12. **SSPC-VIS 2**, Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces


15. **SSPC Publication No. 91-12**, Coating and Lining Inspection Manual

16. **SSPC-SSPC Visual Comparison Manual**

J. Equipment and Coating Manufacturers' Published Instructions.

### 1.10 COMPLIANCE WITH ENVIRONMENTAL REGULATORY REQUIREMENTS

A. Contractor shall comply with all current federal, state, and local environmental laws and regulations, including, but not limited to the laws and regulations of the U.S. Environmental Protection Agency (USEPA), the California Air Resources Board (CARB), and the South Coast Air Quality Management District (SCAQMD).

### 1.11 SUBMITTALS

A. For compliance with these Specifications, the Contractor shall prepare and submit three (3) paint and protective coating samples of each finish, including all coats thereof, to the Owner for review, as specified. The samples shall be clearly marked with the manufacturer's name and product identification, and shall be submitted in sufficient time to allow for review, and, if necessary, resubmittal without causing any delay of the Project.

B. **Coating Materials List**

1. The Contractor shall provide eight (8) copies of a paint and coating materials list which indicates the manufacturer and paint number, keyed to the coating schedule herein, for approval of the Owner prior to, or at the time of, submittal of samples required herein.
2. The Contractor shall include with his submittal his protective coating schedule for shop and field coatings of items to receive protection. The schedule shall conform to the specified requirements for surface preparation, priming, and coating for items covered, and shall follow the same requirements for similar work where such work has not been specifically called-out. No bare ferrous nonworking surfaces shall be omitted from the schedule. Particular care shall be taken to cover in sufficient detail the coating of mechanical joints and other mechanical devices, which shall conform to the recommended practice of the manufacturer of the joint or other mechanical devices.

3. Submittals shall be sufficiently early to permit Owner's review and then Contractor's coordination with affected material and equipment suppliers to assure their use of reviewed shop coats of same manufacture as field coats and compatibility with field applied coats for respective coating system.

4. The coating system shall include a letter from the paint or coating manufacturer endorsing the use of the submitted system for the service environment.

5. Coatings to be used on plastic and fiberglass materials shall be certified as acceptable by all plastic and fiberglass manufacturers whose products are to be coated. Certification copies shall be submitted to the Owner. The Contractor shall be certified in writing by the painting and coating material manufacturers as qualified applicators of their products, and copies of the certification submitted to the Owner.

C. Contractor shall submit paint and coatings material manufacturers' printed Product Data Sheets for materials intended for use in each of various paint and coating systems. Data sheets shall fully describe material as to its intended use, make-up, recommended surface preparation and application conditions, primers, material mixing and application (including recommended dry mil thickness), thinners, precautions, safety and maintenance cleaning directions.

1.12 PROTECTION OF WORK

A. The Contractor shall be responsible for any and all damage to his work or the work of others during the time his work is in progress. The Contractor shall conduct all operations so as to confine general debris, abrasive blasting debris, and paint overspray to within the bounds of the site. The Contractor shall take all precautions necessary to prevent adverse consequences of painting operations. Any complaints received by the Owner relating to any such potential problems will be immediately delivered to the Contractor. The Contractor shall immediately halt work and shall take whatever corrective action is required to mitigate any such problems. All costs associated with protection of off-site properties and/or correction of damage to property as a result of painting operations shall be borne directly by the Contractor at no additional expense to the Owner.
PART 2 - PRODUCTS

2.01 GENERAL

A. Surfaces to receive paint and protective coating materials as herein specified in this Section shall be coated in conformance with the applicable coating systems specified herein. All materials specified by name and/or manufacturer or selected for use under these Specifications shall be delivered unopened at the job site in their original containers and shall not be opened until inspected by the Owner. Whenever a manufacturer's brand name is specified, it is intended to define the general type and quality of paint or coating desired. Other coatings or paints of equal quality may be used, under the approval of the Engineer.

B. Coating materials shall be as specified herein or approved equal. Architectural paint finishes are specified hereinafter. All paint and coatings shall be produced and applied as herein called for, or, if not specifically called for, it shall be applied in accordance with the manufacturer's printed recommendations as reviewed by Owner. So far as possible, all paint and coating materials shall be provided by a single source supplier.

C. Materials specified are those which have been evaluated for the specific service. Products are listed to establish a standard of quality. Standard products of manufacturers other than those specified will be accepted when proven to the satisfaction of the Engineer they are equal in composition, durability, usefulness and convenience for the purpose intended. Substitutions will be considered provided the following minimum conditions are met:

1. The proposed coating or paint system shall have a dry film thickness equal to or greater than that of the specified system.

2. The proposed coating or paint system shall employ an equal or greater number of separate coats.

3. The proposed coating or paint system shall employ coatings or paints of the same generic type.

4. All requests for substitution shall carry full descriptive literature and directions for application, along with complete information on generic type, non-volatile content by volume and a list of 10 similar projects, all at least three years old, where the coatings or paints have been applied to similar exposure. Substitutions shall be endorsed in writing from the materials manufacturer that these substituted materials will provide equivalent performance as those specified.

5. If the above mentioned data appears to be in order, the Engineer may require that the Contractor provide certified laboratory data sheets showing the results
of complete spectrographic and durability tests accomplished on the proposed substitute. An independent testing laboratory satisfactory to the Engineer shall accomplish tests and all costs incurred in the testing program shall be borne by the Contractor. In any case, the Engineer shall be sole and final judge of the acceptability of any proposed substitution. Requests for substitution must be approved in writing.

D. Flammability, toxicity, allergenic properties, and any other characteristic requiring field precautions shall be identified and specific safety practices shall be stipulated.

E. All paint and coating materials shall be stored in enclosed structures to protect them from weather and excessive heat or cold. Flammable coatings and paints must be stored to conform to local, county, state and federal safety codes for flammable coating and paint materials. At all time the paint and coatings shall be protected from freezing.

2.02 PAINT AND COATING MATERIALS

A. Paint and protective coating materials shall be sealed in containers that plainly show the designated name, formula or specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer, all of which shall be plainly legible at the time of use. Pigmented paints shall be furnished in containers not larger than five (5) gallons.

B. Materials shall conform to the specifications shown herein and to the requirements hereinafter specified. Containers shall not be opened or used until Engineer has physically inspected contents and obtained necessary data from information printed on containers or labels. Materials exceeding storage life recommended by the manufacturer shall be rejected.

C. Products shall be standard for recognized manufacturer engaged in production of such materials for essentially identical or similar applications in the water and wastewater treatment industry and industrial plants.

D. Only compatible materials shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats. If necessary, subject to review of the Owner, a compatible barrier coat shall be applied between all existing prime coats and subsequent field coats to ensure compatibility.

E. All colors and shades of colors of all coats of paints and protective coating material shall be as selected by the Owner. Each coat shall be of a slightly different color to facilitate inspection of surface coverage of each coat.
F. Any discrepancies between the coating supplier's written recommendations and the specified requirements herein shall be brought to the attention of the Owner prior to application.

2.03 SERVICE CONDITION A

A. Ferrous metals, other than stainless steel, submerged or intermittently submerged in water, sludge, sewage, chemical mixtures or similar corrosive liquid and all steel angles in contact with concrete shall be prepared and coated in accordance with the following requirements.

B. Surface Preparation. All metal surfaces shall be field abrasive blast cleaned in accordance with SSPC-SP10, Near White Blast Cleaning. A sharp jagged anchor profile of not less than 2 mils, as determined by a Test-Ex Tape Replica Tape, shall be attained. Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed in accordance with NACE SP0178.

C. Application. Application shall be in strict conformance with the manufacturer's printed recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall receive a stripe coated with a brush-applied coat of the specified coating prior to application of each coat.

D. Coating System A. Except as otherwise noted, the prime coat shall have minimum dry film thickness of 10 mils; and the final coat, 10 mils. The total system shall have a minimum dry film thickness of 20 mils.

   Carboline System: Primer - Carboguard 891 VOC  
   Final - Carboguard 891 VOC

   Sherwin Williams System: Primer - Sherglass FF Low VOC  
   Final - Sherglass FF Low VOC

   Tnemec System: Primer - L69 Hi-Build Epoxoline II  
   Final - L69 Hi-Build Epoxoline II

2.04 SERVICE CONDITION B

A. Ferrous metals, other than stainless steel, not subject to chemical attack, normal indoor or outdoor exposure, shall be prepared and coated in accordance with the following requirements.
B. **Surface Preparation.** All surfaces shall be free of dirt, dust, grease, or other foreign matter that may act as a contaminant. Surfaces, except galvanized, shall be cleaned in accordance with the Steel Structures Painting Council Specification SSPC-SP7 (Brush-Off Blast Cleaning). Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed in accordance with NACE SP0178.

C. **Application.** Application shall be in strict conformance with the manufacturer’s printed recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application of each coat.

D. **Coating System B.** Except as specified below, the prime coat shall have a minimum thickness of 1.5 mils and two or more finish coats minimum total dry film thickness of 4.5 mils. The total system shall have a minimum of 6.0 mils.

   Carboline System: Primer – Carbocrylic 3358 MC
                   2 Finish Coats – Carbocrylic 3359 MC

   Sherwin Williams System: Primer – Procryl Universal Primer
                           2 Finish Coats – Pro Industrial Acrylic

   Tnemec System: Primer - Series 115 Uni-Bond DF
                   2 Finish Coats - Tnemec - Series 1029 Enduratone

**2.05 SERVICE CONDITION C**

A. Ferrous metals, other than stainless steel, subject to a corrosive atmosphere and condensation shall be prepared and coated in accordance with the following requirements.

B. **Surface Preparation.** All metal surfaces shall be sandblasted in accordance with Steel Structures Painting Council Specification SSPC-SP10 (Near White Metal Blast Cleaning). A sharp, jagged anchor profile of not less than 2 mils as determined by a profile comparator shall be attained. Weld surface, edges and sharp corners shall be ground to a curve and all weld splatter removed.

C. **Application.** Application shall be in strict conformance with the manufacturer’s recommendations.

D. **Coating Systems C.** Except as hereinafter specified, the prime coat shall have a minimum dry film thickness of 3.0 mils; the intermediate coat, 4 mils; and the final coat, 2 mils. The total system shall have a minimum dry film thickness of 9.0 mils.
Carboline System:  
Primer - Carbozinc 11HS (Shop)  
Primer - Carbozinc 859 VOC (field)  
Intermediate - Carboguard 890 VOC  
Finish - Carbothane 133 MC  

Sherwin Williams System:  
Primer – Corothane I Galvapak -100  
Intermediate – Macropoxy 646-100  
Finish – Hi Solids Polyurethane-100  

Tnemec System:  
Primer - Series 94H2O Tnem Zinc  
Intermediate - L69 Hi-Build Expoxoline II  
Finish - 750 UVX Hybrid Polyurethane, Semi-Gloss  

2.06 SERVICE CONDITION D  

A. Concrete which is subject to submerged and intermittent submergence in water, sludge or chemical mixtures, or which is exposed to corrosive atmospheres, shall be prepared and coated in accordance with the following requirements:  

B. Surface Preparation.  

1. All green concrete surfaces shall be aged for at least 30 days prior to application.  

2. Prior to final preparation of the concrete surfaces, the contractor shall thoroughly clean the surfaces to be lined to remove dirt, residue, and other foreign deposits. Surfaces shall be tested by placing droplets of clean water onto sample locations. Satisfactory surfaces will allow water to be easily absorbed or penetrated into the concrete, while contaminated surfaces will result in the water beading. Contaminated surfaces shall be cleaned. Surfaces showing evidence of such contamination shall be cleaned using solutions of caustic soda or trisodium phosphate (TSP). They should be applied with vigorous scrubbing, followed by flushing with fresh water to remove all traces of both the detergent and contaminant and then allowed to thoroughly dry.  

3. The contractor shall use either abrasive blasting or high-pressure waterjetting surface preparation methods to remove any loose concrete and produce a clean, contamination-free, sound, roughened surface acceptable to the lining manufacturer. Abrasive blast cleaning shall be completed in accordance with SSPC-SP7 and SSPC-SP13. The actual water pressure required during any water jetting to achieve the proper removal of deteriorated concrete is not known, but it is projected that pressures between 10,000 to 30,000 psi will be required. Any water jetting equipment shall utilize an oscillating tip.
4. No efflorescence, laitance, or deteriorated concrete shall remain following final surface preparation. Only sound concrete shall remain. The remaining sound concrete shall be uniformly gray in color and appearance.

5. The integrity testing of the prepared concrete shall include dragging the dull edge of putty knife along the prepared surfaces. Properly prepared surfaces will leave behind a scratch without substantial substrate removal. Areas where the scraping action leaves behind a groove or indentation shall be further prepared and retested.

6. All surfaces shall have a surface profile or anchor pattern equal to the International Concrete Repair Institute (ICRI) replica coupon recommended by the coating supplier.

7. The pH of the prepared concrete shall range between 7.0 and 9.0. The pH of the prepared surfaces shall be tested by the contractor according to ASTM D4262.

8. If any reinforcing steel is exposed after removing concrete, it shall be thoroughly cleaned by sandblasting to a near-white metal blast condition (SSPC-SP10).

9. The moisture vapor transmission of the area shall be tested in accordance with ASTM D4263. All testing shall be completed by the contractor and witnessed by the Owner.

10. Prior to installing the coating system, the Contractor shall fill all surface areas with depressions deeper than 1/4-inch by filling in with a resurfacing material that is compatible with the coating system selected. The Contractor shall follow the instructions and recommendations of the manufacturer as to application, curing time requirements, depth of repair, and surface preparation procedures. Any resurfacing material shall be properly prepared through scarification prior to the application of any coatings.

11. The Contractor shall not start application until the surface pH, moisture content, and surface temperature are within the recommended limits, and the prepared surfaces have been accepted by the Engineer. Application shall only be performed when the surface temperature is stable or on the decline.

12. Leading Edges/Terminations: If in the opinion of the Engineer the concrete surfaces specified for coating application does not include a well defined beginning or ending anchor (e.g. terminating edge on lined concrete) or a proper anchored transition between concrete and steel substrates, the coating shall be mechanically anchored to a dry, clean saw cut to a minimum depth of 1/4 inch and width of 1/4 inch. This includes any steel appurtenances penetrating concrete surfaces. The coating system shall be applied into the saw cut to full depth.
13. Should cracks be identified after preparation of concrete that require sealing to assure prevention of moisture intrusion or proper continuous lining work, seal all cracks in accordance with the written recommendations of the lining supplier, as approved by the Engineer.

C. Application. Application shall be in strict conformance with the manufacturer's printed recommendations. All coats shall be applied within 24 hours of the previous coat and within the written recoat limitations.

D. Coating System D. The prime coat shall have a minimum dry film thickness of 6 mils and two finish coats shall have a minimum total dry film thickness of 16 mils. The total system shall have a minimum dry film thickness of 22 mils.

Sherwin Williams System:  
Prime – Corobond 100  
Two Finish Coats – Sherglass FF Low VOC

Tnemec System:  
Primer - Series 218 MortarClad (surfacер)  
Two Finish Coats - 436 Perma-Shield FR

2.07 SERVICE CONDITION E

A. Concrete surface subject to corrosive atmosphere and condensation shall be prepared and coated in accordance with the following requirements.

B. Surface Preparation.

1. All concrete surfaces shall be aged for at least 30 days prior to application.

2. Prior to final preparation of the concrete surfaces, the Contractor shall thoroughly clean the surfaces to be lined to remove dirt, residue, and other foreign deposits. Surfaces shall be tested by placing droplets of clean water onto sample locations. Satisfactory surfaces will allow water to be easily absorbed or penetrated into the concrete, while contaminated surfaces will result in the water beading. Contaminated surfaces shall be cleaned. Surfaces showing evidence of such contamination shall be cleaned using solutions of caustic soda or trisodium phosphate (TSP). They should be applied with vigorous scrubbing, followed by flushing with fresh water to remove all traces of both the detergent and contaminant and then allowed to thoroughly dry.

3. The Contractor shall use either abrasive blasting or high-pressure waterjetting surface preparation methods to remove any loose concrete and produce a clean, contamination-free, sound, roughened surface acceptable to the lining manufacturer. Abrasive blast cleaning shall be completed in accordance with SSPC-SP7 and SSPC-SP13. The actual water pressure required during any water
jetting to achieve the proper removal of deteriorated concrete is not known, but it is projected that pressures between 10,000 to 30,000 psi will be required. Any water jetting equipment shall utilize an oscillating tip.

4. No efflorescence, laitance, or deteriorated concrete shall remain following final surface preparation. Only sound concrete shall remain. The remaining sound concrete shall be uniformly gray in color and appearance.

5. The integrity testing of the prepared concrete shall include dragging the dull edge of putty knife along the prepared surfaces. Properly prepared surfaces will leave behind a scratch without substantial substrate removal. Areas where the scraping action leaves behind a groove or indentation shall be further prepared and retested.

6. All surfaces shall have a surface profile or anchor pattern equal to the International Concrete Repair Institute (ICRI) replica coupon recommended by the coating supplier.

7. The pH of the prepared concrete shall range between 7.0 and 9.0. The pH of the prepared surfaces shall be tested by the Contractor according to ASTM D4262.

8. If any reinforcing steel is exposed after removing concrete, it shall be thoroughly cleaned by sandblasting to a near-white metal blast condition (SSPC-SP10).

9. The moisture vapor transmission of the area shall be tested in accordance with ASTM D4263. All testing shall be completed by the Contractor and witnessed by the Owner.

10. Prior to installing the coating system, the Contractor shall fill all surface areas with depressions deeper than 1/4-inch by filling in with a resurfacing material that is compatible with the coating system selected. The Contractor shall follow the instructions and recommendations of the manufacturer as to application, curing time requirements, depth of repair, and surface preparation procedures. Any resurfacing material shall be properly prepared through scarification prior to the application of any coatings.

11. The Contractor shall not start application until the surface pH, moisture content, and surface temperature are within the recommended limits, and the prepared surfaces have been accepted by the Engineer. Application shall only be performed when the surface temperature is stable or on the decline.

12. Leading Edges/Terminations: If in the opinion of the Engineer the concrete surfaces specified for coating application does not include a well defined beginning or ending anchor (e.g. terminating edge on lined concrete) or a proper anchored transition between concrete and steel substrates, the coating shall be mechanically anchored to a dry, clean saw cut to a minimum depth of 1/4 inch
and width of 1/4 inch. This includes any steel appurtenances penetrating concrete surfaces. The coating system shall be applied into the saw cut to full depth.

13. Should cracks be identified after preparation of concrete that require sealing to assure prevention of moisture intrusion or proper continuous lining work, seal all cracks in accordance with the written recommendations of the lining supplier, as approved by the Engineer.

C. **Application.** Application shall be in strict conformance with the manufacturer's recommendations, including recoat times.

D. **Coating System E.** First and second coats shall have a minimum dry film thickness of 4.0 mils each. The top coat, minimum dry film thickness shall be 1.5 mils. The total system shall have a minimum dry film thickness of 9.5 mils.

<table>
<thead>
<tr>
<th>System</th>
<th>First Coat</th>
<th>Second Coat</th>
<th>Topcoat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carboline System</strong></td>
<td>Semstone 110</td>
<td>Carboguard 890 VOC</td>
<td>Carbothane 133 MC</td>
</tr>
<tr>
<td><strong>Sherwin Williams System</strong></td>
<td>Macropoxy 646-100</td>
<td>Macropoxy 646-100</td>
<td>Hi Solids Polyurethane-100</td>
</tr>
<tr>
<td><strong>Tnemec System</strong></td>
<td>Series 287 Enviro-Pox</td>
<td>Series 287 Enviro-Pox</td>
<td>Series 297 Enviro-Glaze</td>
</tr>
<tr>
<td><strong>Lifelast System</strong></td>
<td>Primall 160</td>
<td>Durasheild 310</td>
<td></td>
</tr>
</tbody>
</table>

2.08 **SERVICE CONDITION F**

A. Coating for plastic and fiberglass pipe for purposes of color coding and label stenciling. Coatings to be used for this category shall be certified by the pipe manufacturer to be completely acceptable and non-injurious to the pipe.

B. **Surface Preparation.** Lightly sand pipe and wipe with a solvent to degrease and clean surface.

C. **Application.** Application shall be in strict conformance with manufacturer's printed recommendation.

D. **Coating System F.** Two (2) coats having a total dry film thickness of 8.0 mils.
Carboline System: 
Prime Coat - Carbothane 133 MC 
Second Coat - Carbothane 133 MC 

Sherwin Williams System: 
Prime Coat – Macropoxy 646-100 
Finish Coat – Hi Solids Polyurethane-100 

Tnemec System: 
Series 115 Uni-Bond DF 
Series 1029 Endurotome 

2.09 SERVICE CONDITION G

A. Submerged moving parts including cables, chains, gears, pulleys, etc. shall be prepared and coated in accordance with the following requirements.

B. Surface Preparation. All rust, scale, dust, and foreign matter removed by power or hand tool cleaning.

C. Application. Application shall be in strict accordance with manufacturer's recommendation.

D. Coating System G. The system shall have a total thickness of 25 mils and shall consist of the following:

Chevron - E.P. Roller Grease 
Texaco - Rust Inhibitive Grease 

2.10 SERVICE CONDITION H

A. Ferrous metals requiring a heat resistant coating. To ensure proper coating selection, accurately measure surface temperatures. Surface preparation shall be performed in strict conformance with manufacturer's printed directions and treated surfaces shall be coated as soon as possible to avoid surface contamination. In conformance with printed directions of manufacturer: mix and apply coats of each system; and cure coats before recoating or before reaching surface operating temperature. Contingent upon expected temperature range, apply one of the following or equal systems, and avoid excessive film thickness.

B. Coating System H apply high-temperature coating in strict accordance with the manufacturer recommendations. Some systems may exceed VOC limit restrictions for SCAQMD Rule 1113 and will require installation in a jurisdiction with higher VOC limits.
Rust-Oleum Systems:

300-800° F Temp. Range  4200 System
400-1200° F Temp. Range  4300 System

Carboline Systems:

Up to 450° F Temp.  Thermaline 2977 VOC / Thermaline 4900 VOC
400-1200° F Temp.  Carbozinc 11 Series / Thermaline 4700 VOC

Sherwin Williams Systems:

Ambient To 250° F:  Prime – Corothane I Galvapak -100
                   Finish – Pro Industrial Acrylic
To 500°F:  Prime - Heat-Flex Hi Temp 1200
           Finish – Heat-Flex Hi Temp 500
500°F to 1200°F:  Prime - Heat-Flex Hi Temp 1200
                  Finish – Heat-Flex Hi Temp 1100

2.11 SERVICE CONDITION I

A. Coating of concrete and metal surfaces within the extremely corrosive areas as indicated on the Schedule.

B. Surface Preparation - Concrete.

1. All concrete surfaces shall be aged for at least 30 days prior to application.

2. Prior to final preparation of the concrete surfaces, the Contractor shall thoroughly clean the surfaces to be lined to remove dirt, residue, and other foreign deposits. Surfaces shall be tested by placing droplets of clean water onto sample locations. Satisfactory surfaces will allow water to be easily absorbed or penetrated into the concrete, while contaminated surfaces will result in the water beading. Contaminated surfaces shall be cleaned. Surfaces showing evidence of such contamination shall be cleaned using solutions of caustic soda or trisodium phosphate (TSP). They should be applied with vigorous scrubbing, followed by flushing with fresh water to remove all traces of both the detergent and contaminant and then allowed to thoroughly dry.
3. The Contractor shall use either abrasive blasting or high-pressure waterjetting surface preparation methods to remove any loose concrete and produce a clean, contamination-free, sound, roughened surface acceptable to the lining manufacturer. Abrasive blast cleaning shall be completed in accordance with SSPC-SP7 and SSPC-SP13. The actual water pressure required during any water jetting to achieve the proper removal of deteriorated concrete is not known, but it is projected that pressures between 10,000 to 30,000 psi will be required. Any water jetting equipment shall utilize an oscillating tip.

4. No efflorescence, laitance, or deteriorated concrete shall remain following final surface preparation. Only sound concrete shall remain. The remaining sound concrete shall be uniformly gray in color and appearance.

5. The integrity testing of the prepared concrete shall include dragging the dull edge of putty knife along the prepared surfaces. Properly prepared surfaces will leave behind a scratch without substantial substrate removal. Areas where the scraping action leaves behind a groove or indentation shall be further prepared and retested.

6. All surfaces shall have a surface profile or anchor pattern equal to the International Concrete Repair Institute (ICRI) replica coupon recommended by the coating supplier.

7. The pH of the prepared concrete shall range between 7.0 and 9.0. The pH of the prepared surfaces shall be tested by the Contractor according to ASTM D4262.

8. If any reinforcing steel is exposed after removing concrete, it shall be thoroughly cleaned by sandblasting to a near-white metal blast condition (SSPC-SP10).

9. The moisture vapor transmission of the area shall be tested in accordance with ASTM D4263. All testing shall be completed by the Contractor and witnessed by the Owner.

10. Prior to installing the coating system, the Contractor shall fill all surface areas with depressions deeper than 1/4-inch by filling in with a resurfacing material that is compatible with the coating system selected. The Contractor shall follow the instructions and recommendations of the manufacturer as to application, curing time requirements, depth of repair, and surface preparation procedures. Any resurfacing material shall be properly prepared through scarification prior to the application of any coatings.

11. The Contractor shall not start application until the surface pH, moisture content, and surface temperature are within the recommended limits, and the prepared surfaces have been accepted by the Engineer. Application shall only be performed when the surface temperature is stable or on the decline.
12. **Leading Edges/Terminations:** If in the opinion of the Engineer the concrete surfaces specified for coating application does not include a well defined beginning or ending anchor (e.g. terminating edge on lined concrete) or a proper anchored transition between concrete and steel substrates, the coating shall be mechanically anchored to a dry, clean saw cut to a minimum depth of 1/4 inch and width of 1/4 inch. This includes any steel appurtenances penetrating concrete surfaces. The coating system shall be applied into the saw cut to full depth.

13. **Should cracks be identified after preparation of concrete that require sealing to assure prevention of moisture intrusion or proper continuous lining work, seal all cracks in accordance with the written recommendations of the lining supplier, as approved by the Engineer.**

C. **Surface Preparation - Steel.**

   1. **All metal surfaces shall be field abrasive blast cleaned in accordance with SSPC-SP10, Near White Blast Cleaning. A sharp, jagged anchor profile not less than 3.5 mils shall be attained. Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed in accordance with NACE SP0178.**

D. **Application.** Application shall be in strict conformance with the manufacturer's printed recommendations. The applicator shall be a licensed applicator by the coating manufacturer. The finished coating shall be spark tested and all holidays repaired in accordance with NACE SP0188.

E. **Coating System I.** Except as otherwise noted, the prime coat on metal surfaces shall have a minimum thickness of 2.0 mils and a maximum thickness of 3.0 mils. The finish coat on a non-abrasive metal surface shall be 30 mils and in an abrasive area shall be 40 mils. The prime coat on concrete surfaces shall have a minimum thickness of 3.0 mils and a maximum thickness of 5.0 mils. The finish coat shall be a minimum 65 mils dry film thickness.

   **Carboline System:**
   - Primer - Plasite 4503
   - Topcoat - Reacatamine 760 Series

   **Sherwin Williams System:**
   - Concrete Primer - Corobond 300
   - Steel Primer – Macropoxy 646-100
   - Finish Coat – Sherflex Elastomeric Polyurethane

   **Sancon System:**
   - Concrete Primer - Sancon 100 Epoxy
   - Steel Primer - United 302 Urethane
   - Topcoat - Sancon 100 Polyurethane

   **Lifelast System:**
   - Concrete Primer - Primall 160
   - Topcoat - Durachield 310
2.12 ARCHITECTURAL PAINT FINISHES

A. Manufacturer. Unless otherwise noted, products listed below are the standards of quality. Other materials may be approved if they meet the requirements of Section 2.01.

1. System P–1 - Enamel on Structural Steel Members

- **Frazee Paint System:**
  - First Coat - C309 UltraTech Water-Based Universal Metal Primer (Delete on factory primed materials)
  - Second Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss
  - Third Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss

- **Sherwin Williams System:**
  - First Coat – Procryl Universal Primer (Delete on factory or shop primed materials)
  - Second Coat – Procryl Universal Primer
  - Third Coat – Pro Industrial Acrylic
  - Fourth Coat – Pro Industrial Acrylic

- **Vista Paint System:**
  - First Coat - Vista 9600 Protec Primer (Delete on factory primed materials)
  - Second Coat - Vista 9800 Protec Semi-Gloss Enamel
  - Third Coat - Vista 9800 Protec Semi-Gloss Enamel

- **Dunn Edwards System:**
  - First Coat - BLOC-RUST Premium Red Rust Preventative Primer (BRPR00-1-RO) (delete on factory primed materials)
  - Second Coat – Ultrashield – Gloss ULSH60
  - Third Coat – Ultrashield Gloss ULSH60
  - Fourth Coat – not necessary
2. **System P-2 - Concrete Masonry Paint on Concrete Unit Masonry**

   **Frazee Paint System:**  
   First Coat - C251 Flex Lox Epoxy-Acrylic High pH Masonry Primer
   Second Coat - 146 Aro-Thane Water Based Urethane Mod. Alkyd Gloss
   Second Coat - 146 Aro-Thane Water Based Urethane Mod. Alkyd Gloss

   **Sherwin Williams System:**  
   Monochem System:  
   First Coat – Aquaseal ME12
   Second Coat – Permasheeld Premium
   Third Coat – Permasheeld Premium

   **Vista Paint System:**  
   First Coat - Vista 4600 Uniprime II Masonry Primer
   Second Coat - Vista 290 Uretech Acrylic Gloss Urethane
   Third Coat - Vista 290 Uretech Acrylic Gloss Urethane

   **Dunn Edwards System:**  
   First coat – Carboline – Sanitile 100 (If on concrete block)
   First coat – Carboline – Sanitile 120 (If not on block)
   Second coat – Carboline, Carbothane 134
   Third coat – Carboline, Carbothane 134

3. **System P-3 - Concrete Masonry Paint on Concrete**

   **Frazee Paint System:**  
   First Coat - 203 Duratec II Exterior 100% Acrylic Flat
   Second Coat - 203 Duratec II Exterior 100% Acrylic Flat
Sherwin Williams System:
- First Coat – Loxon Concrete Masonry Primer
- Second Coat – Loxon Acrylic Coating

Vista Paint System:
- First Coat - Vista 4600 Uniprime II Masonry Primer
- Second Coat: Vista 2000 Duratone 100% Acrylic Flat
- Third Coat - Vista 2000 Duratone 100% Acrylic Flat

Dunn Edwards System:
- First Coat - Eff Stop Premium Primer (ESPR00)
- Second Coat - Evershield 100% Acrylic (EVSH10)
- Third Coat - Evershield 100% Acrylic (EVSH10)

4. **System P-4 - Enamel on Galvanized Metal** (Doors, Frames, & Sheet Metal)

Frazee Paint System:
- Pretreatment - Krud Kutter Metal Clean and Etch
- First Coat - C309 UltraTech Water-Based Universal Primer
- Second Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss
- Third Coat - 136 Aro-Thane Water-Based Urethane Modified Alkyd Semi-Gloss

Sherwin Williams System:
- Pretreatment – Great Lakes Clean and Etch
- First Coat – Procryl Universal Primer
- Second Coat - Pro Industrial Acrylic
- Third Coat – Pro Industrial Acrylic

Vista Paint System:
- Pretreatment - Jasco Prep N Prime
- First Coat - Vista 4800 Acrylic Metal Prime
Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

Dunn Edwards System: Pretreatment – Carboline – Galoseal (if substrate is unpainted galvanized)

First Coat – If previously painted use Ultrashield DTM Gray Primer ULDM00GR

Second Coat - Ultrashield Gloss ULSH60

Third Coat - Ultrashield Gloss ULSH60

5. System P-5 - Enamel on Primed Metal

Frazee Paint System: First Coat - 168 Prime+Plus Primer/Sealer

Second Coat - 136 Aro-Than Water-Based Urethane Modified Alkyd Semi-Gloss

Sherwin Williams System: Prime Repair Coat - Procryl Universal Primer

First Coat – Pro Industrial Acrylic

Second Coat - Pro Industrial Acrylic

Vista Paint System: First Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

Dunn Edwards System: First Coat – Ultrashield Multi Surface Primer ULMS

Second Coat - Ultrashield Gloss ULSH60
6. **System P-6 - Semi Gloss Enamel Paint on Interior Concrete Unit Masonry**

- **Frazee Paint System:**
  - First Coat - C302 Ultra Tech 100% Acrylic Block Filler
  - Second Coat - 124 Mirro Glide 100% Acrylic Semi-Gloss
  - Second Coat - 124 Mirro Glide 100% Acrylic Semi-Gloss

- **Sherwin Williams System:**
  - First Coat – Loxon Block Resurfacer
  - Second Coat – Pro Industrial Acrylic
  - First Coat - Pro Industrial Acrylic

- **Vista Paint System:**
  - First Coat - Vista 040 Block Coat
  - Second Coat- Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel
  - Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

- **Dunn Edwards System:**
  - First Coat - "Blocfill" Smooth W305SMOOTH BLOCFILL (SBPR00)
  - Second Coat - Decoglo W450SUPREMA (SPMA50)
  - Third Coat - Decoglo W450SUPREMA (SPMA50)

7. **System P-7 - Sealer for Unpainted Masonry Surfaces**

   A transparent waterproofing sealer shall be applied to all above grade masonry surfaces, with the exception of interior building walls, both smooth face and split face block as shown on plans and in Coating Systems Schedule. Apply to dry, clean split faced surface with airless spray. Rate of application shall be in accordance with manufacturer's recommendations.

- **Frazee Paint System:**
  - Monochem 4990 Aquaseal SS Water Repellent
8. **System P-8 - Interior Pipe Insulation**

- **Frazee Paint System:**
  - First Coat - C152 Ultratech Multi-Solution Latex Primer
  - Second Coat - 077 Velvin ETU Latex Flat

- **Vista Paint System:**
  - First Coat - Vista 8000 PrimeZall
  - Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel
  - Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

- **Dunn Edwards System:**
  - First Coat - Sanitile 120
  - Second Coat - Ultrashield Gloss ULSH60

9. **System P-9 - Metal Protected Exterior Pipe Insulation**

- **Frazee Paint System:**
  - First Coat - C309 Ultratech Water Based Universal Primer
  - Second Coat - 203 Duratech II Exterior 100 Acrylic Flat

- **Vista Paint System:**
  - First Coat - Vista 9600 Protec Primer
  - Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel
  - Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

- **Dunn Edwards System:**
  - First Coat - Ultrashield DTM Gray Primer ULD00GR
  - Second Coat - Ultrashield Gloss ULSH60
10. **System P-10 - New Galvanized Surfaces**

   **Frazee Paint System:**
   - Pretreatment - Krud Kutter Metal Clean and Etch
   - First Coat - C309 UltraTech Water-Based Universal Primer
   - Second Coat - 136 Aro-Than Water-Based Urethane Modified Alkyd Semi-Gloss
   - Third Coat - 136 Aro-Than Water-Based Urethane Modified Alkyd Semi-Gloss

   **Vista Paint System:**
   - Pretreatment - Jasco Prep N Prime
   - First Coat - Vista 4800 Acrylic Metal Prime
   - Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel
   - Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

   **Dunn Edwards System:**
   - Pretreatment – Carboline – Galoseal (if substrate is unpainted galvanized)
   - Prime Coat – If previously painted use Ultrashield DTM Gray Primer ULDM00GR
   - Second Coat - Ultrashield Gloss ULSH60
   - Third Coat - Ultrashield Gloss ULSH60

11. **System P-11 - Spot Repair of Damaged New Galvanized Metal**

   **Frazee Paint System:**
   - First Coat - C309 UltraTech Water-Based Universal Primer
   - Second Coat - 136 Aro-Than Water-Based Urethane Modified Alkyd Semi-Gloss

   **Vista Paint System:**
   - First Coat - Vista 4800 Acrylic Metal Prime
   - Second Coat - Vista 8400 Carefree 100%
Acrylic Semi Gloss Enamel

Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

12. **System P-12 - Primer Over Bituminous Coating**

Frazee Paint System: First Coat - Macropoxy 646-100 Fast-Cure (VOC 100 g/l)
Second Coat - Macropoxy 646-100 Fast-Cure (VOC 100 g/l)

Vista Paint System: First Coat - Vista 8000 PrimeZall Primer
Second Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel
Third Coat - Vista 8400 Carefree 100% Acrylic Semi Gloss Enamel

Dunn Edwards System: First Coat - Carboline Sanitile 120
Second coat - Ultrashield Gloss ULSH60

2.13 **MISCELLANEOUS COATINGS**

A. Hydrants, indicator post, traffic posts, guard rails and ladders shall be safety yellow, matching OSHA Safety Yellow Color and using specified Service Condition "B".

B. Handwheels and operating handles of all valves and equipment shall be safety red, matching OSHA Safety Red Color, using, contingent upon exposure, Coating System "B" in non-corrosive atmosphere and Coating Services Condition "C" in corrosive atmosphere and high humidity exposures.

**PART 3 - EXECUTION**

3.01 **GENERAL**

A. All surface preparation, coating and paint application shall conform to applicable standards of SSPC and the manufacturer's printed instructions. Material applied prior to approval of the surface by the Engineer shall be removed and reapplied to the satisfaction of the Engineer at the expense of the Contractor.
B. All work shall be performed by skilled craftsmen qualified to accomplish the required work in a manner comparable with the best standards of practice. Continuity of personnel shall be maintained and transfer of key personnel shall be coordinated with the Engineer.

C. The Contractor shall provide a supervisor to be at the work site during cleaning, application operations. The supervisor shall have the authority to sign any change orders, coordinate work and make other decisions pertaining to the fulfillment of their contract.

D. Contractor shall provide approved sanitary facilities for all project personnel, as no existing facilities will be available to the Contractor. Facilities shall be maintained during the project to complete standards established by Owner, and shall be removed prior to Contractor's departure from the site at completion of the project.

E. Dust, dirt, oil, grease or any foreign matter which will affect the adhesion or durability of the finish must be removed by washing with clean rags dipped in an approved commercial cleaning solvent, rinsed with clean water and wiped dry with clean rags.

F. The Contractor's painting and coating equipment shall be designed for application of materials specified and shall be maintained in first class working condition. Compressors shall have suitable traps and filters to remove water and oils from the air. Blotter test shall be accomplished at each start-up period and as deemed necessary by the Engineer. Contractor's equipment shall be subject to approval of the Engineer.

1. Cleanliness of compressed air supply used for conventional equipment or blow down operations shall be verified daily, and as deemed necessary by Engineer, by directing a stream of air, without abrasive, from the blast nozzle onto a white blotter or cloth for twenty seconds in accordance with ASTM D4285. If air contamination is evident, change filters, clean traps, add moisture separators or filters, or make adjustments as necessary to achieve clean, dry air.

G. Application of the first coat shall follow immediately after surface preparation and cleaning within an eight-hour working day. Any cleaned areas not receiving first coat within an eight-hour period shall be recleaned prior to application of first coat.

H. Because of the presence of moisture and possible contaminants in the working atmosphere, care shall be taken to ensure previously coated or painted surfaces are protected or recleaned prior to application of subsequent coat(s). The Engineer shall approve methods of protection and recleaning.

1. The project is subject to intermittent shutdown if, in the opinion of the Engineer, cleaning, coating and painting operations are creating a localized condition
detrimental to ongoing facility activities, personnel, or adjacent property.

2. In the event of emergency shutdown by the Engineer, Contractor shall immediately correct deficiencies. All additional costs created by shutdown shall be borne by Contractor.

I. The Contractor shall provide, at his own expense, all necessary power for his operations under the contract.

J. Inspection: all operations will be monitored 100% by an Owner-appointed quality assurance inspector. All additional costs incurred by off-site inspection shall be borne by the Contractor. These include, but are not limited to travel, lodging, food, auto rental (where applicable) and any other expenses directly related to the inspection.

3.02 QUALITY CONTROL

A. Ambient Conditions: no coating shall be applied when the surrounding air temperature or the temperature of the surface to be coated or painted is below 50 degrees F. No coatings shall be applied at temperatures above 110 degrees F. No coatings shall be applied to wet or damp surfaces or in rain, snow, fog or mist, when the surface temperature is less than 5 degrees F. above the dewpoint, or when it is expected the air temperature will drop below 50 degrees.

B. Dewpoint shall be measured by the use of an instrument such as a Sling Psychrometer in conjunction with U.S. Department of Commerce Weather Bureau Psychrometric Tables or equivalent in accordance with ASTM D337. Relative humidity shall not be more than 85 percent. If unacceptable conditions are prevalent coating or paint application shall be delayed or postponed until conditions are favorable. The day's coating or paint application shall be completed in time to permit the film sufficient drying time prior to damage though atmospheric conditions. Temperature and dewpoint requirements noted above and herein shall apply to all surface preparation operations, except low and high temperature limits.

C. Surface Preparation: surface preparation will be based upon comparison with: "Pictorial Surface Preparation Standards for Painting Steel Surfaces," SSPC-Vis 1 and as described herein. Anchor profile for prepared steel surfaces shall be sharp and jagged (not peened) and measured by using a nondestructive instrument such as a Testex Press-0-Film System in accordance with ASTM D4417. Anchor profile for prepared concrete shall be measured by using a ICRI CSP comparison coupons.

D. The Contractor shall conduct all operations so as to confine debris and overspray to within the bounds of the site. The Contractor shall take all precautions necessary to prevent adverse off-site consequences of painting operations. Any complaints received
by the Owner relating to any such potential offsite problems will be immediately delivered to the Contractor. The Contractor shall immediately halt work and shall take whatever corrective action is required to mitigate any such problems. All costs associated with protection of off-site properties and/or correction of damage to property as a result of painting operations shall be borne directly by the Contractor at no additional expense to the Owner.

E. Film Thickness Testing: thickness of each coat of coating shall be checked with a non-destructive film thickness gauge in accordance with ASTM D7091, where applicable.

F. Inspection Devices: Contractor shall furnish, until final acceptance of coating and painting, inspection devices in good working condition for hardness, adhesion, detection of holidays, and measurement of dry-film thickness of coatings and paints, where required. They shall also furnish National Institute of Standards and Technology/National Bureau of Standards (NIST/NBS) certified thickness calibration plates to test accuracy of thickness gauges. Acceptable devices for ferrous metal surfaces include, but are not limited to Tinker-Rasor Models M-1, AP, and AP-W holiday detectors and SSPC, Type II units for dry film thickness gauging. Inspection devices shall be calibrated and operated in accordance with specified requirements. High-voltage testing shall require written acceptance from the lining manufacturer. Adhesion shall be measured using a fixed alignment, type II pull-off adhesion tester such as an Elcometer 106. Hardness testers shall be Type Shore D or as recommended by the lining manufacturer.

G. Gauges and detectors shall be available at all times until final acceptance of application. Inspection devices shall be operated by, or in the presence of the Engineer with location and frequency basis determined by the Engineer. The Engineer is not precluded from furnishing his own inspection devices and rendering decisions based solely upon these quality assurance tests. Should in the opinion of the Engineer a 24-hour, continuous reading surface temperature gauge be required to assure that maximum recoat windows are observed, the Contractor shall provide a working calibrated instrument to meet this need. The gauge shall be digital and capable of providing instantaneous average measurements of the temperatures recorded.

3.03 SURFACE PREPARATION, GENERAL - INDUSTRIAL

A. Slag, weld spatter, or sharp edges such as those created by flame cutting shall be removed by chipping and grinding. All sharp edges shall be peened, ground or otherwise blunted as required by the Engineer in accordance with NACE SP 0178. The rolled edges of angles, channels, and wide flange beams do not normally require further rounding unless specifically directed by the Engineer.

B. Abrasive blasting nozzles shall be equipped with "deadman" emergency shut-off nozzles. Blast nozzle pressure shall be a minimum of 95 P.S.I. and shall be verified by using an approved nozzle pressure gage at each start-up period or as directed by the Engineer.
Number of nozzles used during all blast cleaning operations must be sufficient to insure timely completion of project as approved and directed by Engineer.

C. All blast hose connections shall be connected with external couplings. These connections shall be taped with duct tape prior to pressurizing. All taped connections shall be visually inspected for leaks within five minutes after start of blast cleaning operations and at the end of blast cleaning operations. Leaking connections shall be immediately repaired to prevent further damage.

D. Particle size of abrasives used in blast cleaning shall be that which will produce a surface profile or anchor pattern specified herein, or in accordance with recommendations of the manufacturer of the specified coating or paint system to be applied, subject to approval of Engineer. Surface Profile or Anchor pattern shall be sharp and jagged in nature (not peened).

E. Abrasive used in blast cleaning operations shall be new, washed, graded and free of contaminants, which would interfere with adhesion of coatings and paints and shall not be reused unless specifically approved by the Engineer. Abrasives shall be certified for unconfined dry blasting pursuant to the California Administrative Code, Section 92520 of Subchapter 6, title 17, and shall appear on the current listing of approved abrasives.

F. The Contractor shall select an abrasive media that is proper for the quality of surface preparation specified. Should it be determined that the production rate and quality of the surface preparation is less than specified, it shall be the Contractor’s responsibility to use other types and/or sizes of abrasive to meet the requirements of this contract. At no time shall considerations of extra effort be considered by the Owner unless, in the opinion of the Engineer the Contractor has explored all alternative means of abrasive blasting during their operations.

G. Blast cleaning from rolling scaffolds shall only be performed within the confines of the interior perimeter of the scaffold. Reaching beyond the limits of the perimeter will be allowed only if blast nozzle is maintained in a position, which will produce a profile acceptable to the Engineer.

H. The Contractor shall keep the area of work in a clean condition and shall not permit blasting materials to accumulate as to constitute a nuisance or hazard to the prosecution of the work or the operation of the existing facilities. Spent abrasives and other debris shall be removed at the Contractor's expense as directed by the Engineer. If waste is determined to be hazardous, disposal by Contractor shall meet requirements of all regulatory agencies for handling such wastes.

I. Blast cleaned surfaces shall be cleaned prior to the application of specified coatings or paints through a combination of blowing with clean dry air, brushing/brooming and/or vacuuming as directed by the Engineer. Air hose for blowing shall be at least 1/2" in
diameter and shall be equipped with a shut-off device.

J. The surfaces of any non-carbon steel substrates, or specialty items (i.e. galvanized, anodized, etc.) shall be properly treated and prepared prior to any coating operations in accordance with the coating manufacturer's written recommendations, subject to approval of the Engineer.

3.04 SURFACE PREPARATION, GENERAL - ARCHITECTURAL

A. Before priming, correct all finish surfaces which are not properly prepared. Assure that all surfaces to be painted are in a proper condition as required by the manufacturer's written recommendations and will provide a proper uniform appearance. Do not prime any surface that has not been approved by the Engineer.

B. Prior to surface preparation and painting operations, remove all hardware, hardware accessories, plates, lighting fixtures and similar items in contact with painted surfaces and not to be painted. Replace all removed items following completion of all paint work in the area. Items may be protected and not removed if approved by the Engineer.

C. Program and schedule cleaning and painting so that dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.

D. Clean concrete and masonry surfaces of all dirt, encrustations, efflorescence and other foreign matter. Roughen all glazed surfaces on concrete.

E. Clean ferrous metal not provided with a shop prime of all loose rust, mill scale, oil, grease and foreign matter by wire brushing, scraping or sandblasting as required by the written requirements of the paint manufacturer and SSPC-SP2/3. Clean ferrous metal provided with shop prime of all oil, grease and foreign matter in accordance with SSPC-SP1 and the manufacturer's written requirements.

F. Clean gypsum board (drywall) of all dust, dirt, encrustations and foreign matter.

3.05 APPLICATION, GENERAL

A. Coating and paint application shall conform to the requirements of the SSPC's Paint Application Specification No. 1 (SSPC-PA1), latest revision, for "Shop, Field and Maintenance Painting," the manufacturer of the coating and paint materials printed literature, and as specified herein.

B. All surfaces to receive paint and protective coatings shall be cleaned as specified herein prior to application of coating materials. The Contractor shall examine all surfaces to be coated, and shall correct all surface defects before application of any coating material. Beginning the coating work without reporting unsuitable conditions to the Owner constitutes acceptance of conditions by the Contractor. Any required removal, repair, or
replacement of the work caused by unsuitable conditions shall be done at no additional cost to the Owner. All marred or abraded spots on shop-primed and factory-finished surfaces shall receive touch-up restoration prior to any other coating application.

C. Paint and coating materials shall be protected from exposure to excessive hot or cold weather, and shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Materials of different manufacturers shall not be mixed together. Packaged materials may be thinned immediately prior to application in accordance with the manufacturer’s directions.

D. All coatings shall be thoroughly mixed utilizing an approved slow-speed power mixer until all components are thoroughly combined and are of a smooth consistency.

E. Thinning shall only be permitted as recommended by the manufacturer and approved by the Engineer, and shall not exceed the limits set by applicable regulatory agencies.

1. If the Contractor applies any coatings which have been modified or thinned to such a degree as to cause them to exceed established VOC levels, Contractor shall be responsible for any fines, costs, remedies, or legal action and costs which may result.

F. Each application of coating and paint shall be applied evenly with a uniform appearance. The system shall be free of brush marks, unfeathered edges, sags, runs, and evidence of poor workmanship, or any aesthetic defects, as defined by SSPC. Care should be exercised to avoid lapping on glass or hardware. Coating and paint shall be sharply cut to lines. Finished surfaces shall be uniform in appearance and shall be free from defects or blemishes.

G. Coatings shall not be applied when area wind speeds exceed fifteen miles per hour.

H. Protective coverings or drop cloths shall be used to protect floors, concrete, fixtures, equipment, prepared surface and applied coatings. Personnel entering work area shall take precautions to prevent damage or contamination of coated or painted surfaces. Care shall be exercised to prevent coating or paint from being spattered onto surfaces, which are not to be coated or painted. Surfaces from which such material cannot be removed satisfactorily shall be replaced, repainted or recoated as required to produce a finish satisfactory to the Engineer.

I. All welds and irregular surfaces, as defined by the Engineer shall receive a brush coat of the specified product prior to application of each complete coat. Coating/paint shall be brushed in multiple directions to insure penetration and coverage, as directed by the Engineer.
J. Coating which has endured an excessive time element beyond manufacturer’s recommended recoat cycle, shall be scarified by methods approved by the Engineer, prior to application of additional coating or paint. Scarified coating shall have sufficient depth to assure a mechanical bond of subsequent coat.

K. All attachments, accessories, and appurtenances, as defined by the Engineer, to be painted shall be prepared and finished in the same manner as specified for adjacent sections.

3.06 APPLICATION, SPECIFIC - ARCHITECTURAL

A. Coating shall be thoroughly stirred or agitated to uniformly smooth consistency and prepared and handled in a manner to prevent deterioration and inclusion of foreign matter. Straining shall be completed as recommended by the paint manufacturer. Unless otherwise specified or reviewed, no materials shall be reduced, changed, or used except in accordance with the manufacturer's label or tag on container.

B. Unless otherwise specified herein, the paint and coating manufacturer’s printed recommendations and instructions for thinning, mixing, handling, applying, and protection of coating materials; for preparation of surfaces for coating; and for all other procedures relative to coating shall be strictly observed. No substitutions or other deviations shall be permitted without written permission of the Owner.

C. Materials shall be delivered in manufacturer's original, sealed containers, with labels and tags intact. Coating materials and equipment shall be stored in designated areas. Coating containers shall be opened only when required for use. Coatings shall be mixed only in designated rooms or spaces in the presence of the Engineer.

D. Apply material evenly, free from sags, fisheyes, runs, drips, crawls, holidays or other defects. Mix to proper consistency, brush out all areas smooth leaving only minimum brush marks.

1. Sand and dust between each coat to remove defects visible from a distance of five feet.

2. Finish coats shall be uniform in appearance, smooth, free of brush marks, streaks, laps, and skipped or missed areas. Finished metal surfaces shall be free of skips, voids or pinholes in any coat when tested with a low voltage detector.

3. Do not apply initial coating until moisture content of surface is within limitations recommended by paint manufacturer.
4. Rate of application shall not exceed that as recommended by paint manufacturer for the surface involved less ten percent allowance for losses.

5. Keep brushes and spraying equipment clean, dry, free from contaminants and suitable for the finish required.

6. Apply paint by clean brushes, roller or spray. Rollers shall be cleaned of loose nap prior to use.

7. Tint all pigmented undercoats to approximately same shade as final coat. Perceptibly increase the depth of shade in successive coats.

8. Allow each coat to dry thoroughly before succeeding coat application. For oil paints, allow at least 48 hours between coats of exterior work, except where otherwise recommended by the manufacturer.

9. Finish all four edges of doors with the same number and kind of coatings as specified for their main surfaces. Where openings into rooms having different finishes, finish door edges as directed by Engineer.

10. Do not paint factory finished items unless specifically directed.

11. Paint surfaces of metal ducts and vents.

12. Apply two finish coats of paint to shop primed metal surface of all mechanical and electrical equipment, to match adjoining wall or ceiling surfaces. In addition to above, prime coat all unprimed surfaces. Principal items of this work include interior of hose cabinets, air grilles, ceiling diffusers, electric panels, telephone panels, access panels, conduit, outlet and pull boxes, ducts and pipes.

13. Miscellaneous Painting: Paint surfaces to be painted and not specifically described herein, with a product specifically manufactured or prepared for the material and surface; prime coat and two finish coats, as approved by Engineer.

14. Upon completion, remove all rubbish caused by this trade. Remove spots from floors, glass and other surfaces. Leave in a clean and orderly condition.

15. At the completion of other trades, touch up damaged surfaces as required.
3.07 COLOR IDENTIFICATION

A. All exposed and/or unburied pipe, including steel, copper and brass tubing, galvanized pipe, polyvinyl chloride pipe, fiberglass reinforced pipe, and stainless steel pipe, shall be identified by color to show its use/function. Color bands of an approved tape type may be used on PVC, FRP, and stainless steel pipe and all other pipe not readily susceptible to painted finish. Bands shall be adhesive type with extra strength and suitable for continuous duty at 250 degrees F. All markers shall have a protective silicone film.

B. Color shall be those listed in the COLOR CODE SCHEDULE.

3.08 STENCIL IDENTIFICATION

A. Both the direction of fluid flow and the name of the fluid in the pipe shall be stenciled on all piping at least once every twenty-five (25) feet and at every change of direction. Color bands shall be spaced at fifteen (15) foot intervals and every change in direction. The size in inches of the letters and color bands shall be as specified in the table below:

<table>
<thead>
<tr>
<th>Outside Diameter Pipe or Covering</th>
<th>Width of Color Band</th>
<th>Height of Legend Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4 to 1-1/4</td>
<td>1</td>
<td>1/2</td>
</tr>
<tr>
<td>1-1/2 to 2</td>
<td>1</td>
<td>3/4</td>
</tr>
<tr>
<td>2-1/2 to 6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>8 to 10</td>
<td>6</td>
<td>2-1/2</td>
</tr>
<tr>
<td>Over 10</td>
<td>6</td>
<td>3-1/2</td>
</tr>
</tbody>
</table>

B. The stenciled labels shall be abbreviated and conform to the piping abbreviations shown on COLOR CODE SCHEDULE. The labels shall be safety yellow, matching OSHA Safety Yellow. Engines and listed electrical items shall be color coded as follows:

White: Sherwin Williams F65W1
       Electrical (Excluding panels)

Gray: ANSI 61
      Electrical panels

Light Yellow: (EMWD)
             Engines

C. After the painting of process piping is complete, the Contractor shall stencil the tag numbers, as supplied by the Owner, of all process valves on the pipe adjacent to the
valve for pipe 2 inches and over. Characters shall be one inch high minimum and shall be oriented to be visible from the valve operating position. When the valve has extended operator shaft or chain operator, the number shall be placed both at the operating position and at the valve if practicable. The latter requirement does not apply if the valve is buried or in a pit. Valves in pipes under 2 inches shall have characters as large as the pipe will permit or at the Owner’s option, on an adjacent surface. Characters shall be preferably white; however, if this would not provide sufficient contrast to the pipe, the Owner may select another color. Paint used shall be of the same type and quality as used for painting the pipe.

3.09 APPLICATION, SPECIFIC - INDUSTRIAL

A. All coating components shall be mixed in exact proportions specified by the manufacturer. Care shall be exercised to insure all material is removed from containers during mixing and metering operations.

B. Catalyzed coatings shall not be applied beyond pot-life limits specified by manufacturer. Any required induction requirements shall be strictly followed.

D. Application shall be by conventional or airless spray method except as otherwise specified, or approved by the Engineer. Drying time between coats shall be strictly observed as stated in the manufacturer's printed instructions.

E. When two or more coats are specified, where possible, each coat shall be of contrasting color.

F. Care shall be exercised during spray operations to hold the spray nozzle perpendicular and sufficiently close to surfaces being coated to avoid excessive evaporation of volatile constituents and loss of material into the air or the bridging of cracks and crevices. Reaching beyond limits of scaffold perimeter will not be permitted. All dryspray or overspray shall be removed as directed by Engineer and the area recoated.

3.10 FINAL TESTING OF INDUSTRIAL COATING

A. The final testing of the coating system shall include visual appearance, dry film thickness (DFT) measurements, hardness, cure, and adhesion testing and shall be performed in the presence of the Engineer.

B. Visual Appearance: The coating system shall be uniform in appearance and free of any defects as defined by SSPC's Visual Comparison Manual.

C. Dry Film Thickness: The thickness of each coat of coating shall be checked with a non-destructive film thickness gauge in accordance with ASTM D7091, where applicable. An
instrument such as Tooke Gage should be used in accordance with ASTM D4138 if a destructive tester is deemed necessary by the Engineer. The testing of film thickness of flat (e.g. plate) surfaces shall be tested in accordance with SSPC-PA2. The sampling of structural members or irregular surfaces shall be tested in frequency and locations, as directed by the Engineer. Final dry film thickness applied to concrete surfaces shall be determined by cutting out dry coupons for cross sectional measurement.

D. Hardness - The hardness of catalyzed elastomeric coating systems shall be tested using a type Shore D hardness tester or device approved by the material manufacturer in accordance with ASTM D2240. The hardness of the final system shall be tested in areas randomly selected by the Engineer including any area suspected of being improperly mixed. The lining hardness after at least 48 hours shall be at least 70 when measured with a shore D hardness scale, or per the lining manufacturer’s written recommendations.

E. Holiday Detection - No pinholes or holidays will be permitted in any coating film. Upon completion of the final coat operations and after the required drying intervals, holiday detection shall be accomplished on all coated surfaces in intermittently submerged, submerged, or severe environments (Service Conditions A, C, D, E, and I) in accordance with NACE SP0188. For thin film coatings, the Contractor shall obtain a letter from the coating manufacturer approving the use of high-voltage testing equipment, prior to any testing. Should the manufacturer not approve of high-voltage, a 67.5 volt low-voltage tester such as a Tinker and Rasor M-1 device shall be used for thin film systems. All holiday detection of coatings shall be performed in the presence of the Engineer.

F. Cure Evaluation - The proper cure of any inorganic zinc-rich (IOZ) primers and the final system(s) shall be verified. IOZ primers shall be evaluated in accordance with ASTM D4752. IOZ primers shall not be overcoated until fully cured. Organic, catalyzed coatings shall be tested in accordance with ASTM D5402 to verify adequate curing has been attained. If final cure has not been attained, the ventilation shall be continued until applied coating passes the solvent wipe test.

G. Adhesion Testing - Adhesion of the catalyzed elastomeric lining systems shall be tested in areas selected by the Engineer in accordance with ASTM D4541. The number and locations of the testing shall be at the sole discretion of the Engineer. Acceptable adhesion values shall be at least the lining manufacturer’s written recommendations for applications over concrete. The value obtained on the unlined concrete substrate itself shall be the minimum value requirement as long as the preparation of the substrate was found to be hard and sound by the Engineer.
3.11 CLEAN-UP

A. Upon completion of the work, all staging, scaffolding and containers shall be removed from the site or destroyed in a manner approved by the Engineer. Coating or paint spots upon adjacent surfaces shall be removed and the entire jobsite cleaned. All damage to surfaces resulting from the work of this section shall be cleaned, repaired, or refinished to the complete satisfaction of the Engineer at no cost to the Owner.

3.12 OMISSIONS

A. Care has been taken to delineate herein those surfaces to be coated. However, if coating or painting requirements have been inadvertently omitted from this section or any other section of the specifications, it is intended that all surfaces, unless specifically exempted herein, shall receive a first-class protective coating or paint system equal to that given the same type surface pursuant to these specifications.

3.13 COLOR CODE SCHEDULE

<table>
<thead>
<tr>
<th>Item</th>
<th>Color Code</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeration Air</td>
<td>Light Green</td>
<td>AA</td>
</tr>
<tr>
<td>Belt Press Return Water</td>
<td>Gray</td>
<td>BPRW</td>
</tr>
<tr>
<td>Building Drain</td>
<td>NA</td>
<td>BD</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>Light Green w/Yellow</td>
<td>CA</td>
</tr>
<tr>
<td>Chlorinated Effluent</td>
<td>Blue</td>
<td>CE</td>
</tr>
<tr>
<td>Chlorine Gas</td>
<td>Yellow/Green Band</td>
<td>CG</td>
</tr>
<tr>
<td>Chlorine Solution</td>
<td>Yellow</td>
<td>CS</td>
</tr>
<tr>
<td>Cold Digested Sludge</td>
<td>Brown</td>
<td>CSL</td>
</tr>
<tr>
<td>Diesel Fuel</td>
<td>Yellow</td>
<td>DF</td>
</tr>
<tr>
<td>Digested Sludge</td>
<td>Brown</td>
<td>DSL</td>
</tr>
<tr>
<td>Digested Sludge Transfer</td>
<td>Brown</td>
<td>XSL</td>
</tr>
<tr>
<td>Digester Gs</td>
<td>Red</td>
<td>DG</td>
</tr>
<tr>
<td>Drain</td>
<td>NA</td>
<td>D</td>
</tr>
<tr>
<td>Electrical Panel (within bldg)</td>
<td>ANSI 61 - Gray</td>
<td>--</td>
</tr>
<tr>
<td>Electrical Conduit and Equipment (except panels)</td>
<td>White (Sherwin Williams F6SW1)</td>
<td>--</td>
</tr>
<tr>
<td>Item</td>
<td>Color Code</td>
<td>Label</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Engine Coolant Water</td>
<td>Blue</td>
<td>ECW</td>
</tr>
<tr>
<td>Froth Spray</td>
<td>Blue</td>
<td>FS</td>
</tr>
<tr>
<td>Flotation Thickener Overflow</td>
<td>NA</td>
<td>FTO</td>
</tr>
<tr>
<td>Fresh Water</td>
<td>Light Blue</td>
<td>FW</td>
</tr>
<tr>
<td>Gravity Thickener Overflow</td>
<td>Gray/Yellow Bands</td>
<td>GTO</td>
</tr>
<tr>
<td>Grit</td>
<td>Brown</td>
<td>GRIT</td>
</tr>
<tr>
<td>Grit Washer Overflow</td>
<td>Gray</td>
<td>GWO</td>
</tr>
<tr>
<td>Ground Water Drain</td>
<td>NA</td>
<td>GWD</td>
</tr>
<tr>
<td>Heated Digested Sludge</td>
<td>Brown/Yellow Bands</td>
<td>HSL</td>
</tr>
<tr>
<td>High Temperature Water</td>
<td>Blue/Yellow Bands</td>
<td>HTW</td>
</tr>
<tr>
<td>Irrigation Water</td>
<td>NA</td>
<td>IW</td>
</tr>
<tr>
<td>Low Temperature Water</td>
<td>Blue/Orange Bands</td>
<td>LTW</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Light Yellow</td>
<td>NG</td>
</tr>
<tr>
<td>Oil Lines</td>
<td>Black</td>
<td>Oil</td>
</tr>
<tr>
<td>Polymer</td>
<td>Light Blue/Yellow Bands</td>
<td>POLY</td>
</tr>
<tr>
<td>Primary Tank Drain</td>
<td>Brown</td>
<td>PTD</td>
</tr>
<tr>
<td>Primary Sludge</td>
<td>Brown</td>
<td>PSL</td>
</tr>
<tr>
<td>Primary Scum</td>
<td>Brown</td>
<td>PSK</td>
</tr>
<tr>
<td>Raw Sewage</td>
<td>Brown</td>
<td>S</td>
</tr>
<tr>
<td>Return Digested Sludge</td>
<td>Brown</td>
<td>RDS</td>
</tr>
<tr>
<td>Return Water</td>
<td>Gray</td>
<td>RW</td>
</tr>
<tr>
<td>Secondary Scum</td>
<td>Brown</td>
<td>SSK</td>
</tr>
<tr>
<td>Sludge Bed Drain</td>
<td>NA</td>
<td>SBD</td>
</tr>
<tr>
<td>Sludge Heater Bypass</td>
<td>Brown</td>
<td>SLHB</td>
</tr>
<tr>
<td>Storm Water Drainage</td>
<td>NA</td>
<td>SWD</td>
</tr>
<tr>
<td>Thickened Sludge</td>
<td>Brown</td>
<td>TS</td>
</tr>
<tr>
<td>Thickener Dilution Water</td>
<td>Blue</td>
<td>TDW</td>
</tr>
<tr>
<td>Waste Activated Sludge</td>
<td>Brown</td>
<td>WAS</td>
</tr>
<tr>
<td>Waste Digested Sludge</td>
<td>Brown</td>
<td>WDS</td>
</tr>
<tr>
<td>Wash Water</td>
<td>Red</td>
<td>WW</td>
</tr>
<tr>
<td>Architectural System</td>
<td>Descriptive Color Code</td>
<td>Manufacturers' Paint Designation</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>PLANT BUILDINGS:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Surface</td>
<td>Tan</td>
<td>Rustoleum #865 (Dunes Tan)</td>
</tr>
<tr>
<td>Trim &amp; Doors</td>
<td>Dark Brown</td>
<td>Rustoleum #977 (Chestnut Brown)</td>
</tr>
<tr>
<td>Walls (metal)</td>
<td>Yellow-White</td>
<td>Dunn-Edwards #CH-60B (Parchment)</td>
</tr>
</tbody>
</table>

END OF SECTION 09900
## SPECIFICATIONS - DETAILED PROVISIONS

Section 11005 - General Mechanical and Equipment Provisions

### CONTENTS

PART 1 - GENERAL

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.01</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>1.02</td>
<td>MANUFACTURER'S EXPERIENCE</td>
</tr>
<tr>
<td>1.03</td>
<td>FACTORY INSPECTION</td>
</tr>
<tr>
<td>1.04</td>
<td>STANDARD OF QUALITY</td>
</tr>
<tr>
<td>1.05</td>
<td>ADAPTATION OF EQUIPMENT</td>
</tr>
<tr>
<td>1.06</td>
<td>GUARANTEES AND WARRANTIES</td>
</tr>
<tr>
<td>1.07</td>
<td>SUBMITTALS</td>
</tr>
<tr>
<td>1.08</td>
<td>PRODUCT DELIVERY, STORAGE AND HANDLING</td>
</tr>
<tr>
<td>1.09</td>
<td>JOB CONDITIONS</td>
</tr>
<tr>
<td>1.10</td>
<td>EQUIPMENT</td>
</tr>
</tbody>
</table>

PART 2 - PRODUCTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.01</td>
<td>MATERIALS AND WORKMANSHIP</td>
</tr>
<tr>
<td>2.02</td>
<td>LUBRICATION</td>
</tr>
<tr>
<td>2.03</td>
<td>STRUCTURAL STEEL FABRICATIONS</td>
</tr>
<tr>
<td>2.04</td>
<td>EQUIPMENT BASES AND BEDPLATES</td>
</tr>
<tr>
<td>2.05</td>
<td>ANCHORS AND SLEEVES</td>
</tr>
<tr>
<td>2.06</td>
<td>SAFETY GUARDS</td>
</tr>
<tr>
<td>2.07</td>
<td>DRIVE UNITS</td>
</tr>
<tr>
<td>2.08</td>
<td>GEARS</td>
</tr>
<tr>
<td>2.09</td>
<td>ELECTRICAL MOTORS FOR MECHANICAL EQUIPMENT</td>
</tr>
<tr>
<td>2.10</td>
<td>CONTACTS</td>
</tr>
<tr>
<td>2.11</td>
<td>GAUGES</td>
</tr>
<tr>
<td>2.12</td>
<td>NAMEPLATES AND DATA PLATES</td>
</tr>
<tr>
<td>2.13</td>
<td>PAINTING</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.01</td>
<td>COORDINATION</td>
</tr>
<tr>
<td>3.02</td>
<td>INSPECTION</td>
</tr>
<tr>
<td>3.03</td>
<td>PREPARATION</td>
</tr>
<tr>
<td>3.04</td>
<td>MANUFACTURERS' SUPERVISION AND INSTALLATION CHECK</td>
</tr>
<tr>
<td>3.05</td>
<td>INSTALLATION</td>
</tr>
<tr>
<td>3.06</td>
<td>FIELD QUALITY CONTROL</td>
</tr>
<tr>
<td>3.07</td>
<td>CONSOLIDATION OF DEMONSTRATION, TESTING, AND INSTRUCTION REQUIREMENTS</td>
</tr>
<tr>
<td>3.08</td>
<td>SOUND LEVEL TESTING AND WORKER PROTECTION</td>
</tr>
<tr>
<td>3.09</td>
<td>IN-SERVICE CHECKS</td>
</tr>
<tr>
<td>3.10</td>
<td>PUMPS</td>
</tr>
<tr>
<td>3.11</td>
<td>EARTHQUAKE DESIGN AND RESTRAINT</td>
</tr>
</tbody>
</table>

Rev: 05/14/13
PART 1 - GENERAL

1.01 DESCRIPTION
These General Mechanical and Equipment Provisions, which apply to all systems and equipment, are hereby made a part of each and all of the separate Sections of this Specification. Contractor shall direct the attention of all Subcontractors and suppliers of mechanical and related appurtenances for the Work to the provisions of the Contract Documents located in these specifications.

1.02 MANUFACTURER'S EXPERIENCE
Unless specifically named in the detailed Specifications, a manufacturer shall have furnished equipment of the type and size specified which has demonstrated successful operation and is in regular use.

1.03 FACTORY INSPECTION
The District or its representative may inspect fabricated equipment at the factory without cost to the Contractor. The Contractor shall notify the District in sufficient time so that factory inspection can be arranged. Factory inspection will be made after manufacturer has performed satisfactory checks, adjustments, tests and operations. Approval of equipment at the factory only allows the manufacturer to ship the equipment to the site, and does not constitute final acceptance by the District.

1.04 STANDARD OF QUALITY
Items of equipment are specified by the name of the manufacturer for the purpose of establishing a standard of quality and acceptable experience. Substitute equipment will be acceptable if it can be demonstrated to the District that the substitute is in strict accordance with the Specifications and equal in quality to those models specifically named. Manufacturers specified have been determined by the District to meet or exceed the minimum acceptable standard for the designated equipment style and model. Refer to the General Provisions for requirements pertaining to substitutions and equals. All mechanical equipment furnished under the Specification shall be new and of current design.

1.05 ADAPTATION OF EQUIPMENT
No responsibility for alteration of a planned structure to accommodate substitute equipment will be assumed by the District. Equipment which requires alteration of the structures will be considered only if the Contractor assumes all responsibility for making and coordinating all necessary alterations. All revisions to structures, mechanical, electrical, or other work made necessary by such substitution shall be approved by the District and the cost of said revisions, including cost of redesign, shall be made at the Contractor's expense. Refer to General Provisions.
A. **Horsepower Ratings.** Horsepower ratings specified and/or shown for the proposed equipment are in accordance with the best information available to the District. In the event any equipment item proposed by the Contractor should require motors with larger horsepower rating than indicated on Electrical Drawings, it shall be the Contractor's responsibility to provide the proper control equipment, required modifications to motor control centers, starting equipment, feeder and branch circuit, and accessories as required to make the installation comply with the electrical code and to prevent excessive voltage drop without added cost to the District.

B. **Equipment.** Where equipment to be furnished is installed in an existing enclosure or adjacent to existing equipment, the Contractor shall field check the dimensions of existing equipment, location of conduits, etc., and shall familiarize himself with all existing conditions and difficulties to be encountered in performing such work.

1.06 GUARANTEES AND WARRANTIES
The Contractor shall guarantee all equipment in accordance with the Conditions of the Contract. In addition to the general guarantee requirements, equipment guarantee shall cover (1) faulty or inadequate design; (2) improper assembly or erection; (3) defective workmanship or materials; and (4) leakage, breakage, or other failure. For equipment bearing a manufacturer's warranty in excess of one (1) year, furnish a copy of the warranty to District with District named as beneficiary. The period of all guarantees shall be initiated from the date of the District written acceptance of the Work.

1.07 SUBMITTALS
Refer to Section F Labor and Construction, F-30 "Submittals" and to specific Divisions and Sections for additional submittal requirements.

A. **Shop Drawings.** Shop drawings shall be submitted to the District in complete sets indexed by Specification paragraph and Drawing number describing the various equipment items or systems. Unless otherwise specified or directed, submit shop drawings for all mechanical equipment specified herein.

B. **Earthquake Design Data.** Submit with the shop drawings complete calculations or test results, details of constructions, and method of attachment for all manufactured products showing compliance with Paragraph 3.11, "Earthquake Design and Restraint." The calculations and details shall be signed by a Professional Engineer who has demonstrated proficiency in Structural Engineering or Civil Engineering and is registered in the State of California.

C. **Instruction Manuals.** Prepare and submit instruction manuals covering all mechanical equipment and machinery specified herein.
D. Manufacturers' Certified Reports. Each equipment manufacturer, or his authorized representative, shall submit a notarized written report with respect to his equipment certifying that (1) the equipment has been properly installed and lubricated under his supervision, (2) the equipment is in accurate alignment, (3) he was present when the equipment was placed in operation, (4) he has checked, inspected, and adjusted the equipment as necessary, (5) the equipment is free from any undue stress imposed by connecting piping or anchor bolts, (6) has been satisfactorily operated under full load conditions, (7) he has inspected his equipment during the operational demonstrations and system validation tests to the extent specified, and (8) the equipment is fully covered under the terms of the guarantee.

E. Submittals For Operational Demonstration and System Validation Tests

1. Operation Demonstration. When the Contractor's application for a progress payment equals or exceeds 75% of the Contract value for the first time, submit a detailed and comprehensive procedure plan for performance of each operation demonstration required. Identical equipment items may be covered under one plan. Include an estimated date and duration for each procedure and personnel required.

2. System Validation Tests. When the Contractor's application for a progress payment equals or exceeds 75% of the Contract value for the first time, submit a detailed and comprehensive procedure plan for performance of each separate validation test and for each validation test that covers two or more systems. Each procedure plan shall describe and itemize the involved system, including associated electrical equipment and instrumentation and control systems, and shall include evidence of an organized step-by-step procedure properly coordinating the efforts of various trades and manufacturers' representatives involved and of the operation of the facilities. Procedures shall include an estimated duration and date for each procedure and the personnel required.

3. Procedure Plan Information. In addition to the information specified above, each procedure plan shall include the following information as applicable.

   a) Description of temporary procedure facilities, including Drawings and sketches as required to fully illustrate the facilities.

   b) List of test materials and estimated quantities.

   c) List of instruments, measuring and recording devices, and other test equipment, whether a part of the plant or furnished separately for temporary use.

   d) Names of supervising and inspecting manufacturers.
e) Complete listing of all functional parameters to be observed and recorded.

f) Recording intervals.

4. Records Materials. Submit samples of the forms, charts, and other materials to be used in recording demonstration and validation test results.

5. Results. Within 10 days after completion of each procedure plan submit 3 copies of all recordings and results of all operational demonstrations and system validation tests.

F. Electric Motors. Conform with applicable requirements specified in Sections 16150 and 16151 herein.

1.08 PRODUCT DELIVERY, STORAGE AND HANDLING
Box, crate, or otherwise enclose and protect equipment during shipment, handling, storage, and following installation until final acceptance of the project. Keep equipment dry and covered from exposure to weather. Store pumps, motor, electrical equipment, and equipment having anti-friction or sleeve bearings in weathertight storage facilities. Lift large equipment items only at the points designated by manufacturer.

A. Factory Painted Surfaces. Protect against impact, abrasion, discoloration, and other damage. Repair damage as directed and approved (Refer to Section 09871).

B. Electrical Equipment. Maintain electrical equipment, controls, and keep insulation dry at all times. Keep heaters in equipment connected and operating until equipment is placed in operation.

1.09 JOB CONDITIONS
Drawings are diagrammatic and show the intended arrangement of principle apparatus, piping, and appurtenances. Conform to Drawings as closely as possible and exercise care to secure approved headroom and space conditions, neat arrangement of piping, valves, hangers, and like items, and to overcome structural interferences. Verify dimensions and conditions at the place of installation, and install materials and equipment in the available spaces. Submit written details and reasons for proposed deviations from Drawings and Specifications, and do not deviate therefrom unless authorized by Field Order or Change Order. If approved changes require alteration of structures or related work, make such alterations as approved in advance by District at no additional cost to District.

1.10 EQUIPMENT
All equipment furnished shall be complete, ready for installation and operation. All bolts, nuts, washers, mounting plates, bed plates, bases, anchor bolts and other miscellaneous items necessary to form a complete, installed, operational system shall be furnished whether specifically specified or not.
PART 2 - PRODUCTS

2.01 MATERIALS AND WORKMANSHIP
All equipment furnished shall be new and guaranteed free from defects in materials, design, and workmanship. It shall be the manufacturer’s responsibility to ascertain the conditions and service under which the equipment will operate and to warrant that operation under these conditions shall be successful. All parts of the equipment shall be amply proportioned for all stresses that may occur during fabrication, erection, and intermittent or continuous operation.

All equipment shall be designed, fabricated, and assembled in accordance with the best modern engineering and shop practice. Individual parts shall be manufactured to standard sizes and gauges so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests. Materials shall be suitable for service conditions. Iron castings shall be tough, close-grained gray iron free from blowholes, flaws, or excessive shrinkage and shall conform to ASTM A48. Except where otherwise specified, structural and miscellaneous fabricated steel used in items of equipment shall conform to the Standards of the American Institute of Steel Construction. All structural members shall be considered as subject to shock or vibratory loads. Unless otherwise specified, all steel which will be submerged, all or in part, during normal operation of the equipment shall have a minimum nominal thickness of 1/4-inch. Provide equipment and materials suitable for the service conditions and meeting standard specifications such as ANSI, ASME, AWWA, ASTM, NEMB, UBC, and UL. The location of the fabricator and his shop schedule shall be furnished to the District prior to the beginning of fabrication so that the District can schedule shop inspection.

2.02 LUBRICATION

A. Lubricants. Provide lubricants of types recommended by equipment manufacturers, quantities sufficient for consumption prior to completion, testing, and final acceptance.

B. Lubrication Systems. Lubrication of equipment shall ensure constant presence of lubricant on all wearing surfaces. Lubricant fill and drain openings shall be readily accessible. Easy means for checking the lubricant level shall be provided. Prior to testing and/or operation, the equipment shall receive the prescribed amount and type of lubricant as required by the equipment manufacturer. Equipment lubrication systems shall be systems that require attention during start up of shut down, and shall not waste lubricants.
2.03 STRUCTURAL STEEL FABRICATIONS
Conform to "Code of Standard Practice for Steel Buildings and Bridges" and "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" of the AISC unless otherwise indicated or specified. Design all fabrications for dynamic and vibratory loadings. Use structural steel shapes conforming to ASTM A36, A440, A500, A501, A570, A618, or equal, as applicable. Conform welding to AWS D1.1 Structural Welding Code. Galvanized specified items in accordance with ASTM A123, A153, or A386 as applicable; use galvanized bolts and fasteners with galvanized assemblies.

2.04 EQUIPMENT BASES AND BEDPLATES
Mount equipment assemblies on a single heavy cast iron or welded steel bedplate unless otherwise shown or specified. Provide bases and bedplates with machined support pads, tapered dowels for alignment or mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits. Continuously weld seams and contact edges between steel plates and shapes, and grind welds smooth. Do not support machinery or piping on bedplates other than that which is factory installed. Provide jacking screws in equipment bases and bedplates to aid in leveling prior to grouting. Provide plates of minimum thickness of 1/4-inch. Pump bedplates shall include a drip lip and provisions for directing leakage to a single disposal point.

2.05 ANCHORS AND SLEEVES
Each equipment manufacturer shall furnish the required anchor bolts, nuts, washers, and sleeves of adequate design for securing bases and bedplates to concrete bases. Provide sleeves of at least 1-1/2 times anchor bolt diameter. Anchor bolts shall be Type 316 stainless steel. Provide anchor bolts of length to allow for 1-1/2 inch of grout under baseplates and adequate anchorage into structural concrete unless otherwise shown or specified. Conform to designs for attachments to resist seismic forces, as applicable.

2.06 SAFETY GUARDS
Cover belt or chain drives, fan blades, couplings, exposed shafts and other moving or rotating parts on all sides with safety guards conforming to all Federal, state, and local codes and regulations pertaining; conform to the most restrictive requirements. Safety guards shall be free of all sharp edges and corners. Use corrosion-resistant materials at least equivalent to hot-dip galvanized steel. Safety guards shall be fabricated from 16USS gauge, or heavier, galvanized or aluminum-clad steel or 1/2-inch mesh galvanized expanded metal. Design guards for easy installation and removal. Provide necessary supports, accessories, and fasteners, of hot-dip galvanized steel or stainless steel. Design guards in outdoor locations to prevent entrance of rain and dripping water.

2.07 DRIVE UNITS
Provide drive units designed with a AGMA rating and service factor suitable for 24 hour continuous duty service under operating load, constructed to preclude oil leakage around shafts. Drive unit housings shall be constructed of high grade cast iron, welded steel, or other suitable material. Thermal rating of each unit shall exceed the design load or proper cooling devices shall be provided. All drives shall be designed specifically for the service conditions under which they are to operate.
2.08 GEARS
Provide oil-lubricated totally-enclosed gear reducers and increasers.

A. **Service Ratings.** Each gear shall have a nameplate service horsepower rating equal to the nameplate rating of the driving motor. Each gear shall have mechanical and thermal capacity equal to, or greater than an equivalent horsepower determined by multiplying the service horsepower rating by the specified service factor recommended by AGMA for heavy duty service, except each set of worm gears shall have a minimum service factor of 1.50.

B. **Thermal Rating.** Obtain thermal rating for the equivalent horsepower without auxiliary cooling equipment such as heat exchangers. Design units to operate continuously for the conditions specified in a location where ambient temperatures vary from 30° to 130° F. If a cooling coil is required, provide minimum 1-inch diameter tubing and a 1-inch solenoid supply water valve with the gear.

C. **Bearings.** Provide anti-friction bearings throughout, designed to give 20,000 hours B100 life for the specified horsepower in continuous operation, of proportions, mounting and adjustment consistent with acceptable modern practices for applied radial and thrust loads at speeds involved. Provide thrust bearing rates at 1-1/2 times the maximum thrust loadings involved.

D. **Gear Nameplates.** Equip each gear with an AGMA nameplate which shows service horsepower, actual service factor for actual mechanical or thermal rating as applicable, and AGMA gear Class I rating.

2.09 ELECTRICAL MOTORS FOR MECHANICAL EQUIPMENT
Conform with applicable requirements of Division 16.
2.10 CONTACTS
For interlock or failure indicating contacts specified to be supplied as part of equipment, provide SPDT switches rated for 120 VAC, 60 Hz at 5 amperes resistive or 3 amperes inductive loading, terminated at screw-type barrier strips in a NEMA 4 enclosure, unless otherwise shown or specified.

2.11 GAUGES
Gauges shall be installed in the suction (where applicable) and discharge piping of each pump and blower. The gauges shall be 4-inch diameter, liquid filled and shall include a petcock (Corp stop) between the pump/blower piping and the gauge. For solids bearing or corrosive fluids, a diaphragm gauge isolator shall be provided. Suction gauges shall be of the compound type and shall have a range as shown on the Drawings. Discharge gauge ranges shall be a standard commercially available range as shown on the drawings.

2.12 NAMEPLATES AND DATA PLATES
Provide Type 302, 304, or 316 stainless steel nameplates of ample size with embossed or preprinted lettering, fastened to the equipment in a prominent place with corrosion-resisting pins. On nameplates, display manufacturer, serial number, date of manufacture, model number and essential operating characteristics. Inscribe data plates with specific or directed information.

2.13 PAINTING
Conform to applicable requirements of Section 09871 "Coating System for Water Pumping Plants" and following requirements unless modified or superceded under other Sections.

A. Factory Painting. On mechanical equipment, drives, starters, control panels and other similar self-contained or enclosed components, apply a factory primer and high-quality oil-resistant baked industrial enamel finish. Paint or otherwise protect surfaces that are inaccessible after assembly by a method which provides protection for the life of the equipment.

B. Shop Priming. Apply one or more shop coats of metal primer on surfaces to be finish painted at the site to protect surfaces until finished. Use primers specified for the required paint system in Section 09871.

C. Rust Preventive. Coat machined, polished, or other ferrous surfaces, and non-ferrous surfaces, which are not to be painted, with rust preventive compound, Dearborn Chemical No-Ox-Id 2W, Houghton Rust Veto 344, Rust-Oleum 4-9, or approved equal.
PART 3 - EXECUTION

3.01 COORDINATION
The Drawings show in a diagrammatic form the arrangements desired for the principle apparatus, piping, and similar appurtenances, and shall be followed as closely as possible. Proper judgment must be exercised in carrying out the work to secure the best possible headroom and space conditions throughout, to secure neat arrangement of piping, valves, fixtures, hangers, and similar appurtenances, and to overcome local difficulties and interferences of structural conditions wherever encountered.

The Contractor shall take all measurements for his work at the installation sites, verify all subcontractor drawings and be responsible for the proper installation, within the available space for the apparatus specified and shown on the Drawings, and must secure the approval of the District for any variations before making any changes.

Refer to pertinent Sections for items of equipment to be assembled of several components under the unit responsibility of one manufacturer. To coordinate this requirement, the Contractor shall monitor and verify the unit responsibility processes and submit the following information to the District in writing on a monthly basis:

A. Shipment dates of the various components to the unit responsibility manufacturers.
B. Scheduled dates of factory tests by unit responsibility manufacturers.
C. Scheduled shipments dates to site of unit responsibility items.
D. Scheduled arrival date, installation date and start-up date.

3.02 INSPECTION
Inspect each item of equipment for damage, defects, completeness, and correct operation before installing. Inspect previously installed related work and verify that it is ready for installation of the equipment.

3.03 PREPARATION
Prior to installing equipment, ensure that installation areas are clean and that concrete or masonry operations are completed. Maintain the areas in a broom-clean condition during installation operations. Clean, condition, and service equipment in accordance with the reviewed Instruction Manuals and requirements in other Sections of these Specifications before installing.
3.04 MANUFACTURERS' SUPERVISION AND INSTALLATION CHECK
Each equipment manufacturer shall furnish the services of an authorized representative specially
trained and experienced in the installation of his equipment to (1) supervise the equipment installation
in accordance with the reviewed Instruction Manual, (2) be present
when the equipment is first put into operation, (3) inspect, check, adjust as necessary, and approve the
installation, (4) repeat the inspection, checking, and adjusting until all trouble or defects are corrected
and the equipment installation and operation are acceptable, (5) witness and supervise operational
demonstrations and system validation tests to the extent specified, and (6) prepare and submit the
specified Manufacturers' Certified Report. Include all costs for representatives service in the Contract
Price.

3.05 INSTALLATION
A. **Structural Fabrications.** Conform to the AISC Code and Specification references in
   Article "Structural Steel Fabrications."

B. **Equipment.** Conform to reviewed Instruction Manuals. Employ skilled craftsmen
   experienced in installation of the types of equipment specified. Use specialized tools
   and equipment, such as precision machinist levels, dial indicators, gauges, and
   micrometers, as applicable. Produce acceptable installations free of vibration or other
   defects.

C. **Anchor Bolts.** Deliver bolts with templates or setting drawings and verify that bolts are
   correctly located before structural concrete is placed.

D. **Base and Bedplate Grouting.** Do not place grout until initial fitting and alignment of
   connected piping is completed. Level and align equipment on the concrete foundations,
   then entirely fill the space under base or bedplates with grout. Bevel exposed grout at
   45 degree angle, except round exposed grout at horizontal surfaces for drainage.
   Trowel or point exposed grout to a smooth dense finish and damp cure with burlap for
   three days. When grout is fully hardened, remove jacking screws and tighten nuts on
   anchor bolts. Check the installation for alignment and level, and perform approved
   corrective work as required to conform to the tolerances given in the applicable
   Instruction Manual.

3.06 FIELD QUALITY CONTROL
A. **General.** All costs for performing operational demonstrations and system validation
tests shall be included in the Contract Price, and no extra payment will be made to the
Contractor due to overtime, weekend, or holiday labor costs required to perform and
complete the demonstrations and validation tests. Requirements specified in this
Article are in addition to the demonstration and test requirements specified under other
Sections of these Specifications.
1. Operational Demonstration and Systems Validation Testing shall be performed by the Contractor in accordance with the approved procedure plans to demonstrate to the District's satisfaction that:

a) All components of the process systems defined herein, the complete systems, and the new plant systems are fully completed and operable.

b) All units, components, systems, and the entire plant systems operate with the efficiency, repeatability, and accuracy indicated and specified.

c) All components, systems, and the entire plant conform to the Contract Documents and the reviewed shop drawings, samples, construction manuals, materials lists, and other reviewed submittals.

2. Scope of Demonstrations and Validation Testing. Operational demonstrations and system validation tests are required for all work, equipment, and systems specified in these Specifications including all associated and related electrical systems and control devices.

a) Equipment and work to be operationally demonstrated are defined as individual equipment items such as pumps, compressors, mixers, sludge collecting mechanisms, belt press and like equipment items. Demonstrations shall be performed simultaneously on groups of identical equipment items and groups of items supplied by one manufacturer to the extent feasible.

b) Systems to be validation tested are defined as complete systems that perform a discrete process function of the plant such as chemical systems, sludge collection system, sludge dewatering system, and similar systems. Each system shall include associated structures, tanks, piping, utilities, instrumentation and controls, and like related items. Two or more separate systems shall be validation tested simultaneously when necessary to validate an entire discrete plant function.

3. Prerequisite Conditions. Operational demonstrations and validation testing shall not commence for any equipment item or system until all related structures, piping, electrical, instrumentation, control, and like work has been installed, tested, and connected in compliance with the pertaining requirements specified elsewhere in the Specifications.
4. Demonstration and Testing Materials. Furnish materials, natural gas and/or electrical power for operation demonstrations and validation tests. Use fresh water to fill tanks, wells, piping, and systems that contain water or wastewater in normal operation. Use the specified chemicals or chemical systems but do not exceed the "in service" concentrations. Furnish temporary facilities as required such as by-pass or re-circulation piping, diversions, storage, and similar facilities. Use procedures that conserve testing materials and avoid wastage, especially with respect to large quantities of fresh water and electrical power.

5. Inspection and Supervision by Manufacturers. Perform operational demonstrations and system validation testing under continuous inspection by the District. Technical representatives of the various equipment manufacturers shall be present at the start of the operational demonstrations, shall examine their equipment at least twice near the beginning and end of the validation tests, shall supervise the start up and adjustment procedures, and shall perform all other services necessary for the manufacturer's certified reports required herein.

6. Correction of Defects. Immediately correct all defects and malfunctions disclosed by demonstrations and validation tests using approved methods and new materials for repairs as required. Interruption time necessary for corrective work shall be added to the specified total demonstration and validation test periods.

7. Acceptance. Satisfactory completion and approval of required operational demonstrations and system validation testing is one of the conditions precedent to the District's acceptance of the work and does not constitute final acceptance. Refer to the Conditions of the Contract.

B. System Validation Tests. All equipment components of each system shall have successfully completed the required operational demonstration before the system is validation tested. Perform validation testing in accordance with the approved procedure plan.

1. Test Period. Test each system, including standby systems, by continuous operation in "in-service" condition for not less than 24 consecutive hours, with no interruptions except for normal maintenance or corrective work.

2. Testing Methods. Operate systems continuously 24 hours a day under constant inspection of trained operators. Cycle system operation from full load to light load and back to full load each 24 hours; cause variable speed equipment to cycle through the applicable speed range at a steady rate of change. Induce simulated alarm and distressed operating conditions, and test controls and protective devices for correct operation in adjusting system functions or causing system shutdown.
3. Simulation of Conditions. Subject to Contractor's request and District's review in each case, the Contractor may simulate certain operating conditions relating to flow rates, water levels, and malfunctions. Permission for simulations will be granted only where it is unwise or impossible to obtain the conditions covered by the capability of ranges or equipment. The simulation methods shall reflect reasonable anticipated operating conditions.


a) Flow Metering Systems shall be tested at not less than 3 values corresponding approximately to a minimum, average and maximum capacity, respectively.

b) Liquid Level Indicating Systems shall be tested at not less than 5 levels corresponding approximately to low, average, normal, maximum and high alarm levels, respectively. Low-low and high-high level alarms and system reaction shall also be tested where equipment or instruments are required to react to such conditions.

c) Remotely Controlled Valves shall demonstrate suitable operation both from local control and remote controls. As a minimum, these procedures shall include full-open and full-close positioning. Each test shall be repeated not less than 3 times for non-throttling and non-modulating valves. In addition to these minimum requirements, and subject to approval, all throttling valves and modulating valves shall be operated at not less than 3 intermediate positions and shall demonstrate the ability of each valve to hold the set position under operating conditions.

d) Variable Speed Equipment shall demonstrate accurate response to speed controlling devices and controls within the required operating ranges. Actual output shaft speeds of manually adjustable speed equipment shall be validated by measurement of shaft speeds versus speeds shown by equipment instruments.

5. Automatic Response of Equipment. Response of equipment to appropriate manual or automatic controls, or combinations of both automatic and manual controls, shall be demonstrated to be correct and accurate. Where applicable, all components shall be tested for both manual and automatic operation. Where a component performs more than one function, every function shall be validated.

a) Pumping Equipment shall respond accurately and reliably to liquid level, pressure and/or flow rate signals from appurtenant reservoirs, pipes or wet wells. Automatic alternation and back-up pump functions shall also be validated.
b) Auxiliary Equipment Items such as automatic samplers, annunciators, alarms, and like items shall respond accurately and reliably to every condition for which they are programmed, in the manner specified.

C. **Recording of Data.** Neat and comprehensive records of each operational demonstration or validation test shall be maintained by the Contractor. Each portion of the demonstration or validation procedure shall be described with all components itemized. Records shall be prepared on forms in a step-by-step fashion paralleling the approved plans. Forms shall list for each condition:

- Step taken;
- Result anticipated;
- Result obtained;
- If incorrect, corrective action taken; and
- Retest result.

The last two steps shall be repeated until all systems operate as required.

1. **Recording Devices.** Instruments, gauges, and other sensor and display devices forming a part of the various systems shall be employed for data acquisition to the extent applicable. The Contractor shall furnish all other instruments, gauges, recorders, and test devices as required, types conforming to the approved procedure plans.

2. **Information and Intervals.** All applicable data such as, but not limited to, water and other liquid levels, pressures, head differentials, duration of runs, instrument readings, chemical feed rates, voltage settings, drive speeds, motor running currents, torque, voltage, GPM, pressures, clarity, residual chlorine and related information, as applicable, and in accordance with the approved procedure plans, shall be recorded at the start and finish of every operational demonstration and at maximum 8-hour intervals during system validation tests, unless shorter intervals are specified elsewhere.

3. **Repetitions.** When a repeat of the same demonstration or validation test is required to verify the results, the repeat procedure shall be indicated on the recorded date by numerical indication, date, and time.

3.07 **CONSOLIDATION OF DEMONSTRATION, TESTING, AND INSTRUCTION REQUIREMENTS**
Operational demonstrations, system validation testing, and instruction of the District's personnel may be performed simultaneously, subject to prior approval of the extent of consolidation in each case.
3.08  SOUND LEVEL TESTING AND WORKER PROTECTION
Measure the sound level developed by all mechanical and electrical equipment provided under the Contract Documents. Perform testing in all rooms and spaces containing such equipment during the final operation test program with all equipment operating. Use an OSHA approved instrument and record the highest sound level developed when measured according to OSHA standards in each room and space. Deliver a copy of records to the District.

3.09  IN-SERVICE CHECKS
As a part of the work, an in-service check of each system required to be validation tested shall be performed twice during the period of the Contractor's guarantee by qualified technical representatives of the various system manufacturers, including manufacturers of equipment and components within systems. Checks shall be detailed and complete, requiring not less than 8 hours at the site, and shall be performed under the observation and to the satisfaction of the District's Plant Superintendent or his designated representative. All costs for in-service checks shall be included in the Contract Price.

A.  **Notification.** The Plant Superintendent shall be notified in writing at least 10 days before the performance of each in-service check. The proposed dates for checking shall be changed if required by the Plant Superintendents.

B.  **Consultation.** At the time of each in-service check, the manufacturer's technical representatives shall consult with the Plant Superintendent to review the Operation and Maintenance Manual and the pertinent operational and maintenance problems encountered, and shall furnish technical advice and recommendations to the Plant Superintendent.

C.  **Schedule.** Initial in-service checks shall be performed approximately 6 months after final acceptance of the plant. The second in-service check shall be performed within 30 days of the end of the Contractor's guarantee period.

D.  **Reports.** A written report of each in-service check signed by the appropriate manufacturer or his representative, shall be delivered to the Plant Superintendent within 10 days following the check. The report shall describe the checking procedure in detail, and shall state all advice and recommendations given to the Plant Superintendent.

3.10  PUMPS
This article covers general stipulations applicable to the plant pumps. All applicable parts of this Section shall also apply:

A.  **Equipment Testing.** The purpose of equipment testing is to demonstrate that the pump units meet the specified requirements.
1. Tests shall be performed on the actual assembled unit over the entire operating range on the certified performance curve. Prototype model tests will not be acceptable.

2. All pumps 10 to 50 horsepower shall be factory-tested in accordance with the above specifications. Pumps larger than 50 horsepower may be subject to a "factory witness test" attended by a District representative. The District shall be notified at least 2 weeks in advance such that a representative can witness the pump testing. Certified test results shall be submitted to the Engineer for approval prior to shipment.

3. Pump curves shall reflect data secured during actual test runs and shall be signed by a responsible representative of the pump manufacture. Test reports and procedures shall conform to applicable requirements of the Hydraulic Institute Standards.

B. Installation. The Contractor shall install all pumping equipment in strict accordance with the manufacturer's instructions. Care shall be used in handling to avoid bumping, twisting, dropping, or otherwise damaging the equipment.

All pump manufacturers shall furnish the services of factory-trained personnel as required to examine the installation, supervise start-up of equipment installed, and repair the equipment at no additional expense to the District.

C. Field Acceptance Test. The contractor under this specification shall have full responsibility for the proper installation and performance of said pumping equipment, including furnishing the services of a pumping equipment Field Service Engineer to inspect equipment installation, and to adjust, if necessary, any portion of the pumping equipment required herein. The manufacturer's Field Service Engineer shall assist the District in the proper conduct of pumping unit field acceptance tests. The pump units shall perform in the field as shown on the certified pump curves furnished by the Contractor. Tests shall also demonstrate operation without cavitation, vibration, overheating of moving parts, and excessive noise. The Contractor and pump manufacturer shall make necessary corrections to achieve smooth pump operation. In the event the tests reveal noncompliance of the workmanship or equipment, the Contractor shall either make alterations as necessary or replace the pumps in order to meet the requirements of the specifications at no additional cost to the District.

D. CERTIFICATION OF INSTALLATION. The Contractor shall submit a letter to the District confirming that all pumping equipment was inspected, operation checked, and installation approved in writing by the respective pumping equipment supplier.
E. **WARRANTY.** All pumping equipment shall carry an extended warranty for a two year period from the date of acceptance. All warranties shall be turned into the District prior to project completion.

F. **MAINTENANCE BOND FOR PUMPING EQUIPMENT.** The contractor or his supplier shall provide a maintenance bond (EMWD Standard form C-14 or C-14.1) from a bonding company acceptable to the District equal to 100% of the pumping equipment value (including motors, pumps and pump assemblies) for a two (2) year term starting when the District has accepted the contracted work. Equipment and/or components failing within this period due to deficiency in design, workmanship or material shall be removed, replaced, and reinstalled at no cost to the District, and said replacement shall be guaranteed for two years continuous service. The maintenance bond shall be submitted to the District prior to the performance test of the pump(s).

3.11 **EARTHQUAKE DESIGN AND RESTRAINT**

All manufacturer equipment supplied under this Contract shall be designed, constructed and attached to resist stresses produced by seismic forces specified in this Section. Equipment that does not vibrate during normal operation shall be rigidly attached. Equipment that vibrates during normal operation shall attached by means of isolators with mechanical stops that limit movement in all directions unless it can be demonstrated by calculations that such stops are not required. Equipment or portions of equipment that move during normal operation shall be restrained with mechanical devices that prevent displacement unless it can by demonstrated by calculations that such restraints are not required.

A. **Work Included.** The work included in this Paragraph includes, but is not limited to, the following equipment items:

1. Pipe supports and hangers.
2. Electrical control panels.

B. **Minimum Earthquake Forces.** The minimum earthquake forces shall be those prescribed for Essential Facilities by the Uniform Building Code and applicable supplements as published by the International Conference of Building Officials, 5360 South Workman Mill Road, Whittier, California  90601, or as specified in the "Soil Investigation Report," whichever is greater.

Contractor shall submit shop drawings, details and data herein before specified in Section F General Conditions, F-30, "Submittals."

**END OF SECTION 11005**
PART 1 - GENERAL

1-1. **SCOPE.** This section covers the furnishing and installation of carbon adsorption odor control systems complete with accessories to be furnished and installed as part of the odor control system as indicated on the Drawings and specified herein. The requirements of this section shall apply to the indicated equipment and systems, including interconnecting piping, controls, and accessories required for a complete and properly operating system.

All components of the activated carbon system shall be provided by a single odor control system supplier who shall be responsible for the design, coordination, and function of the system.

Odor control fans, odor control dampers, fiberglass reinforced plastic pipe for air services, pipe supports, and accessories, which are not an integral part of the carbon adsorption unit or are not specified herein are covered in other sections.

1-2. **GENERAL.** Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by Engineer. All pipe, vessels, equipment and components of plastic construction shall contain ultraviolet inhibitors.

Equipment shall be designed for long life under service conditions as required, including corrosive atmospheres and intermittent or continuous operation. All wearing parts and items requiring adjustment shall be readily accessible. All parts which are exposed to corrosive conditions shall be made from corrosion-resistant materials.

Components which are shipped loose due to transportation limitations shall be assembled and disassembled by the manufacturer prior to shipment to assure that all components fit together and are adequately supported.

1-2.01. **Coordination.** All equipment provided under this section shall be furnished by or through a single odor control System Supplier who shall coordinate with the Contractor, the design, fabrication, delivery, installation, and testing of the odor control carbon adsorption unit components. The System Supplier shall have the sole responsibility for coordination and performance of all components of the system with the performance and design criteria specified herein and on the Drawings.
Activated Carbon Unit
11354-2

Each manufacturer of major equipment shall have a local service center or shall be able to provide service within 24 hours. The service center shall be equipped and staffed to service the system and shall have an available supply of replacement media and maintain a local parts supply. Information on equipment manufacturers' representatives shall be included with the submittals.

Where several manufacturers' names have been listed in this section as possible suppliers, only the products of the first manufacturer listed have been checked for size, functions, and features.

1-2.02. **General Equipment Stipulations.** The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. **Seismic Design Requirements.** Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.04. **Governing Standards.** Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between this section and any state law or local ordinance, the latter shall govern.

All work shall comply with Underwriters' Laboratories (UL) safety requirements.

1-2.05. **Power Supply.** Not used.

1-2.06. **Metal Thickness.** Metal thickness and gages specified herein are minimum requirements. Gages refer to US Standard gage.

1-2.07. **Mechanical Identification.** Not used.

1-2.08. **Anchorage.** Equipment manufacturer shall design the anchorage and base plates for the equipment.

1-2.09. **South Coast Air Quality Management District (SCAQMD) Permit.** The Owner has initiated the air permit to construct from SCAQMD. Contractor shall coordinate with the activated carbon system supplier to obtain system information needed to complete the permit application and obtain the permit. Contractor shall be responsible for permit compliance.
1-3. **SUBMITTALS.**

1-3.01. **Drawings and Data.** Complete fabrication, assembly, and installation drawings, and wiring and schematic diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the General Conditions, Section F-29 Equipment and Material Items. Device tag numbers indicated on the Drawings shall be referenced on the wiring and schematic diagrams where applicable. The data and specifications for each unit shall include, but shall not be limited to, the following:

**Carbon Adsorption Vessel**
- Name of manufacturer.
- Type and model.
- Vessel dimensions.
- Size and location of all connections.
- Arrangement of inlet and discharge nozzle connections, access manways, regeneration manifold connection, activated carbon bed, supports, and other appurtenances.
- Carbon quantity required for design conditions.
- Regeneration manifold.
- Pressure loss at design airflow.
- Net weight.
- Foundation bolting details.
- Resin type and chemical resistance.

**Activated Carbon Media**
- Carbon substrate.
- Base material.
- Granule/pellet manufacturing process.
- Mean particle diameter.
- Total ash.
- Total surface area.
- Apparent density.
- Hardness.
- Moisture content.
- Pressure drop through dense-packed bed at actual face velocity.
- Hydrogen sulfide breakthrough capacity.

**Mist Eliminator**
- Name of Manufacturer.
- Type.
Material types, thicknesses, and finishes.  
Efficiency.  
Size and locations of all connections.  
Net Weight.  
Pressure loss at design airflow.  

Seismic Design Requirements  
Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-3.02.  Operation and Maintenance Data and Manuals.  Adequate operation and maintenance information shall be submitted in accordance with the General Conditions.  Equipment designations used shall correspond to those indicated on the Drawings.  The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-3.03.  Color Selection.  Colors for factory finish of carbon adsorption vessels shall be selected by Owner from the manufacturer's full range of standard and custom colors.  Samples shall be submitted for color selection in accordance with the General Conditions.  Color of all exposed odor control system components shall match, including activated carbon unit, demister, FRP piping, odor control fans, fan enclosures, dampers, and actuators. Future exposed odor control components, including biotrickling filter vessel, degreaser, guardrail, and ladders shall match the color of the installed system components.

1-4.  QUALITY ASSURANCE.

1-4.01.  Manufacturer Experience.  Manufacturer shall be as named herein.

1-4.02.  Performance Tests.  Prior to final acceptance, all the required tests shall be conducted on the odor control media and equipment in accordance with the Field Quality Control paragraph.

1-5.  DELIVERY, STORAGE, AND HANDLING.  Shipping shall be in accordance with the Product Delivery Requirements section.  Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

PART 2 - PRODUCTS

2-1.  SERVICE CONDITIONS.  All equipment shall be designed and selected to meet the specified conditions.
Equipment shall be designed to withstand and operate at the wind conditions indicated in the Meteorological and Seismic Design Criteria section. The carbon adsorption units shall be suitable for the following service conditions and designed for continuous 24 hour per day operation:

- Ambient temperature range: 20 to 130 °F
- Environmental exposure: Outdoor

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. All parts exposed to corrosive conditions shall be made from corrosive-resistant materials.

The carbon units will be used to deodorize malodorous air which contains hydrogen sulfide and which is fully saturated with water vapor. Each unit shall be designed for the performance requirements structural design indicated herein and on the Drawings. Key design criteria are as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Winchester Lift Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Carbon Units</td>
<td>1</td>
</tr>
<tr>
<td>Design Air Flow (scfm)¹</td>
<td>3,630</td>
</tr>
<tr>
<td>Sewer Air Temperatures (°F)</td>
<td>45-100</td>
</tr>
<tr>
<td>Vessel Design Pressure (in wc)</td>
<td>16</td>
</tr>
<tr>
<td>Average H₂S Loading (ppm)</td>
<td>5</td>
</tr>
<tr>
<td>Discharge H₂S (ppm)</td>
<td>&lt;0.1 ppm</td>
</tr>
<tr>
<td>Vessel Type</td>
<td>Horizontal flow</td>
</tr>
<tr>
<td>Max Vessel Footprint, LxW (ft)</td>
<td>12'-0&quot; x 9'-6&quot;</td>
</tr>
<tr>
<td>Max Vessel Height (ft)⁴</td>
<td>7'-0&quot;</td>
</tr>
<tr>
<td>Superficial Velocity (fpm)</td>
<td>50</td>
</tr>
<tr>
<td>Empty Bed Residence Time (sec)</td>
<td>3.6</td>
</tr>
<tr>
<td>Media Depth Layer 1: High Capacity Carbon (ft)³</td>
<td>2</td>
</tr>
<tr>
<td>Media Depth Layer 2: Virgin Activated Carbon (ft)³</td>
<td>1</td>
</tr>
<tr>
<td>Max Pressure Drop through Carbon Unit (inlet to outlet flange) (in wc)²</td>
<td>6</td>
</tr>
<tr>
<td>Inlet Relative Humidity</td>
<td>90% to 100%</td>
</tr>
</tbody>
</table>

NOTES:
1. Standard conditions are one atm and 70°F per ASHRAE.
2. At specified superficial velocity with clean media.
Activated Carbon Unit
11354-6

3 Media bed shall be configured to allow for two media chambers; the chamber adjacent to the inlet plenum shall be 2’-0” wide and the chamber adjacent to the discharge plenum shall be 1’-0” wide.

4 Vessel height with top access hatches shall not exceed 7’-6”.

2-2.01. Alternate Configuration and Dimensional Restrictions. Layout dimensions will vary between manufacturers and the layout area and arrangement indicated on the Drawings is based on an acceptable arrangement of a horizontal flow vessel. Contractor shall review the Contract Drawings, the manufacturer’s layout drawings, and installation requirements and shall make any modifications required for proper installation subject to acceptance by Engineer. At least 3 feet of clear access space shall be provided on all sides of the unit unless otherwise indicated. The maximum vessel height shall not exceed the limits as indicated on the Drawings. Alternate vessel type, flow direction, and configuration for the equipment is acceptable pending review and approval by Engineer. Contractor shall size and build an equipment pad suitable for the approved activated carbon unit. Contractor shall make all necessary concrete pad size and piping connection adjustment at no cost to District.

2-2.02. Elevation. Equipment shall be designed to operate at the elevation as indicated in the Meteorological and Seismic Design Criteria section. All equipment furnished for sites 2000 feet above sea level and greater shall be properly derated to operate and meet the specified capacities at the site conditions.

2-3. ACCEPTABLE MANUFACTURERS. The carbon adsorption vessel and media shall be provided by, Daniel Company, ECS Environmental Solutions, BioAir Solutions, Evoqua, or Pure Air Filtration, without exception.

2-4. MATERIALS.

2-4.01. Carbon Media. The carbon media shall composed of a layer of high capacity carbon followed by a layer of virgin activated carbon provided by the equipment manufacturer. The two media types shall not be blended.

2-4.01.01. Virgin Activated Carbon Media. The carbon media shall be virgin coconut intended for vapor phase applications. Virgin coconut media shall have the following physical and chemical properties:

<table>
<thead>
<tr>
<th>CARBON SUBSTRATE</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent density (bulk dense packing) g/cc, minimum density.</td>
<td>0.44</td>
<td>ASTM D2854</td>
</tr>
<tr>
<td>Ball-pan hardness number, minimum.</td>
<td>95%</td>
<td>ASTM D3802</td>
</tr>
<tr>
<td>Mean particle diameter, mm, minimum.</td>
<td>3.7</td>
<td>ASTM D2862</td>
</tr>
</tbody>
</table>
Activated Carbon Unit
11354-7

Iodine Number, mgl₂/g, minimum. 1,100 ASTM D4607
Moisture, percent, maximum. 5% ASTM D2867
Maximum head loss at 50 fpm face velocity through a dense-packed bed, inches water column / ft bed depth. 1.7
Butane Activity, weight percent, minimum. 23.3 ASTM D5742
Hydrogen sulfide breakthrough capacity, g H₂S/cc carbon 0.06 ASTM D6646

2-4.01.02. Water Washable Carbon Media. Not used.

2-4.01.03. High Capacity Carbon Media. The high capacity carbon media shall be of a type that provides hydrogen sulfide odor control without causing an acute acidic environment. When spent, the carbon bed shall not demonstrate a pH<3. High capacity carbon media shall have the following physical and chemical properties:

<table>
<thead>
<tr>
<th>CARBON SUBSTRATE</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent density (bulk dense packing) g/cc, minimum density.</td>
<td>0.44</td>
<td>ASTM D2854</td>
</tr>
<tr>
<td>Ball-pan hardness number, minimum.</td>
<td>95</td>
<td>ASTM D3802</td>
</tr>
<tr>
<td>Mean pellet diameter, mm, minimum.</td>
<td>4.0</td>
<td>ASTM D2862</td>
</tr>
<tr>
<td>Iodine Number, mgl₂/g, minimum.</td>
<td>1050</td>
<td>ASTM D4607</td>
</tr>
<tr>
<td>Butane Activity, weight percent, minimum.</td>
<td>26</td>
<td>ASTM D5742</td>
</tr>
<tr>
<td>Maximum head loss at 50 fpm face velocity through a dense-packed bed, inches water column / ft bed depth.</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Hydrogen sulfide breakthrough capacity, g H₂S/cc carbon, minimum.</td>
<td>0.30</td>
<td>ASTM D6646</td>
</tr>
</tbody>
</table>

2-5. CONSTRUCTION. Carbon adsorption units shall include adsorber vessel, activated carbon, support assembly, connections, controls, instrumentation, and all accessories.

2-5.01 Carbon Adsorption Units. Units shall be horizontal flow single bed type as indicated on the Drawings with a minimum carbon bed depth of at least 3 feet.

2-5.01.01. Carbon Adsorption Vessel. Carbon adsorption vessels shall be constructed of fiberglass reinforced plastic in accordance with ASTM D3299 or ASTM D4097. All vessels shall be arranged for horizontal flow.
Alternate flow arrangements shall be considered if the maximum vessel height as indicated on the Drawings is not exceeded and if the total weight of carbon provided and foul air residence time equals or exceeds that of the specified vessel. All fiberglass reinforced plastic fabrications shall have a flame spread of 25 or less when tested in accordance with ASTM E84. The resin used shall be premium vinyl ester fire retardant suitable for contact with water-saturated air containing hydrogen sulfide at 180°F. Resin used in the fabrication of vessels to be installed outdoors shall contain ultraviolet inhibitors.

Each vessel shall be provided with lifting lugs and hold-down brackets for mounting on a concrete base. Each vessel shall be a rectangular cuboid shape with flat top and flat bottom. The vessel top shall be self-supporting, structurally reinforced to withstand a super-imposed load of 250 pounds at any point and shall be additionally reinforced as necessary for the specified accessories. Vessel tops shall be provided with a nonslip finish over the entire top surface. The outlet shall be provided with a no loss discharge stack designed to prevent the entry of moisture.

The media bed shall be configured to allow for two distinct media chambers as noted in the design criteria table in subparagraph 2-2. A carbon support system shall be provided inside each vessel. The support system shall consist of nonmetallic, removable grating supported from the vessel sides. Polypropylene mesh shall be installed between the grating and carbon to prevent scouring of media due to the inlet air arrangement. A contact probe, ground lug, and all electrical provisions shall be provided to ground each carbon bed.

2-5.01.02. Connections. All piping connections shall be flanged. Air inlet and outlet connections on each vessel shall conform to ANSI D3982; shall be furnished undrilled; and shall be field drilled to match bolt hole locations on connecting piping. Other flanges for connection to PVC or CPVC piping shall conform to ANSI/ASME B16.1, Class 125 diameter and drilling. The orientation of the piping connections, inspection manholes, and other appurtenances shall be as indicated on the Drawings.

2-5.01.03. Inspection Manways. Two 24-inch diameter inspection manways with flanged covers shall be provided on each containment vessel. One shall be located in the exhaust plenum and the other over the media bed on the side of the vessel. The manhole covers shall be fully gasketed and shall be gastight at the design operating pressure and vacuum specified herein and on the schedules. Manhole flanges shall conform to ASTM D3299 Table 5.

2-5.01.04. Sample Probes. Three sample probes shall be provided on each side of the carbon bed and shall be spaced evenly across the media layer. The probes shall extend at least 6 inches into the bed. The probes shall be suitable for extraction of carbon samples and collection of gas samples from the carbon bed and shall be nonbinding.
The probes shall extend outside the vessel wall and shall terminate with CPVC, ball type shutoff valves.

2-5.01.05.  **Ladders and Guardrails**. Not used.

2-5.01.03.  **Access Hatches**. A flanged access hatch shall be provided on the top of the vessel with the opening over the entire media bed to ensure full access. Hatch shall include lifting lugs separate from those required in paragraph 2-5.01.01. The access hatch shall be fully gasketed and shall be gastight at the design operating pressure and vacuum specified herein and on the schedules. Access hatch flanges shall conform to ASTM D3299 Table 5.

2-5.02.  **Carbon Canister Units**. Not used.

2-5.03  **Discharge Stack**. Discharge stack shall be provided to promote good dilution. Stack outlets shall be sized for a minimum 2,500 feet per minute velocity. Discharge stacks shall no-loss type with a minimum discharge height as indicated on the Drawings and shall be attached to the vessel with a flanged connection. Rain hats that inhibit upward dispersion are not acceptable. Stack shall be provided with guy wire supports where required. Each stack shall be provided with sample ports as indicated on the Drawings.

2-6.  **ACCESSORIES**.

2-6.01.  **Demister**. The demister / mist eliminator shall consist of an FRP enclosure, fabricated per PS 15-69 utilizing premium vinyl ester resin suitable for the indicated service, with an internal demister assembly consisting of a 316L stainless steel pad in front of a polypropylene pad. The demister efficiency shall provide at least 99.9% removal of particulates equal to or larger than 10 microns in size. The pads shall be removable and separable from each other for cleaning and the housing shall be flanged or have a door to allow removal and replacement of the filter pads. This unit shall ship loose and be ready for installation into the odor control system supply ductwork. The FRP housing shall be flanged and drilled, and come complete with gaskets, ready for installation. The mist eliminator shall have a maximum initial resistance of 1-inch wc at 400 feet per minute. The filter/eliminator unit shall be manufactured by the activated carbon unit vendor, Diamond Fiberglass Fabrications, Inc., or equal. One spare filter shall be furnished with the equipment.

2-6.02  **Differential Pressure Gauges**. Differential pressure gauges shall be furnished for monitoring the pressure differential across each carbon media bed. The gauges shall be permanently mounted and shall be furnished with a mounting bracket, tubing, and all required fittings. Unless otherwise indicated, the installation hardware shall be Type 316L stainless steel.
Activated Carbon Unit
11354-10

Tubing shall be 1/2 inch PVC pipe, unless otherwise indicated, properly supported and braced for a permanent installation. Indicators shall be installed approximately 5 feet above the surrounding floor or concrete slab.

Each gauge shall be of the diaphragm actuated dial type with adjustable pointer, white dial and black figures and markings. Each gauge shall have a range such that under normal operating conditions, the reading is approximately in the middle of the range. Accuracy shall be within 3 percent of full scale. Two shutoff cocks shall be furnished with each gauge.

Condensate drip tubing shall be provided on the high and low pressure lines to each gauge. The condensate drip lines shall extend a minimum 4 inches below the bottom elevation of the gauge and terminate with shutoff valves.

The gauges shall be furnished with a transparent red overlay extending from the maximum allowable differential pressure reading to the end of the range.

Differential pressure gauges shall be Dwyer "Series 4000 Capsuhelic" with diaphragm seal made from a material suitable for exposure to a dry hydrogen sulfide air stream.

2-6.03. Signs. Each carbon adsorption unit shall be provided with the following signs in both English and Spanish:

"CAUTION: OXYGEN-DEFICIENT ENVIRONMENT DO NOT ENTER THIS VESSEL."

2-7. MANUFACTURE AND FABRICATION.

2-7.01. Anchor Bolts and Expansion Anchors. Anchor bolts, expansion anchors, nuts, and washers shall be as indicated in the Anchorage in Concrete and Masonry section unless otherwise indicated on the Drawings.

2-7.02. Edge Grinding. All cut or sheared edges shall be ground smooth to a 1/8 inch minimum radius for all material 1/4 inch thickness and larger. For material thickness less than 1/4 inch all cut or sheared edges shall be ground smooth to a radius equal to 1/2 the material thickness. Grinding of rolled edges on standard shapes with a minimum radius of 1/16 inch will not be required.

2-7.03. Surface Preparation. All iron and steel surfaces shall be shop cleaned by sandblasting or equivalent, in strict conformance with the paint manufacturer’s recommendations. All mill scale, rust, and contaminants shall be removed before shop primer is applied.
2-7.04. **Shop Painting.** All steel and iron surfaces shall be protected by suitable coatings applied in the shop. Surfaces which will be inaccessible after assembly shall be protected for the life of the equipment. Coatings shall be suitable for the environment where the equipment is installed. Exposed surfaces shall be finished, thoroughly cleaned, and filled as necessary to provide a smooth, uniform base for painting.

Surfaces to be coated after installation shall be prepared for painting as recommended by the paint manufacturer for the intended service, and then shop painted with one or more coats of a universal primer.

Machined, polished, and nonferrous surfaces which are not to be painted shall be coated with rust-preventive compound as recommended by the equipment manufacturer.

2-7.05. **Special Tools and Accessories.** Equipment requiring periodic repair and adjustment shall be furnished complete with all special tools, instruments, and accessories required for proper maintenance. Equipment requiring special devices for lifting or handling shall be furnished complete with those devices.

2-8. **CONTROLS.** The control systems shall be furnished and installed as indicated on the Drawings and as specified herein. All controls shall consist of electric equipment.

2-8.01. **Control Panels.** The control panels shall be furnished and installed where indicated on the Drawings and as specified herein. Control panels shall be designed for mounting as required, and shall be completely prewired and checked. The control panel shall provide electrical control for the fan.

Control panels shall conform to NEMA ICS 1, NEMA ICS 2, NEMA ICS 3, and NFPA 70. Control panels shall be NEMA 4X. The control panels will be supplied with 120 volts, 60 Hz, single phase power. All electrical accessory devices and internal electrical wiring shall be furnished and installed. All controllers, selector relays, switching relays, interlock relays, manual switches, alarm and indicating lights, and other devices indicated to be panel mounted shall be mounted in or on the respective control panel.

Accessories, such as indicating lights and selector switches, shall be mounted on the front hinged covers of the panels. The accessories and panels shall be identified with engraved phenolic nameplates with 1/4 inch high letters. Twenty-five percent extra terminals shall be provided in each control panel.

2-8.01.01. **Odor Control System Control Panel.** An electrical control panel shall be provided with the odor control system. Motor starters and controls shall be furnished, installed, and prewired in the electrical control panel.
Activated Carbon Unit
11354-12

The enclosure shall have a NEMA rating suitable for the location or shall be NEMA 4X FRP if located in an unclassified area. The devices within the control panel shall be controlled by a PLC, as specified in 17010, Programmable Logic Controller. The PLC shall interface with the existing RTU, via Modbus/TCP, routed through the Ethernet switch in the Odor Control Panel. Ethernet switch shall have no fewer than two dedicated ports for integration of the future biotrickling filter system PLC. Each electrical control panel shall be furnished with a main power disconnect switch and weather shield. Each electrical control panel shall be furnished with a reset pushbutton which will enable the system after a loss of power. The electrical control panel shall provide electrical control for the fans. The panel shall be factory tested to full operation with all other components prior to shipment. The panel shall have the following components or capabilities:

- Fan switches (ON-OFF)
- Fan VFDs

2-7.03. **Selector Switches.** Selector switches shall be heavy-duty oiltight type with gloved-hand or wing lever operators. Position legends shall be engraved on switch faceplate. Switches for electric circuits shall have silver butting or sliding contacts, rated 10 amperes continuous at 120 volts ac. Contact configuration shall be as indicated on the Drawings or required for the application. Switches used in electronic signal circuits shall have contacts suitable for that duty. Switches shall be Micro Switch "Type PT", Cutler-Hammer "Type T", or General Electric "CR".

2-7.04. **Indicating Lights.** Indicating lights shall be heavy-duty, oiltight type, which utilize a low voltage lamp and a built-in transformer. Legends shall be engraved on the lens or on a legend faceplate. Lamps shall be easily replaceable from the front of the indicating light. Indicating lights shall be Micro Switch "Type PT", Cutler-Hammer "Type T", or General Electric "CR".

2-7.05. **Accessory Components.** All additional control components, such as electric relays, controllers, and position switches, shall be furnished as needed to ensure a complete, properly operating installation. Accessory components not mounted inside the control panel shall be furnished with equipment enclosures.

2-7.06. **Electrical Wiring.** Detailed wiring diagrams shall be submitted in accordance with the General Conditions. The wiring diagrams shall show the internal connections of the control panels and all field wiring to equipment remote from the control panels. The wiring diagrams shall be complete, showing all connections necessary to place the control systems in operation.

2-7.07. **Nameplates.** Phenolic nameplates shall be provided and permanently attached to the wall at each control device to indicate the equipment controlled.
The letters used shall be the same as the symbols indicated herein and on the Drawings for various equipment. Each nameplate shall have white letters on a black background.

2-8. ELECTRICAL. Motor starters and controls shall be furnished and installed under the General Electrical Requirements section, except where specified with prewired integral starters. Disconnects for equipment shall be furnished and installed under the General Electrical Requirements section, except where specified with integral disconnects. All electrical controls shall have enclosures suitable for the environment and NEMA rating as indicated on the electrical Drawings for wiring in conduit. Equipment installed outdoors shall have minimum NEMA Type 4 enclosures.

All electrical equipment located within 3 feet of the odor control system malodorous air stream, activated carbon unit, and other leakage sources such as piping, dampers, and fans shall be rated for a NEC Class 1, Division 2, Group D atmosphere in accordance with NFPA 820.

2-8.01. Electric Motors. Motor horsepower scheduled on the Drawings are minimum motor horsepower unless otherwise noted. Larger motors shall be provided if required to meet the specified capacities for the equipment furnished. Motors furnished with equipment shall meet the following requirements.

a. All motor shall be premium efficient motors with a minimum efficiency of at least that specified in the Induction Motors section.

b. Designed and applied in accordance with NEMA, ANSI, IEEE, AFBMA, and NEC for the duty service imposed by the driven equipment, such as frequent starting, intermittent overload, high inertia, mounting configuration, or service environment.

c. Rated for continuous duty at 40°C ambient.

d. Motors used in applications which exceed the usual service conditions as defined by NEMA, such as higher than 40°C ambient, altitude exceeding 3,300 feet, explosive or corrosive environments, departure from rated voltage and frequency, poor ventilation, frequent starting, or adjustable frequency drive applications, shall be properly selected with respect to their service conditions and shall not exceed specified temperature rise limits in accordance with ANSI/NEMA MG 1 for insulation class, service factor, and motor enclosure type.

e. To ensure long life, motors shall have nameplate horsepower equal or greater than the maximum load imposed by the driven equipment and shall carry a service factor rating as follows:

<table>
<thead>
<tr>
<th>Motor Size</th>
<th>Enclosure</th>
<th>Service Factor</th>
</tr>
</thead>
</table>

Activated Carbon Unit
11354-13
Activated Carbon Unit
11354-14

Fractional hp  Open  1.15
         Other Than Open  1.0
Integral hp  Open  1.15
         Other Than Open  1.0

Motors used with adjustable frequency drives shall have a 1.15 service factor on sine wave power and a 1.0 service factor on drive power.

f. Designed for full voltage starting.
g. Designed to operate from an electrical system that may have a maximum of 5 percent voltage distortion according to IEEE 519.

h. Totally enclosed motors shall have a continuous moisture drain that also excludes insects.
i. Bearings shall be either oil or grease lubricated.
j. Motor nameplates shall indicate as a minimum the manufacturer name and model number, motor horsepower, voltage, phase, frequency, speed, full load current, locked rotor current, frame size, service factor, power factor, and efficiency.
k. Dripproof motors, or totally enclosed motors at Contractor's option, shall be furnished on equipment in indoor, above-grade, clean, and dry locations.
l. Totally enclosed motors shall be furnished on:
   (1) Outdoor equipment.
   (2) Equipment for installation below grade.
   (3) Equipment operating in chemical feed and chemical handling locations.
   (4) Equipment operating in wet or dust-laden locations.
m. Explosion proof motors shall be provided where located within 3 feet of the odor control system malodorous air stream, activated carbon unit, and other leakage sources such as piping, dampers, and fans; and shall be rated for a NEC Class I, Group D, Division 2 atmosphere in accordance with NFPA 820.
n. Motors used with adjustable frequency drives shall have insulation system meeting the requirements of NEMA MG 1, Part 31.

2-8.02  Variable Frequency Drives.  Variable frequency drives shall be provided as indicated on the Drawings and shall be coordinated with the requirements of the associated equipment.
The equipment manufacturer shall be responsible for furnishing the adjustable frequency drive, for matching the motor and the drive, and for coordinating the collection of data and the design to limit harmonic. Refer to the Variable Frequency Drive section for additional requirements.

2-9. **BALANCE.** All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient course for rejection of the equipment. The mass of the unit and its distribution shall be such that the resonance at normal operating speeds is avoided. In any case, the maximum measured root-mean-square (rms) value as measured at any point on the equipment shall not exceed those listed in the latest ASHRAE Applications Handbook.

At any operating speed, the ratio of rotative speed to the critical speed of a unit or components thereof shall be less than 0.8 or more than 1.3.

2-10. **SEQUENCE OF OPERATIONS.** The sequence of operation for the odor control system shall be as indicated on Drawings.

**PART 3 - EXECUTION**

3-1. **INSPECTION.** All equipment and accessories shall be inspected for damage and cleanliness before being installed. Any material damaged or contaminated in handling on the job shall not be used unless it is repaired and recleaned to the original requirements by Contractor. Such material shall be segregated from the clean material and shall be inspected and approved by Owner or his representative before its use.

Where penetrations through existing concrete slabs are made, the Contractor shall locate and avoid damage to all rebar, embedded conduit, etc. when making new openings.

3-2. **PREPARATION.**

3-2.01. **Field Measurement.** Contractor shall be responsible for verifying all field dimensions, and for verifying location of all equipment, piping, and ductwork relative to any existing equipment, structural members, piping, ductwork, lighting, conduit, etc. to avoid conflicts with such items.

Equipment installed in facilities with limited access shall be suitable for being installed through available openings. Contractor shall field verify existing opening dimensions and other provisions for installation prior to submittal of bids.
3-2.02. Surface Preparation. All surfaces to be field painted shall be dry and free of dirt, dust, sand, grit, mud, oil, grease, rust, loose mill scale, or other objectionable substances, and shall meet the recommendations of the paint manufacturer for surface preparation. Cleaning and painting operations shall be performed in a manner which will protect freshly painted surfaces from dust or other contaminants. Oil and grease shall be completely removed by use of solvents or detergents before mechanical cleaning is started. The gloss of previously painted surfaces shall be dulled if necessary for proper adhesion of top coats. Surface finish damaged during installation shall be repaired to the satisfaction of Engineer. Field painting shall be as specified in the Paintings and Protective Coatings section.

3-3. INSTALLATION. Equipment and materials furnished under this section shall be installed in proper operating condition in full conformity with the Drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

When grouted bases are used, the space beneath baseplates shall be grouted as specified in the Grouting section.

Immediately after the activated carbon is installed, the odor control system shall be operated continuously for 7 days. The equipment exterior and the surrounding area shall be cleaned after the carbon installation, as needed to remove all carbon dust. The carbon level in the activated carbon unit shall be checked by the Contractor at the following intervals after start-up: 2 days, 7 days, and thirty days. If settling has occurred, additional carbon shall be loaded by the Contractor.

3-2.01. Differential Pressure Gauges. Differential pressure gauges shall be installed to allow gravity drainage of condensate in the sensing lines back to the pipe or vessel. Indicators mounted on towers shall be installed approximately 4'-6" above the surrounding floor or concrete slab.

3-4. FIELD QUALITY CONTROL.

3-4.01. Carbon Media Testing. A random sample of the carbon delivered to the site will be sent to an independent laboratory for testing. A sample of at least 8 ounces will be shipped in a non-porous container. H₂S capacity testing will be performed according to ASTM D6646. The testing shall be performed by Weck Laboratories, Inc, 14859 East Clark Avenue, City of Industry, CA, 91745-2139, Tel:(626) 336-2139, Fax:(626) 336-2634, E-mail: joe@wecklabs.com, Web site:www.wecklabs.com. All costs associated with the testing will be the responsibility of the Contractor. Should the carbon fail the initial testing, subsequent tests will be paid for by the carbon supplier.
3-4.02. **Performance Testing.** A performance test shall be conducted on the odor control equipment to demonstrate that the equipment meets the specified requirements, prior to final acceptance. The performance tests shall not begin until all airflow rates have been adjusted and balanced and a Testing and Balancing Report (performed in accordance with the Testing, Adjusting, and Balancing section) has been approved by the Engineer.

Contractor, with the aid of qualified equipment manufacturers' representatives, shall operate all systems for a minimum of 30 days acclimation period before performance tests are conducted, or until all systems are performing to the satisfaction of Engineer. Written documentation indicating the proper operation of all system components shall be provided to Engineer before the performance test will be allowed.

After completion of the 30-day acclimation period and trial operation, and prior to final acceptance, performance tests shall be conducted on each of the odor control systems to demonstrate that the equipment meets the specified requirements.

Personnel in charge of the tests shall be competent authorized representatives of the manufacturers who are familiar with operation of the equipment furnished and who have previous experience in conducting similar tests. Qualified personnel shall perform the tests, record the data, make the required calculations, and prepare a report on the results. Testing shall be performed in a manner acceptable to Engineer. At least four weeks prior to the proposed testing date, Contractor shall notify Engineer of the testing date and shall submit a report for Engineer's acceptance from the odor control system supplier detailing the proposed performance testing procedure and analyses. The proposed test procedure shall be approved by Engineer before testing may proceed.

Contractor shall provide all necessary personnel, materials and equipment for the tests. Prior to the start of the test, Contractor shall operate the system until the stable operating parameters and controls are established. All fine-tuning of operating conditions shall be performed prior to testing.

The performance tests shall be conducted after installation and initial startup, and after testing and balancing has been completed. The performance test will be conducted under actual loading conditions for each of the systems. Continuous data logging meters (OdaLog meters or similar) will be used to record inlet and outlet H2S for a period of one week. Two meters are required, with the outlet meter having a sensitivity of 0.01 ppm H2S or less. Logging monitors shall be programmed with a maximum sampling interval of 1 minute.

As a minimum, at the start and conclusion of each test, Contractor shall monitor the airflow and pressure.
Activated Carbon Unit
11354-18

The performance tests shall establish that H₂S removal performance meets the requirements specified herein. Required H₂S removal shall be maintained under the variable loading conditions that occur over the week-long test.

Results of the performance tests shall be provided to Engineer in a written report. The report shall include the raw test data and a graphical plot for each of the tests showing inlet and outlet H₂S. The graph shall also show H₂S removal efficiency over the duration of each test. The report shall also include operating data including airflow and pressure for each system tested.

Five copies of the report shall be submitted to Engineer. The information collected will be used as a basis for determining acceptability of the manufacturer's results. In the case of a conflict, interpretations and calculations made by Engineer will govern.

If inspection or tests indicate defects, the defective work or material shall be replaced, and inspection and tests repeated. All repairs to piping shall be made with new materials. Caulking of threaded joints or holes will not be acceptable.

If the equipment fails to meet the performance requirements, operational adjustments to the system and repeat testing may be allowed at the discretion of the Engineer. Subsequent failure of the equipment to meet the performance and design requirements specified will require equipment modifications to be made by, and at the expense of Contractor. Costs of additional testing and subsequent observation by Engineer will be borne entirely by Contractor.

3-4.03. **Applied Pipe Stress Test.** After final alignment and bolting, all flanged connections shall be tested for applied piping stresses by loosening the flange bolts. No stresses shall be transmitted to the activated carbon unit flanges. If any movement or opening of the joints is observed, piping shall be adjusted to proper fit.

3-4.04. **Installation Check.** An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with the Commissioning section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Engineer.

The manufacturer's representative shall furnish a written report certifying that the equipment has been properly installed and lubricated; is in accurate alignment; is free from any undue stress imposed by connecting piping or anchor bolts; and has been operated under full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the Contract Price.
3-5. **ADJUSTING.** Contractor shall make all adjustments to the adsorption system as directed by the equipment manufacturer.

3-5.01. **Applied Pipe Stress Test.** After final alignment and bolting, all flanged connections shall be tested for applied piping stresses by loosening the flange bolts. No stresses shall be transmitted to the scrubber flanges. If any movement or opening of the joints is observed, piping shall be adjusted to proper fit.

3-5.02. **System Balancing.** Testing and balancing for the odor control systems shall conform to the requirements of the Testing, Adjusting, and Balancing section.

3-6. **CLEANING.** At the completion of testing, all equipment, pipes, ductwork, valves, and fittings shall be cleaned of grease, debris, metal cuttings, and sludge. Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired at no additional cost to Owner.

The inside of all pipe, dampers, and fittings shall be smooth, clean, and free from blisters, sand or dirt when erected. All lines shall be thoroughly air purged before placing in service.

3-6.01. **Fabricated Piping Assemblies.** Fabricated piping assemblies shall be cleaned to remove all loose foreign materials such as scale, sand, weld splatter particles, or cutting chips by hand or mechanical cleaning.

3-6.02. **Installed Piping.** All installed piping shall be cleaned and free from debris and any loose foreign materials, as may be introduced during field installation. Installed piping shall be cleaned by hand or by flushing.

3-7. **TRAINING.** After completion of the field testing, operator instruction and training on equipment and system operation shall be provided by Factory-trained service personnel. The training should provide a complete overview of all equipment, testing, adjusting, operation, and maintenance procedures that include complete system operation (including the activated carbon unit, odor control fans, and demister). The training shall take the form of classroom instruction and shall cover:

a. Documentation in the final Operation and Maintenance Manuals.

b. Use the Operation and Maintenance Manuals.

c. Equipment and system startup and shutdown.

d. System operation procedures for all modes of operation.

e. Procedures for dealing with abnormal conditions and emergency situations for which there is a specified system response.
The training shall take the form of classroom sessions at the project site conducted by the equipment manufacturer representatives who are knowledgeable and familiar with the project. Hands-on instruction and training will be conducted so that actual operation and maintenance of the equipment and systems can be performed by Owner upon completion of the training.

At least two weeks prior to the proposed date for the operator instruction and training session, Contractor shall notify Engineer and shall submit an outline for the proposed operator instruction and training session. The proposed outline shall be approved before any training is conducted.

END OF SECTION
PART 1 - GENERAL

1-1. **SCOPE.** This section covers the furnishing and installation of centrifugal fans complete with electric drive motor, base, and accessories as specified herein.

Piping, pipe supports, valves, and accessories which are not an integral part of the equipment or are not specified herein are covered in other sections.

1-2. **GENERAL.** Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by Engineer.

1-2.01. **Coordination.** Equipment furnished under this section shall be coordinated with other components of the applicable odor control system.

Where two or more units of the same class of equipment are required, they shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

Each manufacturer of major equipment shall have a local service center, or with written consent of Engineer, shall be able to provide service from other locations within 24 hours. The service center shall be equipped and staffed to service the system and shall maintain a local parts supply. Information on equipment manufacturers' representatives shall be included with the submittals.

Where several manufacturers' names have been listed in this section as possible suppliers, only the products of the first manufacturer listed have been checked for size, functions, and features.

1-2.02. **General Equipment Stipulations.** The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. **Seismic Design Requirements.** Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.
1-2.04. **Governing Standards.** Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between this section and any state law or local ordinance, the latter shall govern.

All work shall comply with Underwriters' Laboratories (UL) safety requirements.

1-2.05. **Power Supply.** Power supply to equipment with motors shall be as indicated in the schedules on the Drawings. Power supply for controls shall be 120 volts, 60 Hz, single phase unless otherwise required for a properly operating system.

1-2.06. **Metal Thickness.** Metal thickness and gages specified herein are minimum requirements. Gages refer to US Standard gage.

1-3. **MECHANICAL IDENTIFICATION.** Not used.

1-4. **SUBMITTALS.**

1-4.01. **Drawings and Data.** Complete assembly and installation drawings, and wiring and schematic diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the General Conditions, Section F-29 Equipment and Material Items. Device tag numbers indicated on the Drawings shall be referenced on the wiring and schematic diagrams where applicable. The data and specifications for each unit shall include, but shall not be limited to, the following:

**Fans**
- Name of manufacturer.
- Type and model.
- Rotative speed.
- Bearing type and lubrication.
- Connection sizes.
- Net weight.
- Overall dimensions.
- Anchor bolt details.
- Performance curves for each fan with capacity in cubic feet per minute as the abscissa, and brake horsepower, static pressure, and fan efficiency as the ordinate.
- Sound power output data for the fan housing and ducted outlet when operating at the specified volume flow rate. Sound data shall list dB re 10^{-12} watts in each octave band, with midrange frequencies starting at 63 Hz and ending at 8,000 Hz; and dBA at 5 feet.
Motors
As specified in the Induction Motors section.

Transition Pieces
Name of manufacturer.
Materials of construction.
Pressure and vacuum rating.
Dimensions.

Acoustical Enclosures
Name of manufacturer.
Materials of construction.
Dimensions.
Accessories.
Location of louvers.

Seismic Design Requirements
Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-4.02. Operation and Maintenance Data and Manuals. Adequate operation and maintenance information shall be supplied as required in the General Conditions. Operation and maintenance manuals shall be submitted in accordance with the General Conditions. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-4.03. Color Selection. Colors for factory finish of the odor control fans and enclosures shall be selected by Owner from the manufacturer's full range of standard and custom colors. Samples shall be submitted for color selection in accordance with the General Conditions. Color of all exposed odor control system components shall match, including activated carbon unit, demister, FRP piping, odor control fans, fan enclosures, dampers, and actuators. Future exposed odor control components, including biotrickling filter vessel, degreaser, guardrail, and ladders shall match the color of the installed system components.

1-5. QUALITY ASSURANCE.

1-5.01. Welding Qualifications. All welding procedures and welding operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of AWS Standard Qualification Procedures. All procedure and operator qualifications shall be in written form and subject to Engineer's review. Accurate records of operator and procedure qualifications shall be maintained by Contractor and made available to Engineer upon request.
Odor Control Fans
11356-4

1-5.02. **Manufacturer Experience.** Manufacturer shall be as named herein.

1-5.03. **Fan Performance.** Each fan shall bear the AMCA 211 Certified Rating Seal for fan performance.

1-5.04. **Fan Sound Rating.** Each fan shall bear the AMCA 311 Certified Sound Rating Seal for fan sound performance.

1-6. **DELIVERY, STORAGE, AND HANDLING.** Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

1-7. **EXTRA MATERIALS.** Extra materials shall be furnished for the equipment as follows:

<table>
<thead>
<tr>
<th>Extra Materials</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan V-belts</td>
<td>1</td>
</tr>
<tr>
<td>Fan bearing assembly</td>
<td>1</td>
</tr>
<tr>
<td>Fan shaft seal assembly</td>
<td>1</td>
</tr>
</tbody>
</table>

Extra materials shall be packaged in accordance with the Product Delivery Requirements section, with labels indicating the contents of each package. Each label shall indicate manufacturer's name, equipment name, part nomenclature, part number, address of nearest distributor, and current list price. Extra materials shall be delivered to Owner as directed.

Extra materials subject to deterioration such as ferrous metal items and electrical components shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping.

**PART 2 - PRODUCTS**

2-1. **SERVICE CONDITIONS.** Odor control fans shall be designed to operate at the elevation and seismic conditions indicated in the Meteorological and Seismic Design Criteria section. All equipment furnished for sites above 2000 feet above sea level shall be properly derated to operate and meet the specified capacities at the site conditions. The fans shall be suitable for the following service conditions and designed for continuous 24 hours per day operation:

- Ambient temperature range. 20 to 130 °F
- Environmental exposure. Outdoor
2-2. PERFORMANCE AND DESIGN REQUIREMENTS. All fan components of plastic construction shall contain ultraviolet inhibitors. Each fan shall be designed for the conditions indicated herein and in the schedules on the Drawings.

Each fan's operating selection point on the fan curves shall be selected to the right of the peak pressure/efficiency point and below the lowest point along the fan curve to the left of the peak pressure/efficiency point.

Each fan shall be designed for the following conditions:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Winchester Lift Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Fans</td>
<td>2</td>
</tr>
<tr>
<td>Design Sewer Air Flow (scfm)</td>
<td>3,630</td>
</tr>
<tr>
<td>Static Pressure (in WC)</td>
<td>15.5</td>
</tr>
<tr>
<td>Max Motor Power (HP)</td>
<td>15</td>
</tr>
<tr>
<td>Max Speed (RPM)</td>
<td>3,600</td>
</tr>
</tbody>
</table>

NOTES:
1 Standard conditions are one atm and 70°F per ASHRAE.
2 Static pressure is from the wet wells to the carbon exhaust stack and includes the future degreaser and biotrickling filter with associated fittings and appurtenances. Static pressure for the carbon only configuration is 11.5 in wc. Variable frequency drives will be utilized to reduce the fan speed for this operation.
3 Fan motors shall be 480V/3phase/60Hz.
4 Fans shall be suitable for use with a variable frequency drive.

2-2.01. Dimensional Restrictions. Layout dimensions will vary between manufacturers and the layout area indicated on the Drawings is based on typical values. Contractor shall review the contract Drawings, the manufacturer’s layout drawings, and installation requirements and shall make any modifications required for proper installation subject to acceptance by Engineer. At least 3 feet of clear access space shall be provided on all sides of the unit unless otherwise indicated.

2-2.02. Elevation. Equipment shall be designed to operate at the elevation indicated in the Meteorological and Seismic Design Criteria section. All equipment furnished for sites above 2000 feet above sea level shall be properly derated to operate and meet the specified capacities at the site conditions.

2-3. ACCEPTABLE MANUFACTURERS. The fan manufacturer shall be licensed to display the logo of an AMCA member company. Fans of FRP construction shall be as manufactured by New York Blower, Duall, or Hartzell.
2-4. MANUFACTURE AND FABRICATION.

2-4.01. Surface Preparation. All iron and steel surfaces, except motors and speed reducers, shall be shop cleaned by sandblasting or equivalent, in strict conformance with the paint manufacturer’s recommendations. All mill scale, rust, and contaminants shall be removed before shop primer is applied.

2-4.02. Unitary Base. Each fan, inlet elbow, and drive shall be mounted on a common unitary base provided by the fan manufacturer. The base shall have rounded corners, and all exposed seams and contact surfaces of steel plates and shapes shall be continuously welded and ground smooth. Each base shall be arranged to permit drive belt tension adjustment. An opening shall also be provided, if necessary, for electrical conduit to the drive unit.

2-4.03. Fan Construction. The fans shall be single-width, single-inlet type with backward inclined blade construction. Each fan shall be designed for the rotation and discharge direction indicated on the Drawings.

Fiberglass reinforced plastic (FRP) fans shall have housings and fan wheel constructed of FRP. The fan housing and wheel shall be made of chemical grade vinyl ester resin. Except as modified or supplemented herein, the fan shall comply with the applicable provisions of ASTM D4167. The fan shall be suitable for operation with temperatures up to 150°F without derating the safe operating speed of the fan. The entire housing and airstream surfaces shall be graphite impregnated and grounded to prohibit static buildup. The fan shall have an ASTM E-84 Class I flame spread rating. Fan housings and supports shall contain an ultraviolet inhibitor or coating. Lift and hold-down lugs shall be integrally molded into the fabrications. Housings shall have a plugged drain connection at the low point of the scroll and a gasketed access door. The fan shaft shall be completely encapsulated in an FRP sleeve where exposed to the airstream. A Viton shaft seal shall be furnished. All hardware exposed to the airstream shall be 316 stainless steel, embedded in FRP.

The supporting frame shall be of welded carbon steel or fiberglass reinforced plastic construction. All exterior and exposed metal surfaces of the support frames shall be sandblasted, primed, and shop coated with epoxy to a minimum dry film thickness of 10 mils.

Bearings shall be self-aligning, antifriction type with external grease fittings and shall have an AFBMA L₁₀ Life Rating of 100,000 hours at specified operating conditions.

Each fan wheel and shaft shall be statically and dynamically balanced at the factory before shipment.
The first critical speed of the rotating assembly shall be not less than 125 percent of the maximum recommended operating speed. Each fan shall be provided with shaft seals.

The fan inlet shall be straight or flanged. The fan outlet shall be flanged. Flanges shall be the fan manufacturer's standard dimensions and drilling.

2-4.04. Transitions. Refer to Section 15066 for transition requirements.

2-4.05. Weather Cover. Not used.

2-4.06. Vibration Isolators. Not used.

2-4.07. Pressure Differential Switches. Pressure differential switches shall be provided for each fan. Pressure differential switches shall have an operating range selected so the setpoint is between 25 and 75 percent of the scale range. Setpoints shall be set at 50 percent of the fan static pressure rating indicated in the schedules on the Drawings. The switches shall be diaphragm type, operated by differential air pressure. The switches shall be single pole, double throw, and shall be rated 5 amperes at 120 volts ac and a temperature range of -20°F to 125°F. The switches shall be provided with corrosion resistant mounting brackets. Pressure differential airflow switches shall be provided with weather resistant housings and shall be Dwyer Instruments "Series 1800".

2-4.08. Vibration Switches. Each fan shall be furnished with a vibration switch mounted on the fan assembly to initiate an alarm in the event of excessive vibration. Each vibration switch shall utilize solid state circuitry which trips the output alarm contact over an adjustable displacement velocity range of 0.15 to 1.5 inches per second. Vibration switches shall be set to alarm at a level recommended by the fan manufacturer. Each switch shall have a built-in adjustable time delay override feature for startup, shutdown, and short-time transient conditions. Each output alarm contact shall be normally open, closing to indicate alarm, rated 5 amperes at 120 volts ac. Upon alarm activation, the switch shall be held in the alarm position until a remote push-button contact is opened to initiate reset. Vibration switch shall be provided with weather resistant housings and shall be Rochester Instruments Systems PMC/Beta "Model 440S", Vibra-Tect Model VT1215, or equal.

2-4.09. Differential Pressure Gauges. Differential pressure gauges shall be furnished for monitoring the pressure differential across each fan. The gauges shall be permanently mounted and shall be furnished with a mounting bracket, tubing, and all required fittings. Unless otherwise indicated, the installation hardware shall be Type 316L stainless steel. Tubing shall be 1/2 inch PVC pipe, unless otherwise indicated, properly supported and braced for a permanent installation.
Each gauge shall be of the diaphragm actuated dial type with adjustable pointer, white dial and black figures and markings. Each gauge shall have a range such that under normal operating conditions, the reading is approximately in the middle of the range. Accuracy shall be within 3 percent of full scale. Two shutoff cocks shall be furnished with each gauge.

Condensate drip tubing shall be provided on the high and low pressure lines to each gauge. The condensate drip lines shall extend a minimum 4 inches below the bottom elevation of the gauge and terminate with shutoff valves.

The gauges shall be furnished with a transparent red overlay extending from the maximum allowable differential pressure reading to the end of the range.

Differential pressure gauges shall be Dwyer "Series 4000 Capsuhelic" with diaphragm seal made from a material suitable for exposure to a dry hydrogen sulfide air stream.

2-4.10. Fan Inlet Boxes. Not used.

2-4.11. Acoustical Enclosures. Acoustical enclosures shall be provided by the fan manufacturer where indicated on the Drawings. Acoustical enclosures shall be made of all fiberglass reinforced plastic construction with acoustical treatments. Enclosures shall come with access doors, explosion-proof ventilation fan and louvers sized for adequate cooling of the enclosed fan and motor. Louvers shall be provided on opposite corners on back of enclosure near fan motor. Enclosure submittal shall include location of louvers for Engineer review prior to approval.

Enclosures shall provide full access to all fan components. Enclosures shall come with factory applied, gel coat, ultraviolet resistant finish coat. Enclosures shall reduce sound pressure levels a minimum of 10 dBA at a distance of three feet. All fastening and mounting hardware shall be stainless steel. Acoustic enclosures shall be as manufactured by Soundguard or equal.

2-4.12. Flexible Connections. Flexible connections in odor control gas piping shall be installed at the locations indicated on the Drawings and at other locations for proper installation as determined by the odor control systems supplier.

Flexible connections shall be fully molded type rated for a minimum 3 psi working pressure and shall consist of an inner tube, body, and outer cover to be compatible with the specified service conditions. The tube shall be a minimum of 1/4 inch thick EPDM with two ply of high tensile nylon, polyester, or kevlar fabric reinforcement. The cover shall be a minimum 1/16-inch elastomer and shall be resistant to ultraviolet light.
Odor Control Fans
11356-9

Slip on type flexible connections shall fit tightly on the outside diameter of the piping and shall be secured in place by stainless steel adjustable bands with 316L stainless steel worm screw type adjustments to provide a gastight connection.

Flanged type flexible connections shall have split stainless steel retaining rings and shall have ASTM D3982 diameter and drilling. Flexible connections shall be Red Valve "Duct Expansion Joints", Mercer Rubber Company, or Holz Rubber Company.

2-5. ELECTRICAL. Adjustable frequency drives and controls shall be furnished and installed under the General Electrical Requirements section, except where specified with prewired integral starters. Disconnects for equipment shall be furnished and installed under the General Electrical Requirements section, except where specified with integral disconnects. All electrical controls shall have enclosures suitable for the environment and NEMA rating as indicated on the electrical Drawings for wiring in conduit. Equipment installed outdoors shall have NEMA Type 4 enclosures. Prewired electric motors installed in packaged equipment are not required to have clamp type grounding terminals in the conduit box or oversized conduit boxes.

2-6. DRIVE UNITS.

2-6.01. Adjustable Frequency Drives. Adjustable frequency drives shall be provided and shall be coordinated with the requirements of the associated equipment. The equipment manufacturer shall be responsible for furnishing the adjustable frequency drive, for matching the motor and the drive, and for coordinating the collection of data and the design to limit harmonics to the levels specified.

Adjustable frequency drives shall be as covered in the Variable Frequency Drives section.

2-6.02. V-Belt Drives. Each V-belt drive shall include a sliding base or other suitable belt tension adjustment. V-belt drives shall have a service factor of at least 1.5 at maximum speed based on the nameplate horsepower of the drive motor. Multiple belts shall be provided in matched sets and shall be oil resistant, non-static type. External belts and drive assemblies shall be protected by a belt safety guard constructed in accordance with OSHA requirements. The guard shall be provided with a tachometer opening.

Unless otherwise indicated in the specific equipment paragraph, equipment with smaller than 10 horsepower motors shall have adjustable pitch sheaves and equipment with 10 horsepower and larger motors shall have fixed sheaves. Adjustable sheaves shall be selected so that the fan speed at the specified conditions is selected at the mid-position of the sheave range. Fixed sheaves shall be replaced as necessary with sheaves of the proper size during the air system balancing to provide the required speed for the specified airflow.
2-6.03. **Electric Motors.** The electric motors shall be designed as specified in Induction Motors section.

Motor horsepower scheduled on the Drawings are minimum motor horsepower unless otherwise noted. Larger motors shall be provided if required to meet the specified capacities for the equipment furnished. Motors shall be rated for installation in a NEC Class 1, Division 2, Group D environment.

2-7. **BALANCE.** All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient course for rejection of the equipment. The mass of the unit and its distribution shall be such that the resonance at normal operating speeds is avoided. In any case, the maximum measured root-mean-square (rms) value as measured at any point on the equipment shall not exceed those listed in the latest ASHRAE Applications Handbook.

At any operating speed, the ratio of rotative speed to the critical speed of a unit or components thereof shall be less than 0.8 or more than 1.3.

**PART 3 - EXECUTION**

3-1. **INSPECTION.** For new work at existing facilities, Contractor shall field verify the locations of existing piping, structural members, ductwork, equipment, lighting, conduit, etc., and locate all new piping, ductwork, and equipment to avoid conflicts with such items. Equipment installed in existing facilities with limited access shall be suitable for being installed through available openings. Contractor shall field verify existing opening dimensions and other provisions for installation prior to submittal of bids.

3-2. **INSTALLATION.** Each fan shall be leveled, aligned, and positioned to fit connecting piping. Installation procedures for fans and accessories shall be as recommended by the equipment manufacturers. Prior to being placed in operation, each fan shall be inspected by a representative of the manufacturer.

3-3. **INSTALLATION CHECK.** An experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, and approve the equipment installation. The representative shall be present when the equipment is placed in operation in accordance with the Commissioning section, and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of Engineer.
The manufacturer's representative shall furnish a written report certifying that the equipment has been properly installed and lubricated; is in accurate alignment; is free from any undue stress imposed by connecting piping or anchor bolts; and has been operated under full load conditions and that it operated satisfactorily.

All costs for these services shall be included in the Contract Price.

3-4. **FIELD TESTING.** After the installation of the equipment and systems has been completed, tests shall be conducted to demonstrate that each system is functioning as specified and to the satisfaction of Engineer.

If inspection or tests indicate defects, the defective work or material shall be replaced, and inspection and tests repeated. All repairs to piping shall be made with new materials. Caulking of threaded joints or holes will not be acceptable.

3-5. **CLEANING.** At the completion of testing, all equipment, pipes, ductwork, valves, and fittings shall be cleaned of grease, debris, metal cuttings, and sludge. Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired at no additional cost to Owner.

**END OF SECTION**
SECTION 11357
ODOR CONTROL DAMPERS

PART 1 - GENERAL

1-1. **SCOPE.** This section covers the furnishing and installation of air dampers for odor control systems.

Piping, pipe supports, valves, and accessories which are not an integral part of the equipment or are not specified herein are covered in other sections.

1-2. **GENERAL.** Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by Engineer.

1-2.01. **Coordination.** Equipment furnished under this section shall be coordinated with other components of the applicable odor control system.

Where two or more units of the same class of equipment are required, they shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

1-2.02. **General Equipment Stipulations.** The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. **Governing Standards.** Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between this section and any state law or local ordinance, the latter shall govern.

All work shall comply with Underwriters' Laboratories (UL) safety requirements.

1-2.04. **Metal Thickness.** Metal thickness and gages specified herein are minimum requirements. Gages refer to US Standard gage.

1-2.05. **Mechanical Identification.** Not used.
1-4. SUBMITTALS.

1-4.01. Drawings and Data. Complete fabrication, assembly, and installation drawings, wiring and schematic diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the General Conditions, Section F-29 Equipment and Material Items. Device tag numbers indicated on the Drawings shall be referenced on the wiring and schematic diagrams where applicable. The data and specifications for each unit shall include, but shall not be limited to, the following:

- Odor Control Dampers
  - Name of manufacturer.
  - Type and model.
  - Materials of construction.
  - Pressure rating.
  - Vacuum rating.
  - Leakage and performance data.
  - Overall dimensions.
  - Flange dimensions and drilling.
  - Total weight, including actuator.
  - Required operating and break away torque.

1-4.02. Operation and Maintenance Data and Manuals. Operation and maintenance information shall be submitted in accordance with the General Conditions. Equipment designations used shall correspond to those indicated on the Drawings. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1-5. QUALITY ASSURANCE.

1-5.01. Manufacturer Experience. Unless specifically named in the Specifications, a manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than the past 5 years, and shall provide a reference list with the names, addresses, and contact phone numbers for a minimum of 20 similar installations.

1-6. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.
1-7. **EXTRA MATERIALS.** The following extra materials shall be furnished:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat flange gaskets</td>
<td>2 each</td>
</tr>
<tr>
<td>Shaft seals</td>
<td>2 each</td>
</tr>
<tr>
<td>Blade seal</td>
<td>2 each</td>
</tr>
</tbody>
</table>

Extra materials shall be packaged in accordance with the Product Delivery Requirements section requirements, with labels indicating the contents of each package. Each label shall indicate manufacturer’s name, equipment name, part nomenclature, part number, address of nearest distributor, and current list price. Extra materials shall be delivered to Owner as directed.

Extra materials subject to deterioration such as ferrous metal items and electrical components shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping.

**PART 2 - PRODUCTS**

2-1. **PERFORMANCE AND DESIGN REQUIREMENTS.** All equipment shall be designed and selected to meet the specified conditions.

The dampers will be used in malodorous air fully saturated with water vapor and will contain hydrogen sulfide. All equipment and components of plastic construction shall contain ultraviolet inhibitors.

2-1.01. **Dimensional Restrictions.** Layout dimensions will vary between manufacturers and the layout area indicated on the Drawings is based on typical values. Contractor shall review the contract Drawings, the manufacturer’s layout drawings, and installation requirements and shall make any modifications required for proper installation subject to acceptance by Engineer.

2-2. **ACCEPTABLE MANUFACTURERS.** Acceptable manufacturers shall be as listed in the respective product description paragraphs.

2-3. **MANUFACTURE AND FABRICATION.**

2-3.01. **Odor Control Dampers.** Dampers shall be of the single blade type complete with channel type frame, close fitting blade, full length axle, and bearings. Each damper shall have the same inside dimensions as the connecting piping. Axles shall be continuous through the damper.
Dampers used for shutoff and isolation shall be furnished with a blade seal and shaft seal. Shutoff and isolation dampers shall bear the AMCA seal and shall have a maximum air leakage rate of 3 cfm per square foot at a pressure or vacuum of 10 inches of water column. Dampers used for balancing shall be furnished with a blade stop and shaft seal.

Dampers shall be Swartwout "914", Belco Model 203, or DanELAST Zero Leakage Damper Model 303.

2-3.02. Backdraft Dampers. Backdraft dampers shall be constructed of fiberglass reinforced plastic with vinyl ester resin. All linkage, counter balance assemblies, and accessories shall be Type 316 stainless steel.

2-3.02.01 Rectangular Backdraft Dampers. Not used.

2-3.02.02. Round Backdraft Dampers. Not used. The damper frames shall be constructed with a minimum face-to-face dimension of 12 inches and the same inside dimensions as the connecting piping. Axles shall be continuous through the damper. Flanges for air connections shall comply with ASTM D 3982. Dampers shall be furnished with an adjustable counterbalance assembly and shall be suitable for horizontal or vertical installation as indicated on the Drawings. Round backdraft dampers shall have blade stops, shaft seals, and shall be Swartwout, Belco, or Viron.

2-3.03. Actuators and Accessories. Damper actuators and accessories shall be furnished and installed as indicated. All required linkages and accessories required for a complete installation shall be furnished. Actuators shall be installed in the orientation shown on the Contract Drawings.

2-3.03.01. Hand Actuators. Each damper shall be provided with a handwheel with worm gear operator or lever operator. Each hand, crank lever actuator shall be all Type 316 stainless steel construction and shall have a locking quadrant suitable for positioning the blade at the fully open, the fully closed or any intermediate position. Dampers 24 inches and larger shall be provided with epoxy coated worm gear operator with hand crank. Cast arrow and legend indicating direction to rotate operator for opening shall be provided in prominent place.
2-3.03.02. **Chainwheel Actuators.** Not used.

2-3.03.03. **Electric Actuators.** Not used.

### PART 3 - EXECUTION

3-1. **INSPECTION.** All equipment and accessories shall be inspected for damage and cleanliness before being installed. Any material damaged or contaminated in handling on the job shall not be used unless it is repaired and recleaned to the original requirements by Contractor. Such material shall be segregated from the clean material and shall be inspected and approved by Owner or his representative before its use.

3-2. **PREPARATION.** For new work at existing facilities, Contractor shall be responsible for verifying all field dimensions and for verifying location of all equipment, piping, and ductwork relative to any existing equipment, structural members, piping, ductwork, lighting, conduit, etc. to avoid conflicts with such items.

Equipment installed in facilities with limited access shall be suitable for being installed through available openings. Contractor shall field verify existing opening dimensions and other provisions for installation prior to submittal of bids.

3-3. **INSTALLATION.** The dampers shall be positioned to fit in the connecting piping. Unless otherwise necessary for proper operation of the damper, the axles shall be installed in the horizontal position. The inside of the dampers shall be smooth, clean, and free from blisters and dirt when installed.

3-4. **FIELD QUALITY CONTROL.**

3-4.01. **Field Testing.** After the installation of the equipment and systems has been completed, tests shall be conducted to demonstrate that each system is functioning as specified and to the satisfaction of Engineer.

If inspection or tests indicate defects, the defective work or material shall be replaced, and inspection and tests repeated. All repairs to piping shall be made with new materials. Caulking of threaded joints or holes will not be acceptable.

3-5. **CLEANING.** At the completion of testing, all equipment, pipes, ductwork, valves, and fittings shall be cleaned of grease, debris, metal cuttings, and sludge. Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired at no additional cost to Owner.

**END OF SECTION**
Odor Control Dampers
11357-6

[PAGE INTENTIONALLY LEFT BLANK]
PART 1 - GENERAL

1-1. SCOPE. This section covers the installation of piping and accessories as indicated on the Drawings for the following piping sections:

   Section Title
   Miscellaneous Plastic Pipe, Tubing, and Accessories
   Plastic (PVC) Pressure Water Pipe & Fittings

Contractor shall furnish all necessary jointing materials, coatings, and accessories that are specified herein.

Pipe supports and anchors shall be furnished by Contractor, and are covered in the Pipe Supports section. Pipe trenching and backfilling are covered in the Trenching and Backfilling section.

1-2. GENERAL.

1-2.01. Coordination. Materials installed under this section shall be installed in full conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the manufacturer, unless exceptions are noted by Engineer.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete specifications, data, and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Items requiring submittals shall include, but not be limited to, the following:

   Materials as specified herein.


1-3.03. Spool Drawings. Not Used.

1-4. QUALITY ASSURANCE.

1-4.01. Welding and Brazing Qualifications. Not Used.
1-4.02. **Tolerances.** These tolerances apply to in-line items and connections for other lines.

The general dimension, such as face-to-face, face or end-to-end, face- or end-to center, and center-to-center shall be 1/8 inch.

The inclination of flange face from true in any direction shall not exceed 3/64 inch per foot.

Rotation of flange bolt holes shall not exceed 1/16 inch.

1-5. **DELIVERY, STORAGE, AND HANDLING.** Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

Plastic pipe, tubing, and fittings shall be stored between 40°F and 90°F.

1-5.01. **Coated Pipe.** Handling methods and equipment used shall prevent damage to the protective coating and shall include the use of end hooks, padded calipers, and nylon or similar fabric slings with spreader bars. Bare cables, chains, or metal bars shall not be used. Coated pipe shall be stored off the ground on wide, padded skids. Plastic-coated pipe shall be covered or otherwise protected from exposure to sunlight.

**PART 2 - PRODUCTS**

2-1. **SERVICE CONDITIONS.** Pipe, tubing, and fittings covered herein shall be installed in the services indicated in the various pipe sections.

2-2. **MATERIALS.**

<table>
<thead>
<tr>
<th>Threaded Fittings</th>
<th>Anti-Seize Thread Lubricant</th>
<th>Jet-Lube &quot;Nikal&quot;, John Crane &quot;Thred Gard Nickel&quot;, Never-Seez &quot;Pure Nickel Special&quot;, or Permatex &quot;Nickel Anti-Seize&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teflon Thread Sealer</td>
<td>Paste type; Hercules &quot;Real-tuff&quot;, John Crane &quot;JC-30&quot;, or Permatex &quot;Thread Sealant with Teflon&quot;.</td>
<td></td>
</tr>
<tr>
<td>Teflon Thread Tape</td>
<td>Hercules &quot;Tape Dope&quot; or John Crane &quot;Thread-Tape&quot;.</td>
<td></td>
</tr>
</tbody>
</table>
Solvent Welded Fittings

Solvent cement for PVC Systems
ASTM D2564.

Solvent cement for CPVC Systems
ASTM F493.

Sodium Hypochlorite, Sodium Hydroxide, and Sodium Bisulfite Service
IPS Corporation "Weld-On 724".

Primer for PVC Systems
ASTM F656.

Solder or Brazed Fittings

Solder
Solid wire, ASTM B32, ANSI/NSF 61 certified, Alloy Grade Sb5, (95-5).

Soldering Flux
Paste type, ASTM B813.

Brazing Filler Metal
AWS A5.8, BCuP-5; Engelhard "Silvaloy 15", Goldsmith "GB-15", or Handy & Harman "Sil-Fos".

Brazing Flux
Paste type, Fed Spec O-F-499, Type B.

Insulating Fittings

Threaded
Dielectric steel pipe nipple, ASTM A53, Schedule 40, polypropylene lined, zinc plated; Perfection Corp. "Clearflow Fittings".

Flanged
Epco "Dielectric Flange Unions" or Central Plastics "Insulating Flange Unions".

Pipe Insulation
See Mechanical Insulation section.

Watertight/Dusttight Pipe Sleeves
O-Z Electrical Manufacturing "Thruwall" and "Floor Seals", or Thunderline "Link-Seals"; with modular rubber sealing elements, nonmetallic pressure plates, and galvanized bolts.

Pipe Sleeve Sealant
Polysulfide or urethane, as specified in the Caulking section or as indicated on the Drawings.

Protective Coatings
Miscellaneous Piping and Accessories Installation
15020-4

Tape Wrap
ANSI/AWWA C209, except single ply tape thickness shall not be less than 30 mils; Protecto Wrap "200" or Tapecoat "CT".

Primer
As recommended by the tape manufacturer.

Coal Tar Epoxy
High-build coal tar epoxy; PPG Amercoat "Amercoat 78HB Coal Tar Epoxy", Carboline "Bitumastic 300 M", Tnemec "46H-413 Hi-Build Tneme-Tar", or Sherwin-Williams "Hi-Mil Sher-Tar Epoxy".

Epoxy for aeration and process air piping
Shop or field applied high solids epoxy; suitable for protection at continuous pipe wall temperatures up to 300 F. Coating shall be abrasion resistant. The finished coating shall have a minimum total film thickness of 10 mils. The surface shall be prepared in accordance with SSPC-SP7 as a minimum unless otherwise recommended by the coating manufacturer. The coating shall be Carboline “Thermaline 450”, PPG Amercoat “Amerlock 400 with Amercoat 880 Additive”, or approved equal.

Chlorine Tank Car Unloading Connection
Special flanged hose assembly conforming to materials and details on Drawing No. 135, The Chlorine Institute, Inc.

PART 3 - EXECUTION

3-1. **INSPECTION.** All piping components shall be inspected for damage and cleanliness before being installed. Any material damaged or contaminated in handling on the job shall not be used unless it is repaired and recleaned to the original requirements by Contractor. Such material shall be segregated from the clean material and shall be inspected and approved by Owner or his representative before its use.

3-2. **PREPARATION.**

3-2.01. **Field Measurement.** Pipe shall be cut to measurements taken at the site, not from the Drawings. All necessary provisions shall be made in laying out piping to allow for expansion and contraction. Piping shall not obstruct openings or passageways.
Pipes shall be held free of contact with building construction to avoid transmission of noise resulting from expansion.

3-3. INSTALLATION.

3-3.01. General. All instruments and specialty items shall be installed according to the manufacturer’s instructions and with sufficient clearance and access for ease of operation and maintenance.

Flat faced wrenches and vises shall be used for copper tubing systems. Pipe wrenches and vises with toothed jaws will damage copper materials and shall not be used. Bends in soft temper tubing shall be shaped with bending tools.

3-3.02. Pipe Sleeves. Piping passing through concrete or masonry shall be installed through sleeves that have been installed before the concrete is placed or when masonry is laid. Pipe sleeves installed through floors with a special finish, such as ceramic or vinyl composition tile, shall be flush with the finished floor surface and shall be provided with nickel or chromium plated floor plates. Unless otherwise indicated on the Drawings, in all other locations where pipes pass through floors, pipe sleeves shall project not less than 1 inch nor more than 2 inches above the floor surface, with the projections uniform within each area. In the case of insulated pipes, the insulation shall extend through pipe sleeves. Where the Drawings indicate future installation of pipe, sleeves fitted with suitable plastic caps or plugs shall be provided.

Holes drilled with a suitable rotary drill will be considered instead of sleeves for piping which passes through interior walls and through floors with a special finish.

Unless otherwise indicated on the Drawings, all pipes passing through walls or slabs which have one side in contact with earth or exposed to the weather shall be sealed watertight with special rubber-gasketed sleeve and joint assemblies, or with sleeves and modular rubber sealing elements.

3-3.03. Pipe Joints. Pipe joints shall be carefully and neatly made in accordance with the indicated requirements.

3-3.03.01. Threaded. Pipe threads shall conform to ANSI/ASME B1.20.1, NPT, and shall be fully and cleanly cut with sharp dies. Not more than three threads at each pipe connection shall remain exposed after installation. Ends of pipe shall be reamed after threading and before assembly to remove all burrs. Unless otherwise indicated, threaded joints shall be made up with teflon thread tape, thread sealer, or a suitable joint compound.
Threaded joints in plastic piping shall be made up with teflon thread tape applied to all male threads. Threaded joints in stainless steel piping shall be made up with teflon thread sealer and teflon thread tape applied to all male threads. Threaded joints in steel piping for chlorine service shall be made up with teflon thread tape or litharge and glycerine paste applied to all male threads.

3-3.03.02. **Compression.** Not Used.

3-3.03.03. **Flared.** Not Used.

3-3.03.04. **Soldered and Brazed.** Not Used.

3-3.03.05. **Solvent Welded.** Not Used. Solvent welded connections shall only be used for PVC or CPVC pipe. All joint preparation, cutting, and jointing procedures shall comply with the pipe manufacturer's recommendations and ASTM D2855. Pipe ends shall be beveled or chamfered to the dimensions recommended by the manufacturer. Newly assembled joints shall be suitably blocked or restrained to prevent movement during the setting time recommended by the manufacturer. Pressure testing of solvent welded piping systems shall not be performed until the applicable curing time, as set forth in Table X2.1 of ASTM D2855, has elapsed. Solvent welding shall be performed by bonding operators who have met the requirements of ASME B31.3 and A328.

3-3.03.06. **Epoxy and Adhesive Bonded.** Not Used.

3-3.03.07. **Heat Fusion Bonded.** Not Used. Fusion bonded joints shall be used for polyethylene pipe with socket and butt fusion fittings. All joint preparation, cutting, jointing equipment, and jointing procedures shall comply with the pipe manufacturer's recommendations. The heating time, temperature, pressure applied to the joint during bonding, and cooling time shall consistently produce leaktight joints as strong as the pipe being joined.

3-3.03.08. **Flanged.** Flange bolts shall be tightened sufficiently to slightly compress the gasket and effect a seal, but shall not be torqued less than the minimum value required by the gasket manufacturer. Flange bolts shall not be so tight as to fracture or distort the flanges. A plain washer shall be installed under the head and nut of bolts connecting plastic pipe flanges. Anti-seize thread lubricant shall be applied to the threaded portion of all stainless steel bolts during assembly.
Flange bolt holes shall be oriented as follows, unless otherwise indicated on the spool drawings:

- **Vertical flange face:** Bolt holes to straddle the vertical centerlines.
- **Horizontal flange face:** Bolt holes shall be aligned with connecting pipe.

Pipe sealants, thread compounds, or other coatings shall not be applied to flange gaskets unless recommended by the gasket manufacturer for the specified service and approved by Engineer.

Welds at orifice flanges shall have internal surfaces ground smooth to the pipe wall.

Slip-on flanges shall be welded inside and outside. There shall be a distance of approximately 1/16 to 1/8 inch between the edge of the fillet weld and the face of the flange. The seal weld shall be applied so that the flange face shall be free of weld spatter and does not require refacing.

Flat-faced flanges shall be used when mating to Class 125 flanges. Full-face gaskets shall be used with flat-faced flanges and ring gaskets shall be used with raised faced flanges.

Weld neck flanges shall be used with butt-weld fittings. The bore of weld neck flanges shall match the pipe wall thickness.

Insulating joints connecting submerged (buried) piping to exposed piping shall be installed above the maximum water surface elevation and before the first pipe support not having coated anchor bolts or adhesive-bonded concrete anchors. All submerged (buried) metallic piping shall be isolated from the concrete reinforcement. Insulating flanges shall be tested for electrical isolation after installation and bolt-up but prior to introduction of conducting fluid.

3-3.03.09. **Welded.** Not Used.

3-3.03.10. **Grooved Couplings.** Not Used.

3-3.03.11. **Push-on.** Not Used. Gasket installation and other jointing procedures shall be in accordance with the recommendations of the manufacturer. Each spigot end shall be suitably beveled to facilitate assembly. All joint surfaces shall be lubricated with a heavy vegetable soap solution immediately before the joint is completed. Lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean.
Miscellaneous Piping and Accessories Installation
15020-8


3-3.03.13. Other Pipe Joints. Not Used.

3-3.04. Pipe. Pipe shall be installed as specified, as indicated on the Drawings, or, in the absence of detail piping arrangement, in a manner acceptable to Engineer.

Piping shall be installed without springing or forcing the pipe in a manner which would induce stresses in the pipe, valves, or connecting equipment.

Piping shall be supported in conformance with the Pipe Supports section.

Piping shall be connected to equipment by flanges or unions as specified in the various piping sections. Piping connecting to equipment shall be supported by a pipe support and not by the equipment.

Water, gas, and air supply piping shall be provided with a shutoff valve and union at each fixture or unit of equipment, whether or not indicated on the Drawings, to permit isolation and disconnection of each item without disturbing the remainder of the system. Air supply piping shall be provided with sectionalizing valves and valved air inlet connections as needed for isolation of portions of the system for periodic testing. Gas supply lines to buildings shall be provided with a shutoff valve and union located above grade immediately outside the building. A capped drip leg shall be provided at the bottom of the vertical riser of gas supply piping adjacent to gas-fired appliances.

A union shall be provided within 2 feet of each threaded-end valve unless there are other connections which will permit easy removal of the valve. Unions shall also be provided in piping adjacent to devices or equipment which may require removal in the future and where required by the Drawings or the Specifications.

All air piping shall be graded to points of drainage collection where drip legs and drain valves shall be provided.

In all piping, insulating fittings shall be provided to prevent contact of dissimilar metals, including but not limited to, contact of copper, brass, or bronze pipe, tubing, fittings, valves, or appurtenances, or stainless steel pipe, tubing, fittings, valves, or appurtenances with iron or steel pipe, fittings, valves, or appurtenances. Insulating fittings shall also be provided to prevent contact of copper, brass, or bronze pipe, tubing, fittings, valves or appurtenances with stainless steel pipe, tubing, fittings, valves, or appurtenances.

Branch connections in horizontal runs of steam, air, and gas piping shall be made from the top of the pipe.
Buried PVC piping shall be "snaked" in the trench and shall be kept as cool as possible during installation. PVC pipe shall be kept shaded and shall be covered with backfill immediately after installation.

Piping adjacent to flow sensors shall be installed in accordance with the requirements of the manufacturer of the flow sensor and commonly accepted design practices of the appropriate straight pipe runs both upstream and downstream.

Drains required for operation are shown on the Drawings. However, vents at all high points and drains at all low points in the piping that are required for complete draining for pressure test may not be shown on these Drawings. Contractor shall add such items as found to be necessary during detail piping design and/or piping installation.

3-3.05. Reducers. Eccentric reducers shall be installed flat on the bottom for steam, condensate return and digester gas services.

3-3.06. Valves. Isolation valves provided with equipment and instruments shall be located in a manner which will allow ease of access and removal of the items to be isolated. Prior to soldering or brazing valves, teflon and elastomer seats and seals shall be removed to prevent damage.

3-4. PIPING ASSEMBLY.

3-4.01. General. Contractor shall only use labor that has been qualified by training and experience to capably perform the specified activities required to accomplish the work in a satisfactory manner.

Any deviations from the Specifications or piping locations shown on the Drawings require prior review and approval by Engineer.


3-5. PROTECTIVE COATING. Not Used.

3-6. PRESSURE AND LEAKAGE TESTING. All specified tests shall be made by and at the expense of Contractor in the presence, and to the satisfaction of Engineer. Each piping system shall be tested for at least 1 hour with no loss of pressure. The Contractor shall coordinate this section with the Pipeline Pressure and Leakage Testing section. Piping shall be tested at the indicated pressures:
Compressed air or pressurized gas shall not be used for testing plastic piping unless specifically recommended by the pipe manufacturer.

Leakage may be determined by loss-of-pressure, soap solution, chemical indicator, or other positive and accurate method acceptable to Engineer. All fixtures, devices, or accessories which are to be connected to the lines and which would be damaged if subjected to the specified test pressure shall be disconnected and the ends of the branch lines plugged or capped as needed during the testing.

After completion of the specified pressure tests, all anhydrous ammonia, chlorine and sulfur dioxide gas piping shall be tested for leakage using the appropriate gas chemical at operating pressures. Piping shall be thoroughly cleaned and dried before admitting gas chemical into the system. Gas chemical shall be slowly admitted to the piping system.

For chlorine gas piping, leakage shall be checked by waving a swab soaked in aqua ammonia solution near each fitting. Ammonia solution shall not be applied directly to the fittings. Formation of white fumes will indicate the presence of leaks. All chlorine gas shall be purged from the line before leaks are repaired.

Unless otherwise required by the applicable codes, drainage and venting systems shall be water tested. For water testing, the drainage and venting system shall be filled with water to the level of the highest vent stack. For air testing, the system shall be charged with air to a minimum pressure of 5 psig. Openings shall be plugged as necessary for either type of test. To be considered free of leaks, the system shall hold the water or air for 30 minutes without any drop in the water level or air pressure.
All necessary testing equipment and materials, including tools, appliances and devices, shall be furnished and all tests shall be made by and at the expense of Contractor. Contractor shall give Engineer 5 working days advanced notice of scheduled testing.

All joints in piping shall be tight and free of leaks. All joints which are found to leak, by observation or during any specified test, shall be repaired, and the tests repeated.

3-6.01. **Air Pressure Tests.** Pressure tests shall be performed on all air piping systems as specified herein to conform to ASME B31.1.

The test pressure shall be as specified herein and shall not exceed the maximum allowable test pressure of any non-isolated component, such as vessels, compressors, blowers, or valves, in the system. The pressure in the system shall gradually be increased to not more than one-half of the test pressure, after which the pressure shall be increased in steps of approximately one-tenth of the test pressure until the required test pressure has been reached. The pressure shall be continuously maintained for a minimum duration of 10 min. It shall then be reduced to the blower rated discharge pressure held for such time as may be necessary to conduct the examination for leakage.

Examination for leakage detected by soap bubble or equivalent method shall be made at all joints and connections. The piping system, exclusive of possible localized instances at the compressor, blower, or valve packing, shall show no evidence of leaking.

Contractor shall be responsible for ensuring that all air piping is free of leaks. All joints which are found to be leaking shall be repaired and the test repeated.

3-7. **CLEANING.** The interior of all pipe, valves, and fittings shall be smooth, clean, and free of blisters, loose mill scale, sand, dirt, and other foreign matter when installed. Before being placed in service, the interior of all lines shall be thoroughly cleaned, to the satisfaction of Engineer.

Metal anhydrous ammonia, chlorine and sulfur dioxide piping shall be cleaned as recommended by the gas chemical feed system supplier. All surfaces which may come into contact with gas chemical shall be thoroughly dry and free of oil or grease before being placed in service. The recommended cleaning procedures shall be submitted for review in accordance with the Submittals section.

Tin-lined copper tubing for distribution of distilled water shall be flushed and cleaned with distilled water in accordance with the tubing manufacturer’s recommendations.
3-8. **ACCEPTANCE.** Owner reserves the right to have any section of the piping system which he suspects may be faulty cut out of the system by Contractor for inspection and testing. Should the joint prove to be sound, Owner will reimburse Contractor on a time-and-material basis as specified in the Contract. Should the joint prove to be faulty, the destructive test will continue joint by joint in all directions until sound joints are found. Costs for replacement of faulty work and/or materials shall be the responsibility of Contractor.

END OF SECTION
SECTION 15066
FIBERGLASS REINFORCED PLASTIC PIPE (AIR SERVICE)

PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing low pressure fiberglass reinforced plastic pipe for application in exhaust air systems as indicated on the Drawings. Piping shall be furnished complete with all fittings, transitions, jointing materials, expansion joints, and other necessary appurtenances.

Pipe supports, anchors, and odor control dampers are covered in other sections.

1-2. GENERAL. Materials furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the manufacturer unless exceptions are noted by Engineer.

1-2.01. Coordination. Contractor shall verify that each component of the system furnished is compatible with all other parts of the system, that all piping and materials are appropriate for the expected services, and that all devices necessary for a properly functioning system have been provided.

1-2.02. Pipe Identification. Piping identification shall be as specified in the protective coating section.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete specifications, data and catalog cuts, test reports, and shop assembled layout drawings shall be submitted in accordance with the Submittals Procedures section. The data and specifications shall include, but shall not be limited to, the following:

  Pipe
  Manufacturer's name.
  Brand designation.
  Resin manufacturer and type of resin.
  Pressure, vacuum, and temperature rating of pipe.
  Certification of compliance with referenced standards.
  Layouts and dimensions of subassemblies to be shipped.
  Detailed instructions for field butt joints including lay-up sequence, width of each reinforcement layer, and total number of layers.
Test reports in accordance with the referenced standards for stiffness factor (ASTM D2412), longitudinal tensile properties (ASTM D2105 or ASTM D638), longitudinal compressive properties (ASTM D695), and short-term hydrostatic failure strength (ASTM D1599).

Upon request for buried piping, provide test reports in accordance with the referenced standards for manufacturing (ASTM D2996 and ASTM D2997) and long-term cyclic or static hydrostatic strength (ASTM D2992).

Where the pipe sizes needed for the project are larger than the named manufacturer’s standard pipe sizes, the following information shall be submitted for the pipe and fittings that are being provided:

- Manufacturer’s name.
- Certificate of compliance that states compliance with referenced construction standards and test methods.
- Material sources.
- Material types.
- Average reinforced wall thickness for each pipe size.
- Minimum reinforced wall thickness for each pipe size.
- Average outside diameter for each pipe size.
- Liner material.
- Nominal liner thickness for each pipe size.

**Expansion Joints**

- Name of manufacturer.
- Type and model.
- Materials of construction.
- Force required for expansion and contraction.

Certification letter stating that any shop fabrications have been constructed by the pipe manufacturer or pipe manufacturer’s certified pipe fabrication source.

1-4. **QUALITY ASSURANCE.** The manufacturer shall have available a laboratory and quality control facility capable of performing tests and inspections as required by the referenced standards. Material testing, inspection procedures, and manufacturing methods are subject to inspection by the Engineer. The manufacturer shall provide the Engineer at least 3 weeks advance notice of pipe production should the Engineer elect to witness pipe fabrication.

1-4.01. **Manufacturer’s Field Services.** The pipe manufacturer or designated representative shall provide hands-on training for the installation contractor’s employees in the proper assembly of butt joints.
The pipe manufacturer’s representative shall be on-site for at least one 8-hour day, during which they shall observe the assembly of at least three butt joints. The pipe manufacturer shall submit written certification that the installation contractor's employees have satisfactorily completed all training and instruction and can perform the jointing required for this project in accordance with the pipe manufacturer's recommendations and as specified herein. All field butt joints shall be made by representatives of the pipe manufacturer or by employees of the installation contractor who have been trained and certified by the pipe manufacturer. Qualified fitters shall carry and have visible at all times a certificate of qualification issued by the pipe manufacturer. Contractor shall arrange the qualifying training.

1.5. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section. Pipe and fittings shall be properly supported to avoid damage caused by flexural strains. Pipe and fittings shall not be thrown or dropped.

PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. Fiberglass reinforced pipe will be used in odor control service condition(s).

Pipe and appurtenances used in ventilation exhaust air or odor control systems will be continuously exposed to a humid environment containing hydrogen sulfide gas.

2-2. DESIGN REQUIREMENTS.

2-2.01. Minimum Pipe Wall Stiffness. The minimum pipe wall stiffness, at 5 percent deflection, determined in accordance with ASTM D2412 and AWWA C950, shall be not less than the following:

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Pipe Stiffness</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>psi</td>
</tr>
<tr>
<td>1-8</td>
<td>36</td>
</tr>
<tr>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>12-16</td>
<td>9</td>
</tr>
<tr>
<td>18 and larger, buried</td>
<td>10 or greater as required for service conditions</td>
</tr>
</tbody>
</table>
Fiberglass Reinforced Plastic Pipe (Air Service)
15066-4

18 and larger, other locations 5

2-2.02. **Temperature.** All pipe, fittings, and appurtenances shall be suitable for the following temperature conditions.

- **Design maximum temperature:** 130 °F
- **Design minimum temperature:** 20 °F

2-3. **ACCEPTABLE MANUFACTURERS.** The fiberglass reinforced plastic pipe, fittings and specials provided under this section shall be the products of Smith/Fibercast, Daniel Company, or Conley as specified herein.

2-4. **MATERIALS.**

The materials for the specified service conditions shall be as follows:

<table>
<thead>
<tr>
<th>Service Condition</th>
<th>Pipe Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor Control</td>
<td>Epoxy (20” and smaller)orVinyl Ester</td>
</tr>
</tbody>
</table>

Piping materials shall be as follows:

**Epoxy Pipe**

- **Centrifugally Cast**
  - 14 inches and smaller: ASTM D2997, centrifugally cast, reinforced epoxy resin pipe with 50 mil liner; Daniel Company, or Smith/Fibercast "Centricast RB-1520".
  - Filament-Wound
    - 16 inches and smaller: ASTM D2996, with at least a 20 mil reinforced liner; Smith/Fibercast "Green Thread" or Conley "Schedule 30E".
    - 18 through 20 inches: ASTM D2310, with at least a 20 mil reinforced liner; Daniel Company, or Conley "Schedule 30E".

**Vinyl Ester Pipe**

- Centrifugally Cast
Fiberglass Reinforced Plastic Pipe (Air Service)
15066-5

14 inches and smaller
ASTM D2997, centrifugally cast, reinforced vinyl ester resin pipe with 50 mil liner; Daniel Company, or Smith/Fibercast "Centricast CL-1520".

Filament-Wound

16 inches and smaller
ASTM D2996, with vinyl ester resin and at least a 20 mil reinforced liner; Daniel Company, Smith/Fibercast "F-Chem-V" or Conley "Schedule 30V".

18 inches and larger
ASTM D2310, with vinyl ester resin and at least a 20 mil reinforced liner; Daniel Company, Smith/Fibercast "F-Chem-V or Conley "Schedule 30V".

Fittings
Manufacturer's standard, glass fiber reinforced, thickness to match pipe, compatible with the pipe and with chemical resistance equal to or greater than the pipe. Elbows 24 inch and smaller shall be smooth radius. Elbow 30 inch and larger shall be smooth radius or mitered. Mitered elbows shall be constructed of a least 4 sections and 3 mitered joints. Elbows shall be constructed to have a radius-to-diameter ratio of 1.5 unless otherwise indicated on the Drawings.

Flanges
ASTM D3982 made on the specified pipe.

Flange Bolts or Studs
ASTM F593, Type 304 stainless steel having a length such that, after installation, bolts will project 1/8 to 3/8 inch beyond the outer face of the nut.

Nuts
ASTM F594, Type 304 stainless steel.

Flat Washers
ANSI B18.22.1, Type 304 stainless steel.

Flange Gaskets
Full face, 1/8 inch thick, 40-50 durometer, EPDM.

Bell-and-Spigot Joints
Matched tapered bell-and-spiogot ends bonded with adhesive.

Butt Joints
Butt and wrap, resin bonded using same resin as pipe, ASTM D6041, with thickness equal to the wall thickness of the pipe being joined.

Expansion Joints
As specified herein.

Adhesive
Pipe manufacturer's standard.
Fiberglass Reinforced Plastic Pipe (Air Service)
15066-6

All above grade pipe, fittings and appurtenances shall contain ultraviolet (UV) inhibitors.

Resins used in the piping system laminates, except for the inner corrosion liner, shall have a flame spread rating of 25 or less when tested in accordance with ASTM E84. The manufacturer’s products named shall be used with a fire retardant resin substitution that is certified to meet or exceed ASTM requirements by the manufacturer.

2-5. FABRICATION.

2-5.01. Jointing Method. Unless otherwise specified, pipe shall have adhesive bonded bell and spigot joints or laminated butt joints. Shop fabricated assemblies should be provided to the maximum extent possible, to minimize the number of field joints. Shop fabrications including fittings and specials must be constructed by the pipe manufacturer or pipe manufacturer’s certified pipe fabrication source.

Flanged joints shall be provided at each damper and item of equipment to facilitate disassembly, at each change in material, and where indicated on the Drawings. Bolts, nuts, washers, and gaskets shall be provided for all flanged connections in the piping system, including connections to equipment.

Field butt joints shall be located at least 12 inches from any increasing or decreasing cross-section of pipe where the pipe to be jointed has the same diameter.

2-5.02. Transitions. Fiberglass reinforced plastic transition sections shall be furnished for connecting round pipe to rectangular openings on equipment. Transitions shall have a minimum wall thickness equal to the connecting pipe and shall not have a deflection greater than ½ percent of the longest side. Internal lining shall be of the same type of material and thickness as specified for the pipe. Transitions shall have flanged end connections compatible with the connecting equipment.

For connection to fans, each transition shall be flanged on the fan end and shall adapt the flanged inlet/outlet connection of each fan to the flexible connector. Transition pieces shall have a minimum wall thickness of 1/4 inch and an outside diameter equal to that of the connecting fiberglass reinforced plastic pipe. Flanges shall have a thickness of at least 3/8 inch. Flange bolt holes shall be field drilled to match the applicable fan connection.

2-5.03. Expansion Joints. Expansion joints shall be furnished at the locations indicated on the Drawings and at other locations required for proper pipe installation. Expansion joints shall be resistant to ultraviolet light and shall be suitable for the service conditions.
Expansion joints shall be fully molded type rated for a minimum 3 psi working pressure and shall consist of an inner tube, body, and outer cover to be compatible with the specified service conditions. The tube shall be a minimum of 1/4 inch thick EPDM with two ply of high tensile nylon, polyester, or kevlar fabric reinforcement. The cover shall be a minimum 1/16-inch elastomer and shall be resistant to ultraviolet light.

Slip on type expansion joints shall fit tightly on the outside diameter of the piping and shall be secured in place by stainless steel adjustable bands with worm screw type adjustments to provide a gastight connection.

Flanged type expansion joints shall have split stainless steel retaining rings and shall have ASTM D3982 diameter and drilling. Expansion joints shall be Red Valve "Duct Expansion Joints", Mercer Rubber Company, or Holz Rubber Company.

**PART 3 - EXECUTION**

3-1. **INSPECTION.** Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation. Any pipe that is damaged or shows evidence of contamination shall not be installed in the piping system.

3-2. **PREPARATION.**

3-2.01. **Field Measurement.** Pipe shall be cut to measurements taken at the site, not from the Drawings. All necessary provisions shall be made in laying out piping to allow for expansion and contraction. Piping shall not obstruct openings or passageways. Pipe shall be held free of contact with building construction to avoid transmission of noise resulting from expansion.

3-3. **INSTALLATION.** Pipe shall be installed as specified and as indicated on the Drawings. All necessary provisions shall be taken in the fabrication and installation of piping to provide for expansion and contraction. Expansion joints shall be installed as specified in the pipe supports section.

The piping shall be supported as indicated on the Drawings and in accordance with the requirements of the pipe supports section.

The inside of pipe, fittings, and transitions shall be smooth, clean and free from blisters, when installed.

3-3.01. **Pipe Sleeves.** Piping passing through concrete or masonry shall be installed through sleeves installed before the concrete is placed or when masonry is laid.
3-3.02. **Pipe Joints.** Pipe joints shall be carefully and neatly made in accordance with the following specified requirements. All field joints made by trained and certified employees that are not representatives of the pipe manufacturer shall be made using individually packaged joint kits.

3-3.02.01. **Adhesive Bonded Bell and Spigot Joints.** All joint preparation, cutting, and jointing for adhesive bonded joints shall comply with the pipe manufacturer’s recommendations. Adhesive shall be mixed and applied in accordance with the manufacturer’s recommendations. Newly assembled joints shall be suitably blocked or restrained to prevent movement during the recommended curing period.

3-3.02.02. **Flanged Joints.** Flange bolts shall be tightened sufficiently to slightly compress the gasket and make a good seal, but not so tight as to distort the flanges. A flat washer shall be installed under each nut and bolt head.

3-3.02.03. **Laminated Butt Joints.** Laminated butt joints shall be made in accordance with the manufacturer’s recommendations and as specified herein. Twenty inch and larger pipe shall be overlaid both inside (when accessible) and outside. Eighteen inch and smaller pipe shall be overlaid on the outside only. The minimum width of the overlay shall be as specified in the following table. Inside overlaps shall be made to seal the joint but shall not be considered in meeting the strength requirements.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Minimum Total Width of Overlay</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>inches</td>
</tr>
<tr>
<td>2-4</td>
<td>6</td>
</tr>
<tr>
<td>6-20</td>
<td>8</td>
</tr>
<tr>
<td>24-30</td>
<td>10</td>
</tr>
<tr>
<td>36-42</td>
<td>12</td>
</tr>
<tr>
<td>48-54</td>
<td>14</td>
</tr>
<tr>
<td>60</td>
<td>16</td>
</tr>
<tr>
<td>72</td>
<td>18</td>
</tr>
</tbody>
</table>

Finished joints shall be built up in successive layers, shall be as thick as the pieces being joined, and shall be as crevice-free as is commercially practicable, in accordance with ASTM D2563. The width of the first layer shall be at least 4 inches. Successive layers shall be increased uniformly to provide the specified minimum total width of overlay which shall be centered on the joint. Crevices between jointed pieces shall be filled with resin, leaving a smooth inner surface. The interior of joints shall also be sealed by covering with not less than 0.05 inch of liner of the same material as the pipe.
The inner surface shall be free of cracks and crazing, with a smooth finish, and with an average of not more than two pits per square foot, provided the pits are less than 1/8 inch in diameter, not more than 1/32 inch deep, and covered with sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free of pits. Such surfaces may be reinforced with glass surfacing mat, synthetic fibers, or other suitable material.

3-3.03. **Alignment.** Piping installed below grade shall be laid to the lines and grades indicated on the Drawings. Batter boards, laser beam equipment, or surveying instruments shall be used to maintain alignment and grade.

Batter boards, if used, shall be erected at intervals of not more than 25 feet. Batter boards shall be used to determine and check pipe subgrades. At least three batter boards shall be maintained in proper position at all times when trench grading is in progress.

If laser beam equipment is used, periodic elevation measurements shall be made with surveying instruments to verify accuracy of grades. If such measurements indicate thermal deflection of the laser beam due to differences between the ground temperature and the air temperature within the pipe, precautions shall be taken to prevent or minimize further thermal deflections.

3-3.04. **Laying Pipe.** Pipe installed below grade shall be protected from lateral displacement by placing the specified pipe embedment material. Pipe shall not be laid in water or under unsuitable weather or trench conditions.

Pipe laying shall begin at the lowest elevation with bell ends facing the direction of laying, except when reverse laying is permitted by Engineer.

Whenever pipe laying is stopped, the open end of the pipe shall be closed with an end board closely fitting the end of the pipe, to keep sand and earth out of the pipe. The end board shall have several small holes near the center to permit water to enter the pipe and to prevent flotation in the event of flooding of the trench.

3-4. **FIELD QUALITY CONTROL.**

3-4.01. **Field Testing.** All joints in piping shall be tight and free of leaks. Each joint which is found to leak, by observation or during any specified test, shall be repaired, and the tests repeated. All necessary testing equipment and materials, including tools, appliances, and devices, shall be furnished by Contractor. Leak testing shall be conducted prior to backfill. All tests shall be made by and at the expense of Contractor. Tests shall be conducted in a manner acceptable to Engineer and shall be repeated as many times as necessary to demonstrate compliance with specified requirements.
The Engineer or Engineer’s representative shall be present during testing and shall be notified of the time and place of testing at least 3 days prior to commencement of the work.

Leakage may be determined by loss-of-pressure, soap solution, or positive and accurate method acceptable to Engineer. All equipment or other accessories which would be damaged if subjected to the specified test pressure shall be disconnected, and ends of branch lines plugged or capped, as required, during the testing procedures.
PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of miscellaneous plastic pipe, tubing, and accessories. Pipe and tubing shall be furnished complete with all fittings, flanges, unions, jointing materials and other necessary appurtenances.

1-2. SUBMITTALS.

1-2.01. Drawings and Data. Complete specifications, data and catalog cuts or drawings shall be submitted in accordance with the Submittals Procedures section. Submittals are required for all piping, fittings, gaskets, sleeves, and accessories, and shall include the following data:

- Name of Manufacturer
- Type and model
- Construction materials, thickness, and finishes
- Pressure and temperature ratings

Contractor shall obtain and submit a written statement from the gasket material manufacturer certifying that the gasket materials are compatible with the joints specified herein and are recommended for the specified field test pressures and service conditions.

1-3. DELIVERY, STORAGE, AND HANDLING. Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section. All materials shall be stored in a sheltered location above the ground, separated by type, and shall be supported to prevent sagging or bending.

Pipe, tubing, and fittings shall be stored between 40°F and 90°F [4°C and 32°C].

PART 2 - PRODUCTS

2-1. FRP PIPE. Not used.

2-2. PVC PIPE MATERIALS.
PVC pipe materials and services shall be as specified herein.

2-2.01. Material Classification PVC-1. Not used.
2-2.02. **Material Classification PVC-2.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor control condensate drains</td>
<td>Fittings</td>
<td>ASTM D2467, Cell Classification 12454, bearing NSF seal.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flanges or unions shall be provided where needed to facilitate disassembly of equipment or valves.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flanges or unions shall be joined to the pipe by a solvent weld.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When acceptable to Engineer, threaded joints may be used instead of solvent welded joints in exposed interior locations for the purpose of facilitating assembly. The use of threaded joints in this system shall be held to a minimum.</td>
</tr>
</tbody>
</table>

2-2.03. **Material Classification PVC-3.** Not used.

2-2.04. **Material Classification PVC-4.**

| PVC-4 – PVC DWV Pipe (Single Wall) with Solvent Welded Joints. | Pipe                  | ASTM D1785, cell classification 12454, bearing NSF seal.          |
|                                                               | Fittings              | ASTM D2665 and ASTM D3311, cell classification 12454, bearing NSF seal. |
2-2.09. **Accessory Materials.** Accessory materials for the PVC Pipe systems shall be as indicated.

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flanges</strong></td>
<td>Diameter and drilling shall conform to ANSI/ASME B16.5, Class 150. Schedule 80 for DWV systems.</td>
</tr>
<tr>
<td><strong>Flange Bolts and Nuts</strong></td>
<td>ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch [3 to 10 mm] beyond outer face of the nut. Stainless steel for DWV and chemical feed systems, galvanized steel for all other systems.</td>
</tr>
<tr>
<td><strong>Flat Washers</strong></td>
<td>ANSI B18.22.1, plain. Same material as bolts and nuts.</td>
</tr>
<tr>
<td><strong>Flange Gaskets</strong></td>
<td>Full face, 1/8 inch [3 mm] thick, chemical-resistant elastomeric material suitable for the specified service.</td>
</tr>
<tr>
<td><strong>Expansion Joints</strong></td>
<td>Edlon &quot;Thermo-molded TFE&quot; or Resistoflex &quot;Style R6905&quot; molded expansion joint.</td>
</tr>
</tbody>
</table>

2-3. **CPVC PIPE.** Not used.

2-3.02. **Accessory Materials.** Accessory materials for the CPVC Pipe systems shall be as indicated.

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flanges</strong></td>
<td>Diameter and drilling shall conform to ANSI/ASME B16.5, Class 150.</td>
</tr>
<tr>
<td><strong>Flange Bolts and Nuts</strong></td>
<td>ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch [3 to 10 mm] beyond outer face of the nut. Stainless steel for chemical feed systems, galvanized steel for all other systems.</td>
</tr>
<tr>
<td><strong>Flat Washers</strong></td>
<td>ANSI B18.22.1, plain. Same material as bolts and nuts.</td>
</tr>
<tr>
<td><strong>Flange Gaskets</strong></td>
<td>Full face, 1/8 inch [3 mm] thick, chemical-resistant elastomeric material suitable for the specified service.</td>
</tr>
<tr>
<td><strong>Expansion Joints</strong></td>
<td>Edlon &quot;Thermo-molded TFE&quot; or Resistoflex</td>
</tr>
</tbody>
</table>
"Style R6905" molded expansion joint.

2-4. **PE PIPE.** Not used.

2-5. **POLYPROPYLENE PIPE.** Not used.

2-6. **PVDF PIPE.** Not used.

2-7. **REINFORCED PLASTIC TUBING.** Not used.

2.8. **FLEXIBLE PFA TUBING.** Flexible PFA tubing materials and services shall be as specified herein.

2-8.01. **Material Classification PFA-1.**

<table>
<thead>
<tr>
<th>PFA-1 – Flexible PFA Tubing.</th>
<th>Tubing</th>
<th>Boracon “PFA Tubing”, New Age Industries “PFA Tubing”. Connections shall be accomplished with hose barbs constructed of a suitable material and hose clamps constructed of stainless steel.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fittings</td>
<td></td>
</tr>
</tbody>
</table>

2.9 **TEFLON (PFA) HOSE.** PFA hose materials and services shall be as specified herein.

2-9.01. **Material Classification TEFL-1.**

<table>
<thead>
<tr>
<th>TEFL-1 – Teflon Hose.</th>
<th>Hose</th>
<th>Polypropylene braided, convoluted PFA Teflon Hose; PureFlex Inc “ProFlex”, or preapproved equal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium hypochlorite hose in chemical duct banks as indicated on the drawings.</td>
<td>Fittings</td>
<td>Connections shall be accomplished using ProFlex Style 11 or equal fittings constructed of solid Kynar and installed at the factory. Splices and hose fittings shall be factory installed.</td>
</tr>
<tr>
<td>Flexible hose for chemical diffusers.</td>
<td></td>
<td>Tubing connections to hard pipe shall be flange type or as recommended by the tubing manufacturer with wetted parts suitable for the chemical.</td>
</tr>
</tbody>
</table>
Where barbed fittings are required the clamps shall be of stainless steel with blow-off proof crimping collar.

Field connections shall be accomplished using ProFlex Style 03 or equal fittings constructed of solid Kynar.

PART 3 - EXECUTION

3-1. INSTALLATION. Materials furnished under this section will be installed in accordance with the Miscellaneous Piping and Accessories Installation section.

END OF SECTION
Miscellaneous Plastic Pipe, Tubing, and Accessories
15067-6

[PAGE INTENTIONALLY LEFT BLANK]
PART 1 - GENERAL

1.01 REQUIREMENT

1.02 FLANGE INSULATING GASKET KITS
PART 1 - GENERAL

1.01 REQUIREMENT
Gaskets for steel and cast iron flanges shall be of dimensions conforming to the requirements of Standard Drawing B-288, and shall be standard full face for pipe 27” diameter and larger.

Gaskets shall be 1/16”, non-asbestos model # Garlock 3000 or Tripac 5000.

1.02 FLANGE INSULATING GASKET KITS
A. Pipe flange insulating kit materials shall be of the type designated by the manufacturer as suitable for appropriate service at the operating temperatures and pressures specified on the Plans.

B. Flange insulating kits shall consist of a one piece full-face, insulating gasket, an insulating sleeve for each bolt, two insulating washers for each bolt, and a steel washer between each insulating washer and nut.

1. Insulating gasket shall be a full faced NEMA Grade G-10 Glass Epoxy Laminated Retainer with a precision tapered groove to accommodate the compression of a BUNA-N or VITON sealing element. Minimum total thickness shall not be less than 1/8-inch. Dielectric strength shall be not less than 550 volts per mil, and compressive strength of not less than 50,000 psi. Use PSI Linebacker or equal.

   a. Optional Materials:
      1. Neoprene faced phenolic gasket

2. Insulating sleeves shall be full length, one piece, insulating flange bolt sleeves for the appropriate bolt size. Insulating sleeves shall be NEMA G-10 Glass Epoxy Laminated tubing (Pyrox). Dielectric strength shall be not less than 400 volts per mil.

   a. Optional Materials:
      1. Phenolic tubing
      2. Nomex tubing
      3. Mylar tubing
      4. Polyethylene tubing

3. Insulating washers shall be NEMA Grade G-10 Glass Epoxy Laminated Washers with a minimum thickness of 1/8-inch. Dielectric strength shall not be less than 550 volts per mil, and compressive strength of not less than 50,000 psi.
a. Optional Materials:
   1. Phenolic Washers
   2. Nomex Washers

4. Provide cadmium plated steel flange bolt washers for placement over the insulating washers with a minimum thickness of 1/8 inch.
PART 1 - GENERAL........................................................................................................................................1
  1.01 REQUIREMENT ................................................................................................................................... 1
  1.02 USE OF ZINC CAPS FOR BURIED PIPE ......................................................................................... 1
PART 1 - GENERAL

1.01 REQUIREMENT
Bolts and nuts for flanged fittings shall be bare steel conforming to SAE J429 Grade 5 or ASTM A449 medium carbon steel quenched and tempered meeting the following requirements, and shall have hex heads and lite-pattern hex nuts.

\[
\begin{align*}
\frac{3}{4}'' & \text{ Through 1'' diameter} \\
85,000 & \text{ p.s.i. proof strength} \\
92,000 & \text{ p.s.i. yield strength} \\
120,000 & \text{ p.s.i. tensile strength} \\
\end{align*}
\]

Over 1'' to 1½'' diameter

\[
\begin{align*}
74,000 & \text{ p.s.i. proof strength} \\
81,000 & \text{ p.s.i. yield strength} \\
105,000 & \text{ p.s.i. tensile strength} \\
\end{align*}
\]

1.02 USE OF ZINC CAPS FOR BURIED PIPE
Each bolted fitting including couplings, flange adapters, restrained joints, etc. that have manufactured bolts and nuts shall have a minimum of 2 zinc caps anodes as specified below.

Bolt sizes and number of zinc caps:

- through 1'' diameter - 2 zinc caps
- over 1'' diameter - 4 zinc caps

Weight of zinc caps:

- Zinc caps to be 6 oz. weight.

Material reference:

- Zinc caps shall be per ASTM B418-80 and Mil-A-18001J, and be manufactured by Mars, Reliance, or equal.

END OF SECTION 15089
PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing of backflow preventers and associated appurtenances, as indicated herein. Backflow preventers for fire protection service shall be as specified in the fire sprinklers systems section.

Piping, pipe supports, insulation, and accessories which are not an integral part of the backflow preventers or are not specified herein are covered in other sections.

1-2. GENERAL.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials provided under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.02. Identification. Equipment specified herein shall be identified in accordance with the Equipment and Valve Identification section.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete fabrication and assembly drawings, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section. The data and specifications for each unit shall include, but shall not be limited to the following:
   - Name of manufacturer.
   - Type and model.
   - Construction materials and finishes.
   - Net weight.
   - Unit dimensions.
   - Performance curves indicating flow capacity versus pressure drop.

1-3.02. Operations and Maintenance Data and Manuals. Adequate operation and maintenance information shall be supplied as required in the Submittals Procedures section. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.
1-4. **DELIVERY, STORAGE, AND HANDLING.** Shipping shall be in accordance with the Product Delivery Requirements section. Handling and Storage shall be in accordance with the Product Storage and Handling Requirements section.

**PART 2 - PRODUCTS**

2-1. **PERFORMANCE AND DESIGN REQUIREMENTS.** Backflow preventers shall be designed to meet the requirements as indicated herein and in the Backflow Preventer Schedule on the Drawings.

2-2. **ACCEPTABLE MANUFACTURERS.** Acceptable manufacturers and specific products are listed in the Design and Construction paragraph.

2-3. **DESIGN AND CONSTRUCTION.** Backflow prevention device type shall be as indicated herein.

2-3.01. **Reduced Pressure Zone Backflow Preventers.** Reduced pressure zone (RPZ) backflow preventers shall consist of isolation valves, two independent check valves, and differential relief valve. The assembly shall automatically reduce the pressure in the zone between the check valves. In the event that the reduced pressure is not maintained, the differential relief valve shall open, maintaining the proper zone differential. RPZ backflow preventers shall comply with AWWA C511 and ASSE Standard 1013 requirements and shall be suitable for horizontal installation. Backflow preventers shall comply with the requirements of ANSI/NSF 61, Annex G for low lead. Each RPZ backflow preventer shall be provided with a relief valve air-gap drain fitting.

RPZ backflow preventers in 2 inch [50 mm] and smaller sizes shall be provided with bronze bodies and with a threaded bronze bodied ball valve on each end of the device. Two inch [50 mm] and smaller RPZ backflow preventers shall be Febco “Model LF860”, Wilkins “Model 975XL2”, or Watts Regulator “Series LF919”.

**PART 3 - EXECUTION**

3-1. **INSTALLATION.** Materials furnished under this section will be installed in accordance with the Valve Installation section.

**END OF SECTION**
## SPECIFICATIONS - DETAILED PROVISIONS
### Section 15104 - Ball Valves

**CONTENTS**

<table>
<thead>
<tr>
<th>PART 1 - GENERAL</th>
<th>..........................................................</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.01 SUMMARY</td>
<td>..................................................................................................................</td>
<td>1</td>
</tr>
<tr>
<td>1.02 REFERENCES</td>
<td>..................................................................................................................</td>
<td>1</td>
</tr>
<tr>
<td>1.03 SUBMITTALS</td>
<td>..................................................................................................................</td>
<td>1</td>
</tr>
<tr>
<td>PART 2 - PRODUCTS</td>
<td>..................................................................................................................</td>
<td>1</td>
</tr>
<tr>
<td>2.01 METAL BODY BALL VALVES</td>
<td>..........................................................................................................</td>
<td>1</td>
</tr>
<tr>
<td>2.02 PLASTIC BODY BALL VALVES</td>
<td>......................................................................................................</td>
<td>2</td>
</tr>
<tr>
<td>PART 3 - EXECUTION</td>
<td>..................................................................................................................</td>
<td>3</td>
</tr>
<tr>
<td>3.01 INSTALLATION</td>
<td>..................................................................................................................</td>
<td>3</td>
</tr>
</tbody>
</table>
SECTION 15104
BALL VALVES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes. (Metal body ball valves) (and) (plastic body ball valves)

1.02 REFERENCES

A. American Water Works Association (AWWA):

1. C 507 Ball Valves, Shaft or Trunnion Mounted, 6 Inch Through 48 Inch.

1.03 SUBMITTALS

A. Product Data

B. Metal Body Ball Valves: Affidavit of compliance with AWWA C 507.

PART 2 - PRODUCTS

2.01 METAL BODY BALL VALVES

A. Manufacturers: One of the following or equal.

1. Lunkenheimer Company.

2. MARPAC, Inc.

B. General

1. Type: Non-lubricated, and capable of sealing in either flow direction.

2. Conform to AWWA C 507.

3. Stem Packing: Manually adjustable while valve is under pressure.
4. Temperature Limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.

C. Materials

1. Valves in copper lines: Bronze body with solder ends.

2. Valves in steel and ductile iron piping: Ductile iron or cast steel bodies, and ends as follows:
   a) Threaded for sizes 3 inch and smaller.
   b) Flanged for sizes larger than 3 inch.

3. Ball: Type 304 or Type 316 stainless steel.

4. Seats: TFE.

5. Stem seals: TFE or Viton.

2.02 PLASTIC BODY BALL VALVES

A. Manufacturers: One of the following or equal:

1. Asahi America

2. Chemtrol Division, NIBCO Inc.

B. General:

1. Type: Non-lubricated and capable of sealing in either flow direction.

2. End connections: True union.

3. Operator handle: Lever

C. Materials:


2. Ball: Polyvinyl chloride (PVC).

4. O-rings: [FPM (Viton)] (EPDM).

PART 3 - EXECUTION

3.01 INSTALLATION

A. Follow manufacturer's published instructions.

END OF SECTION 15104
PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of pipe hangers, brackets, supports, bracing, anchorage, and the design for the pipe support system for pipes 12 inches and smaller and all FRP odor control piping located at the odor control facility. Pipe supports shall be furnished complete with all necessary inserts, bolts, nuts, rods, washers, and other accessories. This section also covers the spacing of expansion joints in pipes 12 inches in diameter and smaller. Expansion joint products and materials are covered in the respective piping sections. This section covers pipe supports for the following pipe materials:

- Stainless Steel
- PVC/CPVC Schedule 80
- PVC Schedule 40
- FRP

1-2. GENERAL. Contractor shall provide pipe supports, anchors, flexible couplings, and expansion joints for all piping systems. The Drawings indicate pipe hanger supports for the FRP pipe within the wet well. Contractor shall design anchors, pipe supports, expansion joints, and flexible couplings not already shown on the Drawings, in accordance with the requirements specified herein.

Contractor’s design shall include pipe supports, bracing, and anchorage adjacent to expansion joints, couplings, valves, in-line devices, equipment, wyes and tees, or changes in direction as required for dismantling piping, removing valves or other in-line devices, disconnecting piping from equipment, and pipe support, in addition to supports in accordance with the maximum spacing specified herein. The pipe support system design by Contractor shall rigidly support pipe so there is no visible movement or visible sagging between supports. The system shall comply with specified piping code requirements.

Contractor shall not delete or relocate the supports, expansion joints, or couplings indicated on the Drawings without written approval of Engineer.

Pipe supports and expansion joints are not required in buried piping, but concrete blocking or other suitable anchorage shall be provided as indicated on the Drawings or specified in other sections.
1-2.01. **General Equipment Stipulations.** The General Equipment Stipulations shall apply to all supports furnished under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-3. **SUBMITTALS.** Complete data, catalog information, and drawings covering fabricated pipe supports, fabricated inserts, and stainless steel, galvanized, and copper-plated and plastic-coated pipe supports shall be submitted in accordance with the General Conditions. For FRP odor control piping, Contractor shall also submit design calculations stamped and signed by an engineer registered in the state of California. FRP pipe supports shall be designed for appropriate seismic and wind loadings. Prior to fabrication, Contractor shall submit details, calculations, and layout drawings for the fiberglass reinforced plastic pipe supports located at the odor control facility for review and approval by the Engineer.

Data shall include a listing of the intended use and general location of each item submitted.

When a wind and/or seismic design is required, Contractor shall submit confirmation of compliance with the Meteorological and Seismic Design Criteria section.

**PART 2 - PRODUCTS**

2-1. **MATERIALS.** Unless otherwise indicated, all pipe supports shall comply with ANSI/MSS SP-58 and MSS SP-69. Materials of construction for fabricated steel supports are covered in the Structural and Miscellaneous Metals section. All pipe support materials shall be packaged as necessary to ensure delivery in satisfactory condition.

Unless otherwise specified or indicated on the Drawings, pipe supports shall be fabricated of manufacturer's standard materials and provided with manufacturer's standard finish.

Design loads for inserts, brackets, clamps, and other support items shall not exceed the manufacturer's recommended loads.

Pipe supports shall be manufactured for the sizes and types of pipe to which they are applied. Strap hangers will not be acceptable. Threaded rods shall have sufficient threading to permit the maximum adjustment available in the support item. Continuously threaded rod is not acceptable for hanger rods over 12 inches [300 mm] in length.
Unless accepted by Engineer, the use of supports which rely on stressed thermoplastic components to support the pipe will not be permitted.

Contact between dissimilar metals, including contact between stainless steel and carbon steel, shall be prevented. Portions of pipe supports which come into contact with other metals that are dissimilar shall be rubber or vinyl coated. Supports for brass or copper pipe or tubing shall be copper plated or plastic coated.

Stainless steel supports shall be AISI Type 304 or 316 stainless steel, except for stainless steel supports fabricated by welding which shall be AISI Type 304L or 316L. Stainless steel supports shall be provided where indicated on the drawings.

Hot-dip galvanized supports shall be in accordance with ASTM A153 and A385. Galvanized supports shall be provided where indicated on the drawings.

Pipe support types and application shall comply with Table 1.

2-2. WIND AND SEISMIC LOADS. Wind and seismic loads for worst case conditions of either full, partially full, or empty pipes shall be considered in the design. Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

PART 3 - EXECUTION

3-1. APPLICATION. Concrete inserts or anchor bolts shall be used to support piping from new cast-in-place concrete. Fastening of supports to existing concrete and masonry shall be in accordance with the Anchorage in Concrete and Masonry section.

Anchorage shall be provided to resist thrust due to temperature changes, changes in diameter or direction, or dead-ending. Anchors shall be located as specified to force expansion and contraction movement to occur at expansion joints, loops, or elbows, and as needed to prevent excessive bending stresses and opening of mechanical couplings. Anchorage for temperature changes shall be centered between elbows and mechanical joints used as expansion joints. Anchorage for bellows type expansion joints may be located adjacent to the joint.

When expansion joints are required, pipe guides shall be provided adjacent to bellows type expansion joints. Guides will not be required where mechanical couplings are permitted as expansion joints. Guides shall be located on both sides of expansion joints, except where anchors are adjacent to the joint. Unless otherwise indicated on the Drawings, one guide shall be within four pipe diameters from the joint and a second guide within 14 pipe diameters from the first guide.
Pipe supports shall allow adequate movement; pipe guides shall not be used for anchoring pipe against longitudinal forces. Pipe guides shall be provided at locations as recommended by the manufacturer.

Pipe supports for insulated cold piping systems shall be sized for the outside diameter of the insulated pipe, and an insulation protection shield shall be installed between the support and the insulation. Rigid insulation inserts shall be installed between the pipe and the insulation shields for piping larger than 2 inches [50 mm] or when needed to prevent crushing of the insulation. Inserts shall be of the same thickness as the adjacent insulation and shall be vapor sealed.

Insulated hot piping systems shall be supported by clevises, clamps, support saddles, or rollers. Pipe clamps shall be attached directly to the pipe. Support saddles and rollers shall be sized for the outside diameter of the insulated pipe, and an insulation protection saddle shall be installed at the support.

When supports for the FRP piping systems are in contact with less than 180 degrees of the pipe surface or when the width of the support is less than one-third the nominal pipe diameter (4 inches [100 mm] minimum), an FRP or steel saddle, shaped to the outside diameter of the pipe, shall be bonded to at least the bottom 120 degrees of the pipe.

3-2. **TYPES OF SUPPORTS.** The products for pipe supports shall be as indicated in Table 1 for the specified type and size of support. Where stainless steel is specified for pipe supports but is not available from the name suppliers for the model specified in Table 1, Contractor shall provide a heavier duty support that is available in stainless steel.

**TABLE 1 - TYPES OF SUPPORTS**

<table>
<thead>
<tr>
<th>Description and Service</th>
<th>MSS SP 69 Type (Note 1)</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hangers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 2-1/2 inch [63 mm] and smaller pipe for hot and cold insulated piping | 1 | B-Line "B3100", Anvil "260"
| Clevis                  |                         | Piping Technology & Products Fig. 83. |
| Other services          |                         |               |
## TABLE 1 - TYPES OF SUPPORTS

<table>
<thead>
<tr>
<th>Description and Service</th>
<th>MSS SP 69 Type (Note 1)</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-style</td>
<td>5</td>
<td>B-Line &quot;B3690&quot;, Anvil &quot;67&quot;, Unistrut &quot;J Hanger&quot;, or Piping Technology &amp; Products Fig. 67.</td>
</tr>
<tr>
<td>Clevis</td>
<td>1</td>
<td>B-Line &quot;B3104&quot;, Anvil &quot;260&quot;, or Piping Technology &amp; Products Fig. 83.</td>
</tr>
</tbody>
</table>

3 Through 12 inch [75 through 300 mm] pipe (Note 3)

For hot insulated piping

| Double bolt | 3       | B-Line "B3144", Anvil "295", or Piping Technology & Products Fig. 70. |

For cold insulated piping

| Clevis | 1       | B-Line "B3100", Anvil "260", or Piping Technology & Products Fig. 83. |

For uninsulated cold piping

| Clamp | 4       | B-Line "3140", Anvil "212", or Piping Technology & Products Fig. 50. |
|       |         | B-Line "B3100", Anvil "260", or Piping Technology & Products Fig. 83. |
| Clevis | 1       | B-Line "B3100" or Anvil "260" for steel pipe; B-Line "B3102", Anvil "590", or Piping Technology & Products Fig. 83 C. L. for cast iron pipe. |

Other services

| Clevis | 1       | Concrete Inserts, Steel |
# Pipe Supports

15140-6

## TABLE 1 - TYPES OF SUPPORTS

<table>
<thead>
<tr>
<th>Description and Service</th>
<th>MSS SP 69 Type (Note 1)</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 inch [300 mm] and smaller pipe</td>
<td>18</td>
<td>Channel 12 ga [2.66 mm thick], galv, 1-5/8 by 1-3/8 inches [41.3 by 34.9 mm], min. 8 inches [200 mm] long, anchor lugs on 4 inch [100 mm] centers, at least three lugs, end caps, and filler strip.</td>
</tr>
</tbody>
</table>

Beam Clamps, Malleable Iron or Steel, 12 inch [300 mm] and smaller pipe | 21 | B-Line "3050" and "3055", Anvil "133" and "134", or Piping Technology & Products Fig. 130 and Fig. 130 (SP). |
| | 28, 29 | Anvil "292" or Piping Technology & Products Fig. 140. |
| | 30 | B-Line "3054", Anvil "228", or Piping Technology & Products Fig. 140. |

Side Beam Bracket | 34 | B-Line "B3062", Anvil "202", or Piping Technology & Products Fig. 20L. |

Wall Supports and Frames, Steel, 12 inch [300 mm] and smaller pipe (Note 2) | Brackets | 32 | B-Line "B3066", Anvil "195", or Piping Technology & Products Fig. 76. |
| | 33 | B-Line "B3067", Anvil "199", or Piping Technology & Products Fig. 76. |

Prefabricated channels | -- | B-Line "B3066", Anvil "195", or Piping Technology & Products Fig. 76. |

Offset pipe clamp, 1-1/2 inch [38 mm] and smaller pipe | -- | Galv, 1-1/4 by 3/16 inch [32 by 4.7 mm] steel, with 3/8 inch [9.5 mm] bolts. |
TABLE 1 - TYPES OF SUPPORTS

<table>
<thead>
<tr>
<th>Description and Service</th>
<th>MSS SP 69 Type (Note 1)</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset pipe clamp, 2 to 3-1/2 inch [50 to 88 mm] pipe</td>
<td>--</td>
<td>Galv, 1-1/4 by 1/4 inch [32 by 6 mm] steel, with 3/8 inch [9.5 mm] bolts.</td>
</tr>
<tr>
<td>Floor Supports, Steel or Cast Iron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 inch [150 mm] and smaller pipe</td>
<td>37 (with base)</td>
<td>B-Line &quot;B3090&quot;, Anvil &quot;259&quot; or Piping Technology &amp; Products Fig. 48.</td>
</tr>
<tr>
<td>8 through 12 inch [200 to 300 mm] pipe</td>
<td>38</td>
<td>B-Line &quot;B3093&quot;, Anvil &quot;264&quot; or Piping Technology &amp; Products Fig. 46.</td>
</tr>
<tr>
<td>Pipe Alignment Guides</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Turnbuckles Steel</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Hanger Rods, Carbon Steel, Threaded Both Ends, 3/8 inch [10 mm] minimum size</td>
<td>--</td>
<td>B-Line &quot;B3205&quot;, Anvil &quot;140&quot;, or Piping Technology &amp; Products Fig. 128.</td>
</tr>
<tr>
<td>Weldless Eye Nut, steel</td>
<td>17</td>
<td>B-Line &quot;B3200&quot;, Anvil &quot;290&quot;, or Piping Technology &amp; Products Fig. 40.</td>
</tr>
<tr>
<td>Insulation Protection Saddle</td>
<td>39</td>
<td>B-Line &quot;B3160 Series&quot;, Anvil &quot;160 Series&quot;, or Piping Technology &amp; Products Fig. 184.</td>
</tr>
<tr>
<td>Insulation Protection Shield</td>
<td>40</td>
<td>B-Line &quot;B3151&quot;, Anvil &quot;167&quot;, or Piping Technology &amp; Products Fig. 183.</td>
</tr>
</tbody>
</table>

Table 1 Notes:

1. MSS SP-69 supports and hangers are illustrated on Figure 1-15140.
2. Pipe clamps or other devices which rely on the application of a clamping force to the supported pipe in order to maintain the clamp position or location in a prefabricated channel or track will not be acceptable for use with nonmetallic pipe or tubing.
3. Alternatively, pipe hangers for 12 inch pipe may be saddle type as indicated on the Drawings.

3-3. **SUPPORT SPACINGS.** Pipe supports and expansion joints shall be spaced in accordance with Tables 2, 3, 4, and 5. The types of pipes to be supported are as specified herein. Table 2 covers spacings for the standard operating conditions specified for each pipe material. Tables 3 and 4 cover PVC and FRP pipe spacings where operating conditions are in excess of the temperature and specific gravity requirements covered in Table 2. Table 5 covers PVC and FRP pipe which carries air or liquids with a specific gravity other than 1.0. Spacing in the tables is the maximum spacing considering gravity loads. Where Contractor’s design includes lateral and longitudinal forces due to seismic loads, wind loads, and other forces, the spacing requirement may be less than that indicated in the tables.

**TABLE 2 – MAXIMUM PIPE SUPPORT SPACING AT STANDARD TEMPERATURES AND SERVICES**

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Pipe Support Max Spacing feet [m]</th>
<th>Max Run Without Expansion Joint, Loop, or Bend feet [m]</th>
<th>Max Run Expansion Joint Max Spacing feet [m]</th>
<th>Type of Expansion Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-1/2 to 4 inch [38 to 100 mm]</td>
<td>10 [3.0]</td>
<td>30 [9.1]</td>
<td>100 [30.5]</td>
<td>Note 3</td>
</tr>
<tr>
<td>PVC, Schedule 80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/8 and 1/4 inch [3 and 6 mm]</td>
<td>Continuous Support</td>
<td>20 [6.1]</td>
<td>60 [18.3]</td>
<td>Note 3</td>
</tr>
</tbody>
</table>
TABLE 2 – MAXIMUM PIPE SUPPORT SPACING AT STANDARD TEMPERATURES AND SERVICES

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Max Spacing</th>
<th>Max Run Without Expansion Joint, Loop, or Bend</th>
<th>Max Run With Expansion Joint Max Spacing (Note 1)</th>
<th>Type of Expansion Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 inch [38 and 50 mm]</td>
<td>5-1/2 [1.6]</td>
<td>20 [6.1]</td>
<td>60 [18.3]</td>
<td>Note 3</td>
</tr>
<tr>
<td>2-1/2 inch [63 mm]</td>
<td>6 [1.8]</td>
<td>20 [6.1]</td>
<td>60 [18.3]</td>
<td>Note 3</td>
</tr>
<tr>
<td>4 inch [100 mm]</td>
<td>7-1/2 [2.3]</td>
<td>20 [6.1]</td>
<td>60 [18.3]</td>
<td>Note 3</td>
</tr>
</tbody>
</table>

PVC, Schedule 40, for services at a maximum temperature of 100°F [38°C], and a maximum specific gravity of 1.0.

1-1/4 inch and 1-1/2 inch [31 and 38 mm] | Continuous Support | 20 [6.1] | 60 [18.3] | Note 3 |
| 1/2 inch [13 mm] | 3-1/2 [1.0] | 20 [6.1] | 60 [18.3] | Note 3 |
| 1-1/4 inch and 1-1/2 inch [31 and 38 mm] | 4-1/2 [1.3] | 20 [6.1] | 60 [18.3] | Note 3 |
**Table 2 – Maximum Pipe Support Spacing at Standard Temperatures and Services**

<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Max Spacing</th>
<th>Without Expansion Joint, Loop, or Bend</th>
<th>Expansion Joint Max Spacing</th>
<th>Type of Expansion Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inch [75 mm]</td>
<td>6 [1.8]</td>
<td>20 [6.1]</td>
<td>60 [18.3]</td>
<td>Note 3</td>
</tr>
<tr>
<td>4 inch [100 mm]</td>
<td>6-1/2 [1.9]</td>
<td>20 [6.1]</td>
<td>60 [18.3]</td>
<td>Note 3</td>
</tr>
</tbody>
</table>

**Table 2 Notes:**

1. Unless otherwise acceptable to Engineer, an expansion joint shall be provided in each straight run of pipe having an overall length between loops or bends exceeding the maximum run specified herein.
2. Unless otherwise acceptable to Engineer, the spacing between expansion joints in any straight pipe run shall not exceed the maximum spacing specified herein.
3. Expansion joint fittings are specified in the respective piping sections.
4. At least two properly padded supports for each pipe section.
5. At least one support for each pipe section.
6. Expansion joints shall be mechanical couplings.
7. No expansion joints are required.
8. Supports for 5 and 10 foot [1.5 and 3 m] long pipe sections shall be located within 18 inches [460 mm] of each joint. Supports shall be positioned to maintain the piping alignment and to prevent the piping from sagging.
9. References to specific gravity refer to liquid specific gravity and are referenced to water which is assumed to have a specific gravity of 1.0.

**3-3.01. Temperature Adjustments for PVC Pipe.** Not used.
3-3.02. **Temperature Adjustments for FRP Pipe.** Not used.

3-3.03. **Specific Gravity Adjustments for PVC and FRP Pipe.** Not used.

3-4. **INSTALLATION.**

3-4.01. **General.** All piping shall be supported in a manner which will prevent undue stress on any valve, fitting, or piece of equipment. In addition, pipe supports shall be provided at changes in direction or elevation, and adjacent to flexible couplings. Pipe supports and hangers shall not be installed in equipment access areas.

Where horizontal piping is arranged with two or more parallel lines, trapeze hangers may be used in lieu of individual hangers. Trapeze assembly shall consist of structure attachments as previously specified with rod size dependent upon total weight supported. Spacing of assemblies shall be determined by the minimum pipe size included in the group supported. Trapeze horizontal assemblies shall be structural angle or channel section of sufficient size to prevent measurable sag between rods when pipes are full. All lines shall be attached to the horizontal with intermediate pipe guides and U-bolts or one-hole clamps. Pre-engineered support equipment may be used when selected and installed in accordance with the manufacturer's recommendations.

Where copper pipe is installed on a support system of dissimilar metal with other pipes, the copper pipe shall be galvanically isolated from the support using Neoprene strips or other material acceptable to Engineer.

No piping shall be supported from the pipe above.

Horizontal piping hanger support rods shall attach to steel beams with center-loading I-clamps, or welded beam clips. Hanger support rods shall attach to concrete slabs or beams with inserts.

Anchorage shall be provided to resist both lateral and longitudinal seismic forces.

3-4.02. **Inserts.** Reference building structural concrete Drawings for concrete inserts. When not provided as part of the building concrete structure, provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

Where concrete slabs form finished ceilings, provide inserts flush with the slab surface.
Pipe Supports
15140-12

Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab. NDE (Non-Destructive Evaluation) shall be used to locate existing reinforcing before drilling.

3-4.03. **Pipe Hangers and Supports.** Hanger rod sizes for copper pipe and plastic pipe shall be the size of hanger rods for steel pipe. Install hangers to provide a minimum 1/2 inch [13 mm] space between finished covering and adjacent work.

A hanger shall be placed within 18 inches [450 mm] of each horizontal elbow, and on both sides of all piping accessories and valves weighing 20 lbs [9 kg] or more.

Hangers shall have 1-1/2 inches [38 mm] minimum vertical adjustment.

Support horizontal cast iron, ductile iron and no-hub piping systems adjacent to each joint.

Support vertical piping at every floor using riser clamps.

Support riser piping independently of connected horizontal piping.

Hanger and hanger components shall be sized specifically for the pipe size it is to be used on.

3-5. **PLACEMENT.** The maximum spacing for pipe supports and expansion joints shall be as indicated in Tables 2, 3, 4, and 5.

Rubber hose and flexible tubing shall be provided with continuous angle or channel support.

Unless otherwise indicated on the Drawings or acceptable to Engineer, piping shall be supported approximately 1-1/2 inches [38 mm] out from the face of walls and at least 3 inches [75 mm] below ceilings.

**END OF SECTION**
PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of materials, appliances, fixtures, equipment, and appurtenances associated with the plumbing systems as specified herein and as indicated on the Drawings. Additional requirements for plumbing systems shall be as indicated in the schedules on the Drawings. Suitable connections shall be provided for each fixture, piece of equipment, and appurtenance.

Pipe materials, valves, thermal insulation, and pipe supports which are not an integral part of the fixture or piece of equipment and are not specified herein are covered in other sections.

1-2. GENERAL. Materials furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the Drawings, Specifications, engineering data, instructions, and recommendations of the manufacturer unless exceptions are noted by Engineer.

1-2.01. Coordination. Contractor shall verify that each component of the plumbing system is compatible with all other parts of the system; that all piping, fixtures, and appurtenances are appropriate; and that all devices necessary for a properly functioning system have been provided.

Where two or more units of the same class of equipment are required, they shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

Each manufacturer of water heaters, shall have a local service center, or with written consent of Engineer, shall be able to provide service from other locations within 24 hours. The service center shall be equipped and staffed to service the system and shall maintain a local parts supply. Information on equipment manufacturers' representatives shall be included with the submittals.

Where several manufacturers' names have been listed in this section as possible suppliers, only the products of the first manufacturer listed have been checked for size, functions, and features.
1-2.02. **General Equipment Stipulations.** The General Equipment Stipulations shall apply to all equipment and materials provided under this section. If requirements in this specification differ from those in the General Equipment Stipulations, the requirements specified herein shall take precedence.

1-2.03. **Seismic Design Requirements.** Seismic design requirements for products specified herein shall be as indicated in the Meteorological and Seismic Design Criteria section.

1-2.04. **Governing Standards.** Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between this section and any state law or local ordinance, the latter shall govern.

All work shall conform to the requirements of AGA, ASTM, NFPA, and UL safety requirements.

1-2.05. **Power Supply.** Unless otherwise specified, power supply to equipment with motors shall be as indicated on the Drawings. Power supply for controls shall be 120 volts, 60 Hz, single phase unless otherwise required for a properly operating system.

1-2.06. **Metal Thickness.** Metal thicknesses and gages specified herein are minimum requirements. Gages refer to US Standard gage.

1-2.07. **Mechanical Identification.** Mechanical identification shall conform to the requirements of the Basic Mechanical Building Systems Materials and Methods section.

1-3. **SUBMITTALS.**

1-3.01. **Drawings and Data.** Complete assembly and installation drawings, and wiring and schematic diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the Submittals Procedures section. Device tag numbers indicated on the Drawings shall be referenced on the wiring and schematic diagrams where applicable. The data and specifications to be submitted for each unit shall include, but shall not be limited to, the following:

- **Equipment, Piping Accessories, and Appurtenances**
  - Name of manufacturer.
  - Type and model.
  - Construction materials, thicknesses, and finishes.
  - Capacities.
Pressure and temperature ratings.
Overall dimensions.
Piping connection sizes and locations.
Net weight.
Horsepower [kW].
Power requirements.
Wiring diagrams.

**Plumbing Fixtures**
- Name of manufacturer.
- Type and model.
- Construction materials, thicknesses, and finishes.
- Water consumption data.
- Overall dimensions.
- Rough-in dimensions.
- Piping connection sizes and locations.
- Net weight.

**Seismic Design Requirements**
- Confirmation of compliance with the requirements of the Meteorological and Seismic Design Criteria section.

1-3.02. **Operations and Maintenance Data and Manuals.** Adequate operation and maintenance information shall be supplied as required in the Submittals Procedures section. Operation and maintenance manuals shall be submitted in accordance with the Submittals Procedures section.

Operation and maintenance manuals are required for emergency fixtures, water heaters, hose reels.

1-4. **QUALITY ASSURANCE.**

1-4.01. **Welding Qualifications.** All welding procedures and welding operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of AWS Standard Qualification Procedures. All procedure and operator qualifications shall be in written form and subject to Engineer’s review. Accurate records of operator and procedure qualifications shall be maintained by Contractor and made available to Engineer upon request.

1-4.02. **Qualification.** The plumbing system installer shall be licensed as stipulated by the authority having jurisdiction.
1-4.03. **Manufacturer’s Experience.** Unless the equipment manufacturer is specifically named in this section, the manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than the past 5 years.

1-4.04. **Construction.** Plumbing fixtures shall be constructed in accordance with the following standards:

- **Enameled Cast Iron**
  - ANSI/ASME A112.19.1M
- **Vitreous China**
  - ANSI/ASME A112.19.2M
- **Stainless Steel**
  - ANSI/ASME A112.19.3M
- **Faucets**
  - ANSI/NSF 61
- **Emergency/Safety Fixtures**
  - ANSI Z358.1

Electric water coolers shall be UL listed and certified in accordance with the Air Conditioning and Refrigeration Institute (ARI) Standard 1010. All materials in contact with water shall comply with the Reduction of Lead in Drinking Water Act. All plumbing fittings and fixtures intended to convey or dispense water for human consumption shall comply with the requirements of NSF/ANSI 61 and NSF/ANSI 372 for lead-free.

1-5. **DELIVERY, STORAGE, AND HANDLING.** Shipping shall be in accordance with the Product Delivery Requirements section. Handling and storage shall be in accordance with the Product Storage and Handling Requirements section.

1-6. **EXTRA MATERIALS.** Not used

**PART 2 - PRODUCTS**

2-1. **SERVICE CONDITIONS.** All plumbing fixtures and equipment shall be designed and selected to meet the specified conditions.

2-2. **PERFORMANCE AND DESIGN REQUIREMENTS.** All fixtures and equipment shall be designed to meet the performance and design conditions specified herein and indicated on the Drawings.

2-2.01. **Dimensional Restrictions.** Layout dimensions will vary between manufacturers and the layout area indicated on the Drawings is based on typical values. Contractor shall review the contract Drawings, the manufacturer’s layout drawings, and installation requirements and shall make any modifications required for proper installation subject to acceptance by Engineer.
2-3. **ACCEPTABLE MANUFACTURERS.** Acceptable manufacturers shall be as listed in the respective product description paragraphs.

2-4. **MANUFACTURE AND FABRICATION.**

2-4.01. **Anchor Bolts and Expansion Anchors.** Anchor bolts, expansion anchors, nuts, and washers shall be as indicated in the Anchorage In Concrete and Masonry section unless otherwise indicated on the Drawings.

2-4.02. **Surface Preparation.** All iron and steel surfaces, except motors and speed reducers, shall be shop cleaned by sandblasting or equivalent, in strict conformance with the paint manufacturer’s recommendations. All mill scale, rust, and contaminants shall be removed before shop primer is applied.

2-4.03. **Shop Painting.** All steel and iron surfaces shall be protected by suitable coatings applied in the shop. Surfaces which will be inaccessible after assembly shall be protected for the life of the equipment. Coatings shall be suitable for the environment where the equipment is installed. Exposed surfaces shall be finished, thoroughly cleaned, and filled as necessary to provide a smooth, uniform base for painting. Electric motors, speed reducers, starters, and other self-contained or enclosed components shall be shop primed or finished with an oil-resistant enamel or universal type primer suitable for top coating in the field with a universal primer and aliphatic polyurethane system.

Surfaces to be coated after installation shall be prepared for painting as recommended by the paint manufacturer for the intended service, and then shop painted with one or more coats of the specified primer.

Surface finish damaged during installation shall be repaired to the satisfaction of Engineer. Field painting shall conform to the requirements of the Protective Coatings section.

2-4.04. **Equipment Bases.** Unless otherwise indicated or specified, all equipment shall be installed on concrete bases at least 6 inches [150 mm] high. Each unit and its drive assembly shall be supported on a single baseplate of neat design. Baseplates shall have pads for anchoring all components. Baseplates will be anchored to the concrete base with suitable anchor bolts.

2-4.05. **Special Tools and Accessories.** Equipment requiring periodic repair and adjustment shall be furnished complete with all special tools, instruments, and accessories required for proper maintenance. Equipment requiring special devices for lifting or handling shall be furnished complete with those devices.
2-4.06. Piping Systems. Unless otherwise specified herein, piping system materials shall be as specified in other sections.

2-4.07. Valves. Unless otherwise specified herein, valves indicated to be a part of the plumbing systems shall be as specified in other sections.

2-5. WATER SUPPLY PIPING ACCESSORIES.

2-5.01. Water Hammer Arresters. Not used.

2-5.02. Trap Primers. Not used.

2-5.02.01. Flow Activated Trap Primers. Not used.

2-5.02.02. Pressure Activated Trap Primers. Not used.

2-5.02.03. Tailpiece Trap Primers. Not used.

2-5.03. Thermostatic Mixing Valves. Not used.

2-5.04. Vacuum Relief Valves. Not used.

2-5.05. Thermometers. Thermometers shall be Weksler Instruments "Adjust Angle", Ashcroft "Series EI Everyangle" or Weiss Instruments, Inc. “Vari-angle”.

Thermometers shall be bimetal type and shall have a dial at least 4-1/2 inch [114 mm] diameter, with black markings on a white background. Pointer travel shall span not less than 200 degrees nor more than 270 degrees. Each thermometer shall have a stainless steel case, bezel, fittings, and stem and shall be hermetically sealed, with external pointer adjustment and an acrylic or shatterproof glass window.

Each indicator shall be furnished with an angularly adjustable frame for convenient viewing. Unless otherwise indicated, thermometer range shall be 0 to 200°F [-10 to 110°C].

Each thermometer shall be furnished with a stainless steel thermowell for installation in the piping systems. The thermowells shall have 3/4 inch [20 mm] NPT thread mounts, a minimum pressure rating of 250 psig [1725 kPa gauge], and a nominal 4 inch [100 mm] insertion length.

2-5.06. Strainers. Not used.
2-5.07. **Hose Faucets.** Not used.

2-5.08. **Hose Valves.** Each angle type hose valve shall consist of an angle valve and hose nipple. Angle valves shall be Class 150 angle type with bronze body, PTFE disc, union bonnet, rising stem, and threaded ends. Angle type hose valves shall be Stockham “B-222T”, Milwaukee, or Powell. Hose nipples shall be one piece, cast brass or bronze, with male NPT and male hose thread ends. A cap and chain shall be provided for hose valves in interior locations. Hose nipples shall be Potter-Roemer, Inc. “2830 Series”, Croker Corp., or Elkhart Brass.

All hose valves shall be 1-1/2 inch size unless otherwise indicated on the Drawings.

2-5.09. **Wall Hydrants.** Not used.

2-5.10. **Pressure Gauges.** Pressure gauges shall be Ashcroft "Duragauge 1279", Weksler, or Weiss Instruments, Inc.

Except as modified or supplemented herein, all gauges shall conform to the requirements of ANSI B40.1. Accuracy shall be ANSI Grade A or better. Gauges shall be indicating dial type with C-type phosphor bronze Bourdon tube, stainless steel rotary geared movement, phenolic open-front turret, stainless steel or phenolic ring, case, adjustable pointer, and acrylic or shatterproof glass window.

The dial shall be 4-1/2 inch [114 mm] in diameter with black markings on a white background. The units of measurement shall be psi and shall be indicated on the dial face. The pointer shall span not less than 200 degrees nor more than 270 degrees. The range shall be selected so that the normal operating reading is near the midpoint of the scale.

Each gauge shall be provided with a threaded end ball-type shutoff valve as specified in the Ball Valves section.

All stem-mounted gauges shall be provided with 1/2 inch [13 mm] NPT connections.

2-6. **DRAINAGE AND VENT PIPING ACCESSORIES.**

2-6.01. **Cleanouts.** Cleanouts shall be provided where indicated on the Drawings and required by the referenced codes, and shall be of the required type.
Floor cleanouts shall consist of a two piece body, a threaded plug, an adjustable head, and a cover. Cleanouts installed in floors that include a waterproofing membrane shall be provided with a flashing flange and membrane clamp. Cleanouts installed in partition walls shall be provided with an access cover and frame with a securing screw installed over the cleanout plug. Wall cleanout covers shall be stainless steel. Cleanouts installed in exposed piping shall consist of a ferrule or threaded adapter and a cast brass or bronze plug installed in a T-pattern, 90 degree drainage fitting.

Cast iron cleanouts shall be manufactured by Smith, Josam, or Wade. Polypropylene cleanouts shall be manufactured by Orion, Enfield, or Zurn. PVC cleanouts shall be manufactured by Sioux Chief, Plastic Oddities, or Zurn.

2-6.02. Bell-Up Drains. Not used.

2-6.03. Funnel Receptors. Funnel receptors shall consist of cast iron funnels with cast iron dome type bottom strainers. Funnel receptors shall be provided with waterstop flange and threaded or no-hub outlet connections suitable for connection to the waste piping. Funnel receptors connected to chemical resistant waste systems shall be furnished with a factory applied chemical resistant interior coating. Unless otherwise indicated, funnel receptors shall be installed 1 inch [25 mm] above the finished floor.

Funnel receptors shall be Smith “Series 3800 Figure SQ-3-1793-DBS”, Josam, or Wade.

2-6.04. Floor Drains. Floor drains shall be of the types specified herein and indicated on the Drawings. Floor drains shall have a two-piece body, a flashing collar, an adjustable head, and a grate. A trap primer connection shall be provided when indicated on the Drawings. Floor drains installed in floors that include a waterproofing membrane shall be provided with a flashing flange and membrane clamp.

Cast iron floor drains shall be manufactured by Smith, Josam, or Wade. Polypropylene floor drains shall be manufactured by Orion, Enfield, Zurn. PVC floor drains shall be manufactured by Sioux Chief, Plastic Oddities, or Zurn.

2-6.05. Roof Drains and Overflow Roof Drains. Not used.

2-6.06. Downspout Nozzles. Not used.

2-6.07. Modular Trench Drain System. Not used.

2-6.08. Floor Sinks. Not used.

2-6.10. **Vent Flashings.** Plumbing vent flashings shall be furnished and installed as indicated on the Drawings.

2-7. **PLUMBING FIXTURES AND ACCESSORIES.**

2-7.01. **General.** Plumbing fixtures shall be provided with all required supports, fasteners, supply and drain fittings, gaskets, and escutcheons required for a complete installation.

2-7.02. **Water Closets.** Not used.

2-7.03. **Urinals.** Not used.

2-7.04. **Lavatories.** Not used.

2-7.05. **Showers.** Not used.

2-7.08. **Emergency Fixtures.** Emergency fixtures, including showers, eye/face washes, and combination shower/eye/face wash units shall be furnished and installed as indicated on the Drawings. Emergency fixtures shall be manufactured by Haws, Guardian, or Encon.

2-7.08.01. **Indoor Emergency Eyewash Fixtures.**

2-7.08.02. **Indoor Emergency Shower Fixtures.**

2-7.08.03. **Indoor Combination Units.** Not used.

2-7.08.04. **Corrosion Resistant Combination Units.** Corrosion resistant combination emergency shower/eye/face wash fixtures shall be pedestal mounted, with 2-1/2 inch schedule 80 PVC stanchion, floor flange, deluge shower, aerated eye/face wash, eye/face wash dust cover, stay-open stainless steel ball valves, interconnecting piping, and universal emergency sign. The shower shall be stainless steel or ABS plastic with stainless steel pull rod actuator. The eye/face wash receptor shall be stainless steel or plastic with push plate actuator.

2-7.08.05. **Freezeproof Emergency Eyewash Fixtures.** Not used.

2-7.08.06. **Freezeproof Emergency Shower Fixtures.** Not used.
2-7.08.07. **Freezeproof Combination Units.** Freezeproof combination emergency shower/eyewash fixtures shall be pedestal mounted, with a stanchion, a floor flange, a deluge shower, an aerated eye/face washes, freezeproof stay-open valves, interconnecting piping, freeze protection bleed valve, scald protection bleed valve, and a universal emergency sign. The shower and eye/face wash shall be stainless steel or ABS plastic with a stainless steel actuator. The entire unit shall be provided with self-regulating heating cable and shall be insulated with polyethylene foam insulation. The insulation shall be provided with a removable, UV resistant, ABS plastic jacket with gasketing and removable fasteners.

2-7.08.08. **Alarm Systems.** An audible and visual alarm system shall be provided when indicated on the Drawings. The alarm system shall activate based on water flow when either the emergency shower or eyewash fixture is operated. The alarm system shall provide local, remote, or local and remote alarm indication as indicated on the Drawings. The water flow switch shall be provided with double-pole double-throw contacts rated 5 amperes at 125 volts, suitable for remote alarm annunciation. The audible alarm shall provide an intermittent signal rated at 90 dB at 10 feet. The alarm light shall be amber, flashing type. The alarm system shall be pre-wired and shall be furnished with all necessary junction boxes, conduit, wire, and accessories for a complete installation. The alarm system shall be suitable for a 120 volt power supply.

2-7.08.09. **Tempered Water Blending Valves.** Not used.

2-7.08.10. **Scald Protection Valves.** Scald protection valves shall be designed specifically for providing scald protection to emergency shower and eyewash fixtures. Each valve shall be constructed of a one piece bronze or brass body with threaded inlet and outlet connections, and shall contain a removable cartridge for cleaning and maintenance, automatic thermal actuator bleed valve that opens when water temperature exceeds 95° F and closes when the water temperature falls below 87° F. Scald protection valves shall be as manufactured by Haws “Model SP157B”, Guardian or Encon.

2-7.08.11. **Electric Instantaneous Emergency Fixture Water Heaters.** Instantaneous water heaters shall be industrial tankless type designed specifically for emergency shower/eyewash tempered water service, and shall heat water on demand as determined by an integral flow switch. Heaters shall be suitable for operating water pressures of 25 to 150 psig [14 to 1034 kPa gauge]. Heater waterways shall be of brass/copper construction. If required by applicable codes, each heater shall be provided with a temperature and pressure relief valve. Heaters shall be provided with thermostatic control, internal fusing, 100 degree thermal cut off fuses, and digital temperature control. Provide LED controller with dual display of set point and actual temperature with set point temperature locked out to a specified range.
Provide fully modulating PID temperature control with a +/- 1 degree F accuracy on regulated pressure, external emergency stop button, and NEMA 4 enclosures. Provide factory floor stand kit for free standing installation. Electric instantaneous water heaters shall be UL listed and shall be manufactured by Keltech SN Safety Shower Series.

2-7.09. Wash Fountains. Not used.


2-8. PLUMBING EQUIPMENT.

2-8.01. General. Plumbing equipment shall be provided with all supports, fasteners, fittings, and escutcheons required for a complete installation.

2-8.02. Water Heaters and Accessories. Water heaters shall be furnished and installed where indicated on the Drawings. Heater type, storage capacity, recovery rate, energy input, power supply requirements, manufacturer, and model shall be as indicated on the Drawings.

2-8.02.01. Commercial Grade Electric Storage Water Heaters. Not used.

2-8.02.02. Industrial Grade Electric Storage Water Heaters. Not used.

2-8.02.03. Electric Instantaneous Water Heaters. Instantaneous water heaters shall be tankless type and shall heat water on demand as determined by an integral flow switch. Heaters shall be suitable for operating water pressures of 25 to 150 psig [14 to 1034 kPa gauge], and shall be provided with compression type tubing connections. Heater elements shall be constructed of stainless steel or glass reinforced plastic, and shall be replaceable. If required by applicable codes, each heater shall be provided with a temperature and pressure relief valve. Heaters shall be provided with thermostatic control. Electric instantaneous water heaters shall be UL listed and shall be manufactured by Chronomite Laboratories Inc., Eemax, or Stiebel Eltron.


2-8.02.05. Industrial Grade Gas-Fired Water Heaters. Not used.

2-8.02.06. Water Heater Flues. Not used.

2-8.03. Neutralization Tanks. Not used.
2-8.04. **Hose Reels.** Hose reel type, capacity, manufacturer, and model shall be as indicated on the Drawings.

Each hose reel shall be provided complete with a hose storage drum, a handle crank winding mechanism, a spring-actuated pin lock, and a heavy duty frame suitable for anchoring to concrete or masonry wall or floor supports. Unless indicated on the Drawings to be stainless steel, hose reels shall be carbon steel with a baked epoxy enamel finish. When indicated on the Drawings, hose reels shall be provided with a water supply swivel joint rated at 600 psig [4,130 kPa gauge]. The hose storage drum shall be provided with a brass male hose adapter suitable for use with the specified hose. The hose reels shall be manufactured by Hannay, Potter-Roemer, or Reelcraft.

2-8.05. **Hoses.** Hose type, diameter, manufacturer, and model shall be as indicated on the Drawings.

Unless otherwise indicated, each hose shall be provided with one male swivel type brass hose connector, one female brass hose connector, and one regulating wash-up spray nozzle. Spray nozzles in 1 inch [25 mm] and 1-1/2 inch [38 mm] sizes shall be Potter-Roemer Inc. "Series 2970" with a cast brass body, a rubber bumper, and a female hose thread.

2-8.05.01. **Type 1 Hoses.** Type 1 hoses shall be non-collapsible, suitable for water service and shall be rated for 150 psig [1030 kPa gauge] working pressure. The hose shall consist of 1-1/2 inch [38 mm] ID heavy-duty ethylene, propylene diene (EPDM) rubber tubing with synthetic, high tensile textile cord reinforcement and an EPDM cover. Type 1 hoses shall be Gates Rubber Company "Water Master" or Potter-Roemer “Model 2853”.

2-8.05.02. **Type 2 Hoses.** Not used.

2-8.05.03. **Type 3 Hoses.** Not used.

2-8.05.04. **Type 4 Hoses.** Not used.

2-8.06. **Interceptors.** Not used.

2-8.07. **Expansion Tanks.** Not used.

2-8.08. **Water Storage Tank.** Not used.

2-8.09. **Automatic Water Softener Unit.** Not used.
2-9. **COLOR.** Plumbing equipment shall have the manufacturer's standard color and finish unless otherwise indicated in the schedules.

2-10. **ELECTRICAL.** Electrical controls and disconnects shall be furnished and installed under the Electrical section, except where specified herein. All electrical controls shall have enclosures suitable for the environment and NEMA rating as indicated on the electrical Drawings.

**PART 3 - EXECUTION**

3-1. **INSPECTION.** Equipment installed in existing facilities with limited access shall be suitable for being installed through available openings. Contractor shall field verify existing opening dimensions and other provisions for installation prior to submittal of bids.

3-2. **PREPARATION.**

3-2.01. **Surface Preparation.** All surfaces to be field painted shall be dry and free of dirt, dust, sand, grit mud, oil, grease, rust, loose mill scale, or other objectionable substances, and shall meet the recommendations of the paint manufacturer for surface preparation. Cleaning and painting operations shall be performed in a manner which will prevent dust or other contaminants from getting on freshly painted surfaces. Oil and grease shall be completely removed by use of solvents or detergents before mechanical cleaning is started. The gloss of previously painted surfaces shall be dulled if necessary for proper adhesion of top coats.

3-3. **INSTALLATION.** Materials furnished under this section shall be installed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Engineer.

Unless otherwise indicated, sleeves shall be provided for all pipe penetrations through concrete and masonry walls. Sleeves and sealing requirements shall be as indicated in the Miscellaneous Piping and Accessories Installation section and as indicated on the Drawings.

Not all required reducing fittings and unions are indicated. Additional fittings and unions shall be provided as needed to connect all equipment and appurtenances.

Insulating fittings shall be provided to prevent the contact of dissimilar metals in piping systems.
Plumbing
15400-14

When located indoors, fuel gas pressure regulator vents and fuel train vent valves shall be piped to the exterior of the building in accordance with the applicable codes and standards.

Piping shall not be routed over or in front of electrical switchboards or panels unless acceptable to Engineer.

3-3.01  Water Supply Piping and Accessories.  Water hammer arresters shall be provided in the hot and cold water supply piping at all quick closing valves, at solenoid valves, and at plumbing fixtures.  When not indicated on the Drawings, arresters shall be located and sized by Contractor in accordance with PDI Standard No. WH201. Contractor shall submit arrester location and sizing plans to Engineer for approval prior to installation.  Where possible, water hammer arresters shall be installed in an accessible location.

Water supply piping to hose faucets and hose valves shall be secured with a pipe support within 6 inches [150 mm] of the fixture.

Scald protection valves shall be installed per manufacturer’s recommendation, adjacent to the actuation valve for each emergency shower and the eye/face wash where indicated in the schedules. Drain piping from valves shall be secured to adjacent unit support and routed to nearest funnel receptor and discharge with an air gap.

3-3.02  Drainage and Vent Piping and Accessories.  Unless otherwise indicated or required by code, horizontal sanitary drainage piping 3 inches [75 mm] in diameter or smaller shall be installed at a uniform slope of 1/4 inch per foot [2 percent]; horizontal sanitary drainage piping larger than 3 inches [75 mm] in diameter shall be installed at a uniform slope of 1/8 inch per foot [3 mm/300 mm]; horizontal storm drainage piping shall be installed at a uniform slope of 1/8 inch per foot [3 mm/300 mm].

Plastic drainage pipe buried beneath floors shall not be encased.  For buildings supported by piers or piles with plastic drainage piping which is buried beneath floors shall be supported with stainless steel pipe supports per ASTM F2536.

Drainage fittings shall be installed to convey flow in the piping in the intended direction. To the extent possible, changes in direction shall be made by sweep type fittings. Quarter-bends and sanitary tee fittings shall not be installed for vertical to horizontal or horizontal to horizontal changes of direction.
Plumbing vents through roofs shall be located at least 12 inches [300 mm] from a parapet or from the intersection of a cant with the roof deck, and shall be installed with watertight flashings. Plumbing vents shall be located no closer to operable windows or air intakes than is allowed by the applicable code.

Vents connecting to horizontal sanitary piping shall connect above the centerline of the piping and shall rise at an angle of not less than 45 degrees from the horizontal to a point at least 6 inches [150 mm] above the flood level rim of the fixture served before offsetting horizontally.

Floor drains shall be adjusted to the correct elevation for proper drainage. Heads of fastening screws shall be flush with the grate surface.

Cleanouts on drainage piping inside structures shall be located where indicated on the Drawings. Additional cleanouts shall be provided where required by the applicable code or authority having jurisdiction. Cleanouts located in drainage risers shall be located 12 inches [300 mm] above the finished floor.

Unless otherwise indicated or required by the applicable code, cleanout size shall equal the line size for 4 inch [100 mm] and smaller drainage piping, and 4 inches [100 mm] in diameter for drains larger than 4 inch [100 mm]. Proper clearance shall be provided for access to cleanouts. Floor cleanouts shall be installed flush with the finished floor.

Floor drains, trench drains, floor sinks, funnel receptors, and bell-up drains indicated to be equipped with traps shall be provided with deep seal "P" traps located as close to the drain as possible.

3-3.03. **Plumbing Fixtures and Accessories.** Not used.

3-3.04. **Plumbing Equipment.** Plumbing equipment shall be installed in accordance with the manufacturer's recommendations. Adequate clearance shall be provided for access to all components which may require adjustment, servicing, or replacement.

Water heaters shall be installed in accordance with AGA, NSF, NFPA, and UL requirements. Storage type water heaters shall be cleaned and flushed before being connected to the potable water system. Water heater relief valves shall be piped to the nearest drain or as indicated on the Drawings, and shall terminate the appropriate air gap distance above the drain. Unless otherwise indicated, water heater thermostats shall be set such that the maximum water temperature does not exceed 140 °F [60 °C].
3-4. **FIELD QUALITY CONTROL.**

3-4.01. **Installation Check.** An installation check by an authorized representative of the manufacturer of equipment specified herein is not required.

3-4.02. **Startup and Testing.** Field performance tests shall be conducted to demonstrate that each system is functioning as specified and to the satisfaction of Engineer.

If inspection or tests indicate defects, the defective work or material shall be replaced, and inspection and tests repeated. All repairs to piping shall be made with new materials. Caulking of threaded joints or holes will not be acceptable.

3-5. **ADJUSTING.** All devices shall be adjusted for proper flow and quiet operation. All drains shall be checked for proper operation.

3-6. **PROTECTION.** Plumbing equipment and appurtenances shall be protected from damage immediately after installation.

3-7. **CLEANING.** After completion of testing and immediately before the final inspection, plumbing fixtures, equipment, piping, and appurtenances shall be thoroughly cleaned. Cleaning materials and methods shall be as recommended by the manufacturer.

Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired at no additional cost to Owner.

3-8. **DISINFECTION.** Before the potable water system is placed in operation, it shall be disinfected in accordance with the requirements of the local authority having jurisdiction. In the absence of local requirements, the following disinfection method shall be used:

1. The system shall be purged with clean potable water until all dirt and other substances are flushed from the system.

3-9. **OPERATOR INSTRUCTION AND TRAINING.** After completion of the field testing, operator instruction and training on equipment and system operation shall be provided for water heaters (4hours). The training should provide a complete overview of all equipment, testing, adjusting, operation, and maintenance procedures. The training shall take the form of classroom instruction and shall cover:

   a. Documentation in the final Operation and Maintenance Manuals.
b. Use the Operation and Maintenance Manuals.

c. Equipment and system startup and shutdown.

d. System operation procedures for all modes of operation.

e. Procedures for dealing with abnormal conditions and emergency situations for which there is a specified system response.

The training shall take the form of classroom sessions at the project site conducted by the equipment manufacturer representatives who are knowledgeable and familiar with the project. Hands-on instruction and training will be conducted so that actual operation and maintenance of the equipment and systems can be performed by Owner upon completion of the training. The length of the operator instruction and training shall be.

At least two weeks prior to the proposed date for the operator instruction and training session, Contractor shall notify Engineer and shall submit an outline for the proposed operator instruction and training session. The proposed outline shall be approved before any training is conducted.

END OF SECTION
SPECIFICATIONS - DETAILED PROVISIONS

SECTION 15430
EMERGENCY EYEWASH/SOWER UNITS

TABLE OF CONTENTS

PART 1 GENERAL ................................................................................................................ 1
    1.01 SUMMARY ..................................................................................................................... 1
    1.02 REFERENCES ................................................................................................................ 1
    1.03 SUBMITTALS ................................................................................................................. 1
    1.04 QUALITY ASSURANCE ............................................................................................... 2
    1.05 DELIVERY, STORAGE, AND HANDLING ................................................................. 2

PART 2 PRODUCTS .............................................................................................................. 2
    2.01 EMERGENCY SHOWERS AND EYE WASHES ....................................................... 2

PART 3 EXECUTION ............................................................................................................. 4
    3.01 INSTALLATION ............................................................................................................. 4
    3.02 PROTECTION ............................................................................................................... 4
SECTION 15430

EMERGENCY EYEWASH/SHOWER UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Emergency shower and eyewash.

B. Inclusion of a specific manufacturer’s name in the Specifications does not mean that the specific manufacturer’s standard product will be acceptable. Specified manufacturer’s or other manufacturer’s standard product shall be modified as required to meet the specifications.

C. Related Sections/Standard Drawing:
   1. Section F - Labor and Construction.
   3. Section 13422C - Flow Field Instruments.
   4. Section 15050 - Basic Mechanical Materials and Methods.
   5. Section 16050 - Basic Electrical Materials and Methods.

1.02 REFERENCES

A. American National Standards Institute (ANSI):

B. NIOSH Schedule 13F.

1.03 SUBMITTALS

A. Shop Drawings.

B. Product Data:
   1. Submit manufacturer's product literature information for products specified.
   2. Manufacturer's Installation Instructions.

C. Operation and Maintenance Data.

D. Warranty.
1.04 QUALITY ASSURANCE  
A. Manufacturer Qualifications: Show evidence that the firm has been engaged in producing such materials and products for at least 5 years and that the product submitted has a satisfactory performance record of at least 5 years.  
B. Installer Qualifications: Installer shall have 3 years experience in installing these materials for similar projects and shall be approved by the manufacturer prior to bidding of the project.  
C. Regulatory Requirements:  
   1. As applicable, equipment of this Section shall comply with requirements of public agencies of the state where the project is located including OSHA, Cal-OSHA, Underwriters Laboratories, NFPA, and ASME.

1.05 DELIVERY, STORAGE, AND HANDLING  
A. Packing and Shipping: Deliver to the job site in manufacturer's original containers.  
B. Delivery: After wet operations in building are completed.  
C. Storage and Protection: Store materials in original, unopened containers in compliance with manufacturer's printed instructions.  
D. Keep materials dry until ready for use. Keep packages of material off the ground, under cover, and away from sweating walls and other damp surfaces.  
E. Protect finished surfaces from soiling and damage during handling and installation. Keep covered with a protective covering.

PART 2 PRODUCTS  

2.01 EMERGENCY SHOWERS AND EYE WASHES  
A. General Design Requirements:  
   1. Combination Unit Emergency Shower with Eyewash or Eye/Face Wash:  
      a. Floor mounted fixture consisting of pipe standard, shower head assembly, and eyewash assembly.  
      b. Provide stanchion and floor flange, with interconnecting piping.  
   2. Shower Head Flow: 20.0 GPM.  
   3. Eyewash or Eye/Face Wash Flow: 1.2 GPM flow, minimum.  
   4. Provide with manufacturer's standard corrosive resistive coating for steel pipe standards.  
   5. Meet or exceed all requirements of ANSI Z358.1.
6. Provide ANSI compliant identification sign and markings.
7. Provide dielectric coupling/bushing between dissimilar metals.

B. Stainless Steel Combination Unit Emergency Shower and Eye/Face Wash:
   1. Manufacturers: One of the following, no equal:
      a. HAWS, Model No. 8330.
      c. Bradley, Model No. S19-310SSJP.
   2. Pipe Standard: 1-1/4 inch stainless steel pipe (304SS) and fittings, with stainless steel rod providing additional support overhead; 5 inch diameter floor flange.
   3. Shower Head:
      a. Material and Size: Stainless steel (304SS), 10 inch diameter, or greater.
      b. Valve and Actuator: Stay open Type 316 stainless steel ball valve actuated by rigid stainless steel pull rod.
   4. Eye/Face Wash:
      a. Valve and Actuator: Stay open Type 316 stainless steel ball valve with stainless steel ball operated by stainless steel push handle and foot treadle.
      b. Heads: Stainless steel (304SS) soft-flow eye/face wash type heads, with integral flip top protective dust covers releasing with water pressure.
   5. Receptor Bowl: Stainless steel (304SS).

C. Safety Shower Tester:
   1. Manufacturers: One of the following or equal:
      a. Haws, No. 9010.
   2. Kit includes: 5-gallon plastic bucket, 7-foot long watertight 12-gallon translucent vinyl plastic bag for attaching over drench shower head, and testing record card. Bag shall have drawstring at top and be hemmed at bottom.

D. Safety Shower Tepid Water Supply System:
   1. Manufacturers: One of the following or equal:
      a. Haws.
   2. General Requirements:
      a. Provide one Tepid Water System for each safety shower unit or group of safety shower units mounted within 100 feet of each other.
      b. Tepid Water System to provide 20 gpm of water for a period of at least 15 minutes at a delivery temperature of 80 to 85 degrees Fahrenheit.
E. Flow Switch:
   1. Provide N.O. contact for remote indication when eye wash station is in use as indicated on the Drawings.
   2. Switch shall be as specified in Section 13422C.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturers' recommendations.

B. Install fixed equipment in accordance with manufacturer's instructions.

C. Plumbing and mechanical work shall be in accordance with Section 15050.

D. Electrical connections and distribution shall be in accordance with Section 16050.

3.02 PROTECTION

A. Repair or replace defective equipment with new.

END OF SECTION 15430
SECTION 15990
TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1-1. SCOPE. This section covers the cleaning, testing, adjusting, and balancing of the air system(s) associated with the odor control system(s).

1-2. GENERAL. Equipment and systems shall be cleaned, tested, adjusted, and balanced in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by Engineer.

1-2.01. Coordination. Contractor shall verify that all components and devices necessary for a properly functioning system have been provided. Prior to cleaning, testing, adjusting, and balancing, Contractor shall verify that each system has been installed properly and is operating as specified. Equipment bearings shall be lubricated in accordance with the manufacturer's recommendations.

Air systems shall be complete and operating, with dampers, filters, ductwork, air outlet and inlet devices, duct mounted equipment, and control components.

1-2.02. Governing Standards. Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between this section and any state law or local ordinance, the latter shall govern.

All work shall comply with the latest edition of AABC, NEBB, or SMACNA standard manuals for testing, adjusting, and balancing of air systems.

1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete apparatus report sheets for all air systems shall be accurately and completely filled out in accordance with the Standard's manual. The testing and balancing results shall be submitted on the TAB report forms of the applicable standard. Copies of the final test readings and report sheets shall be submitted in accordance with the Submittals Procedures section. A description of the standard procedures used during testing, adjusting, and balancing shall be included in the submittal.
The submittal shall include a reduced set of drawings, with the air outlet devices, air inlet devices, and equipment identified to correspond with the report sheets. Test dates shall be recorded on the individual TAB report forms indicating when the actual testing was performed.

The apparatus report sheets shall include the following information:

1. Title Page:
   a. Company name
   b. Company address
   c. Company telephone number
   d. Project name
   e. Project location
   f. Project Engineer
   g. Project Contractor
   h. Project altitude
   i. Date

2. Instrument List:
   a. Instrument
   b. Manufacturer
   c. Model
   d. Serial number
   e. Range
   f. Calibration date

3. Air Moving Equipment:
   a. Unit number
   b. Location
   c. Manufacturer
   d. Model and serial number
   e. Airflow, design and actual
   f. Total static pressure (total external), design and actual
   g. Static pressure, inlet and discharge
   h. Total pressure
   i. Fan RPM, design and actual

4. Electric Motors:
   a. Manufacturer
   b. Motor type and frame
   c. HP/BHP
   d. Phase, voltage, amperage, nameplate, actual, no load.
   e. RPM
   f. Service factor
   g. Starter size, rating, heater elements
5. V-Belt Drive:
   a. Required driven RPM
   b. Driven sheave make, diameter, and RPM
   c. Belt make, size, and quantity
   d. Motor sheave make, diameter, and RPM
   e. Center to center distance, maximum, minimum, and actual

6. Return Air/Outside Air Data: Not used.
7. Coil Data: Not used.
8. Duct Traverse: Not used.
   a. System zone/branch
   b. Duct size
   c. Area
   d. Velocity, design and actual
   e. Airflow, design and actual
   f. Duct static pressure
   g. Air temperature
   h. Air correction factor

9. Outlet and Inlet Devices: Not used.
10. Sound Level Report:
    a. Location
    b. Octave bands - equipment off
    c. Octave bands - equipment on

11. Package Air Conditioning/Heat Pump Unit: Not used.
12. Air Terminal Unit Data: Not used.
15. Chillers: Not used.
16. Pump Data: Not used.
17. Heat Exchanger: Not used.
18. Combustion Test: Not used.
19. Odor Control Vessels:
    a. Unit number
    b. Manufacturer and model
    c. Air pressure drop across media bed(s), design and actual

20. Mist Eliminators
    a. Manufacturer and model
    b. Equipment served
    c. Air pressure drop, design and actual

1-4. QUALITY ASSURANCE. Contractor shall provide the services of a licensed independent contractor, certified by AABC, NEBB, or TABB and with proven experience on at least three similar projects, to perform operational testing, adjusting, and balancing of the air systems.
The work shall be performed in accordance with the latest edition of the procedural standards as published by the National Organization associated with the testing, adjusting, and balancing contractor.

**PART 2 - PRODUCTS**

2-1. **SERVICE CONDITIONS.** All equipment shall be adjusted or balanced to meet the specified conditions and to operate at the elevation indicated in the equipment sections.

2-2. **CONSTRUCTION.**

2-2.01. **Painting.** Surface finish damaged during cleaning, testing, adjusting, and balancing of equipment shall be repaired to the satisfaction of Engineer. Field painting shall be as specified in the Painting and Protective Coatings section.

**PART 3 - EXECUTION**

3-1. **INSPECTION.** Before testing and balancing the air system, wet well access hatches shall be closed. Fans shall be checked for correct rotation and rotative speed. Dampers shall be open and access doors and panels shall be closed during the testing and balancing period.

A resistance shall be placed at all filter locations to simulate dirty filter conditions. The filter resistance shall be as follows:

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Simulated Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch pleated</td>
<td>0.15 inch water column</td>
</tr>
<tr>
<td>2 inch pleated</td>
<td>0.35 inch water column</td>
</tr>
</tbody>
</table>

3-2. **STARTUP REQUIREMENTS.** System equipment shall be subject to preliminary field tests as indicated in Startup Requirements section.

3-3. **FIELD PERFORMANCE TESTING.** Field performance tests shall be conducted for each system to demonstrate each is functioning as specified and to the satisfaction of Engineer. All tests shall be conducted in a manner acceptable to Engineer and shall be repeated as many times as necessary to secure Engineer’s acceptance of each system. If inspection or tests indicate defects, the defective item or material shall be replaced, and the inspection and tests shall be repeated. All repairs to piping shall be made with new materials. Caulking of threaded joints or holes will not be acceptable.
Air filters which are subject to a pressure loss exceeding the dirty filter values shall be removed and replaced. The spare air filters furnished with equipment shall not be used as the replacement filters. Dirty filter values shall be as follows:

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Dirty Filter Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch pleated</td>
<td>0.75 inch water column</td>
</tr>
<tr>
<td>2 inch pleated</td>
<td>1 inch water column</td>
</tr>
</tbody>
</table>

3-3.01. **Hydronic Piping.** Not used.

3-3.02. **Refrigerant Piping.** Not used.

3-4. **CLEANING.** At the completion of the testing, all parts of the installation shall be thoroughly cleaned. All equipment, ductwork, pipes, valves, and fittings shall be cleaned of grease, debris, metal cuttings, and sludge. Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired by Contractor at no additional cost to Owner.

3-4.01. **Chemical Pipe Cleaning.** Not used.

3-5. **ADJUSTING & BALANCING.** The air system shall be adjusted and balanced.

All instrumentation shall be calibrated in accordance with the governing standard manual and shall be checked for accuracy before testing, adjusting, and balancing the systems. The accuracy of the instrumentation shall be not less than specified by the testing, adjusting, and balancing standard manual or the instrument manufacturer.

All data, including system deficiencies encountered and corrective measures taken, shall be recorded. If a system cannot be adjusted to meet the design requirements, Contractor shall notify Engineer in writing as soon as practicable.

Following final acceptance of the certified balancing reports, the testing and balancing contractor shall permanently mark the settings of all adjustment devices, including valves and dampers, and shall lock the memory stops.

All ceiling tiles, belt guards, panels, and doors removed during testing, adjusting, and balancing shall be reinstalled.
3-5.01. **Air Systems.** Air systems shall be adjusted to the design airflows indicated on the Drawings. Airflows shall be adjusted to maintain a net positive (supply airflow greater than exhaust airflow) or negative (exhaust airflow greater than supply airflow) pressure as indicated on the Drawings. Dampers located behind air outlet and inlet devices shall be used to adjust the airflow only to the extent that the adjustments do not create objectionable air movement or noise. Fans shall not be adjusted above the maximum safe speed as determined by the fan manufacturer.

Dampers with operators shall be checked for tight shutoff when in the closed position. Shutoff dampers shall not be used for balancing.

**END OF SECTION**
SPECIFICATIONS - DETAILED PROVISIONS
Section 16010 - General Electrical Requirements

CONTENTS

PART 1 - GENERAL ................................................................................................................. 1
1.01 DESCRIPTION .................................................................................................................. 1
1.02 QUALITY ASSURANCE .................................................................................................. 1
1.03 UTILITY COMPANY REQUIREMENTS .......................................................................... 5
1.04 SUBMITTALS .................................................................................................................. 6
1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING ................................................. 10
1.06 COORDINATION OF WORK AND TRADES ................................................................ 11
1.07 COORDINATION OF THE ELECTRICAL SYSTEM ..................................................... 12
1.08 RELATED WORK SPECIFIED ELSEWHERE .............................................................. 12
1.09 PERMITS ...................................................................................................................... 13
1.10 OUTAGES ..................................................................................................................... 13
1.11 AREA CLASSIFICATION DESIGNATIONS .................................................................... 13
1.12 WARNING SIGNS .......................................................................................................... 14
1.13 GUARANTEE AND WARRANTY .................................................................................... 15

PART 2 - PRODUCTS ............................................................................................................. 15
2.01 MATERIALS AND EQUIPMENT .................................................................................... 15

PART 3 - EXECUTION ........................................................................................................... 16
3.01 GENERAL ..................................................................................................................... 16
3.02 ELECTRICAL SUPERVISION ....................................................................................... 16
3.03 INSPECTION ................................................................................................................ 16
3.04 PREPARATION .............................................................................................................. 17
3.05 WORKMANSHIP .......................................................................................................... 17
3.06 PROTECTIVE DEVICE ADJUSTMENTS .................................................................... 17
3.07 JOB SITE CONDITIONS AND ELECTRICAL DRAWINGS ....................................... 17
3.08 FIELD TESTING AND QUALITY CONTROL ................................................................. 19
PART 1 - GENERAL

1.01 DESCRIPTION

Contractor shall provide all the materials and equipment, and perform all work necessary for the complete execution of the electrical work as indicated on the Drawings, as specified herein, and as specified in other Specification Sections. Miscellaneous appurtenances are not necessarily specified or indicated on the Drawings. Contractor shall provide all labor and materials not specifically indicated on the Drawings or specified in these Specifications, yet required to ensure proper and complete operation of all systems.

This Section summarizes the general requirements for electrical work, and forms a part of all other Sections of these Specifications, unless otherwise specified.

1.02 QUALITY ASSURANCE

A. General

1. It is the intent of these Specifications and the Drawings, to secure highest quality in all equipment and materials, and to require first-class workmanship, in order to facilitate trouble free operation and minimum maintenance of the electrical system.

2. All work, including installation, connection, calibration, testing and adjustment, shall be performed by qualified, experienced personnel who are technically skilled in their trades, are thoroughly instructed, and are competently supervised by a certified electrician in the state of California. The resulting complete installation shall reflect professional quality work, employing industrial standards and methods. Any and all defective material or inferior workmanship shall be corrected immediately to the satisfaction of the District and at no additional cost to the District.

3. All equipment and materials shall be new, listed by UL and bearing the UL label, unless exception to this requirement is inherent to an individual item specified herein, or exception is otherwise specified, or approved by the District.
4. Equipment and materials shall be the products of reputable, experienced manufacturers. Singular items in the project shall be the products of the same manufacturer. All equipment and materials shall be of industrial grade and heavy duty construction, shall be of sturdy design and manufacture, and shall be capable of long, reliable, trouble-free service.

5. Contractor shall furnish manufacturer's electrical equipment of the types and sizes specified which has successfully operated for not less than the past two years, except where specific types are named by manufacturer and catalog number or designation under other Sections of the Contract Documents.

B. Environmental Sustainability

1. All electrical equipment and their enclosures shall be suitable for operation in the ambient conditions and area classification designations associated with the locations designated in the Contract Documents.

2. All electrical equipment shall be capable of operating successfully at full-rated load, without failure, when the ambient temperature of the air is 50°C. Unless specified otherwise or indicated otherwise on the Drawings, heating and cooling devices shall be provided in order to maintain all electrical equipment and instrumentation devices to within a range equal to 20 percent above the minimum and 20 percent below the maximum of the rated environmental operating ranges. All power wiring and temperature controls for these devices shall be provided by the Contactor.

C. Factory Tests

Factory tests are required for all electrical equipment and assemblies applicable to the specific project. Perform factory tests in accordance with the requirements of the particular equipment specification sections and in accordance with the codes and standards specified as applicable to the equipment. Items to be factory tested shall include, but not be limited to:

1. Motor Control Centers

2. Electrical Service Switchboards and Distribution Switchboards

3. Variable Frequency Drives

4. Solid State Starters

5. Automatic Transfer Switches
6. Manual Transfer Switches
7. Induction Motors
8. Emergency Generators
9. Custom Control Panels
10. Programmable Logic Controllers
11. Instrumentation and Controls

D. Codes and Standards

Provide electrical equipment and materials, including installation, conforming to the following codes and standards, as applicable. The equipment and materials shall bear labels to indicate manufacturing conformance to the specified standards, or equal.

1. American National Standards Institute (ANSI)
2. California Energy Commission (CEC), Title 24
3. Institute of Electrical and Electronic Engineers (IEEE)
4. National Electrical Manufacturers Association (NEMA)
5. Underwriters' Laboratories (UL)
7. Factory Mutual (FM)
8. Insulated Power Cable Engineers Association (IPCEA)
10. NFPA 70 - National Electrical Code (NEC)
12. Occupational Safety and Health Regulations of Occupational Safety and Health Administration (OSHA)
13. City and State Electrical Codes. Applicable portions of local and state codes.

14. Serving Utility Company (service, metering and interconnection requirements)

15. South Coast Air Quality Management District (SCAQMD)

16. National Institute of Standards and Technology (NIST)

17. National Electric Testing Association (NETA)


19. Certified Ballast Manufacturers Standards

20. Illuminating Engineering Society Handbook Standards

21. Basic Electrical Regulations, Title 24, State Building Standards, California Administrative Code

22. Low Voltage Electrical Safety Orders, Title 8, Division of Industrial Safety, State of California

Underwriters' Laboratories Approval: All equipment furnished by the Contractor shall be listed by and shall bear the label of Underwriters' Laboratories, Incorporated (UL), or Edison Testing Labs (ETL), or of a Nationally Recognized Testing Laboratory (NRTL) acceptable to the District.

Where the Drawings or these Specifications call for equipment and workmanship to be of better quality of higher standard than required by the above codes, standards, rules, and regulation, then said Drawings and Specifications shall prevail. Nothing on the Drawings or in these Specifications shall be construed to permit work in violation of the above codes, standards, rules, and regulations and the Contractor shall be held responsible for any work which is not acceptable.

In case of conflict or disagreement between building codes, state law, local ordinances, industry standards, utility company regulations, Drawings and Specifications, or within the Contract Document itself, the most stringent condition shall govern. The Contractor shall promptly notify the District in writing of such differences.
1.03 UTILITY COMPANY REQUIREMENTS

A. Unless specified otherwise, the District will make application for electric and telephone service (if applicable). The District will pay utility company connection fees for permanent service. Fees for temporary service during construction shall be paid by the Contractor.

B. All work for electrical power shall be performed in accordance with the requirements of the respective serving utility companies.

C. Immediately after the award of the contract, the Contractor shall notify the serving utilities that the project is under construction and provide them with all pertinent information, including the dates on which the services will be required.

D. Shop drawings shall be submitted to the power utility company with the appropriate panel dimensions (top view and elevation view) and EUSERC (Electric Utilities Service Equipment Requirement Committee) No. for service entrance and metering sections (electrical service switchboard), unless indicated otherwise on the Drawings. The power utility company serving the District is Southern California Edison (SCE).

E. Contractor shall coordinate details and timing of service switchboard installation with SCE, provide all required temporary service, and include all utility connection fees for temporary service in his bid proposal. In addition, all coordination and fees associated with obtaining from SCE the maximum available short circuit current at the secondary side of the service transformer shall be obtained by the Contractor.

The District will “Green Tag” the service when all SCE requirements and NEC grounding requirements are met. Contractor shall provide the services of an independent testing consultant for all testing required to Green Tag the service, as specified herein and in Section 16040.

F. Where indicated on the Drawings, the Contractor shall construct new electrical services per SCE requirements, the SCE Service Plan, and in accordance with the Contract Documents. Contractor shall furnish and install all facilities as required by the SCE Service Plan and as indicated on the Drawings. Facilities may include conduits, intercept box, transformer pad, slab box, service switchboard, and associated appurtenances. SCE will furnish and install the service transformer and conductors from utility power location to transformer, and from transformer to service meter. Copies of the SCE Service Plan (if available) are attached in Special Conditions or in an Appendix to these Specifications.

G. Contractor shall install telephone service entrance conduit, backboard, receptacles, grounding, and other telephone equipment indicated on the Drawings in accordance with the serving utility’s requirements.
1.04 SUBMITTALS

A. General

Contractor shall provide submittals (shop drawings) in accordance with the requirements of the District’s General Conditions, and as specified herein and in other Sections of Division 16. Shop drawings shall be submitted for the following items:

1. All electrical equipment and materials including conduit, conductors, pull boxes, junction boxes, and appurtenances.

2. Switchboards, panelboards, motor control centers, variable frequency drives, terminal cabinets, transformers, and other major equipment or apparatus.

3. Control panels and other specially-fabricated or custom-made equipment.

4. Other items as may be specifically called for herein or per other Sections of the Specifications.

B. Shop Drawings

1. Submit a complete list of all materials, equipment, apparatus, and fixtures; including manufacturer’s product literature and data; clearly indicating which equipment, materials, accessories, etc. the Contractor proposes to use. The list shall include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

2. Contractor shall submit detailed dimensioned shop drawings of all designated equipment for District’s review before fabrication. Drawings submitted for review shall include front views, top and bottom views, internal elevation views, sections, and anchoring details. Separate drawings shall be submitted for control and wiring diagrams. Wiring diagrams shall be provided for all electrical equipment furnished, except lighting. Shop drawings shall be checked by the Contractor before submittal for review by the District, and the Contractor shall certify that the submittals are in accordance with the Drawings and Specifications. Should an error be found in a shop drawing during installation of equipment, the correction, including any field changes found necessary, shall be noted on the drawings, and the as-built drawings shall be provided with the final equipment operation and maintenance manuals.
3. Manufacturer catalog literature, bulletins, brochures or the like shall be submitted for all materials and equipment. This data shall be submitted together with a clear indication (arrows) of the specific item or items, or class of items proposed, in order to establish written record of the Contractor's intent. A list of items indicating "as specified" will not suffice. A manufacturer's name alone will not suffice. Each sheet of descriptive literature submitted shall be clearly marked by the Contractor to identify the material or equipment as follows:

a. Lamp fixture descriptive sheets shall show the fixture schedule type for which the sheet applies.

b. Equipment and materials descriptive literature and drawings shall indicate the Specification Section and Subsection for which the equipment and/or materials applies.

c. Sheets or drawings showing more than the particular item under consideration shall have crossed out all but the pertinent description of the item for which review is requested.

d. Equipment and materials descriptive literature not readily cross-referenced with the Drawings or Specifications shall be identified by a suitable notation.

e. Schematic, wiring, and connection diagrams for all electrical equipment shall be submitted for review. A manufacturer's standard connection diagram or schematic showing more than one scheme of connection will not be accepted, unless it is clearly marked to show the intended connections. Connection diagrams shall indicate field installed equipment with the specified drawing device number or name as illustrated on the Construction Drawings and submitted shop drawings.

4. Submit data for earthquake (seismic) design and restraint with the shop drawing submittals for all switchboards, panelboards, motor control centers, variable frequency drives, and control panels. Anchorage data and details shall be provided for same. Calculations and details shall be stamped by a California registered "Civil" or "Structural Engineer." Refer to Special Conditions and Section 11005 for special seismic design requirements.
C. As-Built Drawings

Contractor shall prepare, maintain, and submit as-built Drawings in accordance with the District’s General Conditions, and as specified herein.

At the completion of the Work, Contractor shall furnish the District with three (3) final sets of as-built electrical Drawings marked with any changes, deviations or additions to any part of the electrical work. During construction, one (1) red-lined set of as-built Drawings shall be maintained at the job site by the Contractor until the final as-built Drawings are received by the District.

Contractor shall clearly indicate on the as-built Drawings the following information:

1. All conduit runs as actually installed.
2. Location of all underground conduits and stub-outs accurately dimensioned.
3. Forming, cabling, and identification of all power and control conduit and wiring within manholes, pull boxes, junction boxes, and terminal boxes.
4. Interior views of each manhole and pull box identifying each conduit entrance by conduit number.
5. All changes, deviations, or additions to any part of the electrical work, including, but not limited to: locations, routing, dimensions, wiring, or connections.

D. Operation and Maintenance Manuals

Contractor shall provide operation and maintenance (O&M) manuals for all electrical equipment in accordance with District’s General Conditions, Section 01430, and as specified herein.

The manuals shall include all system drawings, block diagrams, single line and control diagrams, wiring schematics, loop diagrams, shop drawings, manufacturer product literature and data for supplied equipment and other pertinent data required to completely describe the operation and maintenance of the installed electrical system.

These manuals shall be submitted prior to final acceptance of the system and shall reflect all as-built conditions.
As a minimum, the electrical system information in the O&M manuals shall contain:

1. System operating instructions written for the benefit of the District's operating personnel for normal operational condition and utilizing names of controls as they appear on nameplates.

2. Installation instructions.

3. Pre-energizing, energizing, and de-energizing procedures.


5. Troubleshooting instructions.


7. Instructions for ordering replacement parts.

8. Part List
   a. List of fuses, lamps, and other expendable equipment and devices with manufacturer names and part numbers.
   b. List of all vendors, addresses, and phone numbers.

E. Miscellaneous Reports

Contractor shall submit all other reports as called for in these Specifications at the times specified. These miscellaneous reports include, but are not limited to, test procedures, records of electrical test results, and manufacturer certificates of inspection.

F. Manufacturer's Certified Reports

Each equipment manufacturer, or his authorized representative, shall submit a written report with respect to his equipment certifying the following:

1. Pre-Startup Complete
   a. The equipment has been properly installed, wired, and connected in accordance with the manufacturer's requirements.
   b. The equipment is in accurate alignment.
c. Manufacturer has checked, inspected, and adjusted the equipment as necessary.

2. Startup and Field Testing Complete
   a. Manufacturer was present when the equipment was placed into operation.
   b. The equipment has been operated under full load conditions and operated satisfactorily.
   c. All field testing, including operational demonstration and system validation testing, has been completed and equipment performed satisfactorily throughout each test.
   d. The equipment is fully covered under the terms of the guarantee.


In accordance with Section 16040, Contractor shall submit electrical short-circuit/coordination study, arc-flash hazard study, and testing report certifying proper setting of all protection devices, ground testing, and arc-flash hazard labeling.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery

Contractor shall require that all electrical materials and equipment be shipped and delivered in accordance with the manufacturer's requirements. Deliver electrical materials and equipment in manufacturer's original cartons or containers with seals intact, as applicable. Unless specified otherwise, deliver conductors in sealed cartons or on sealed reels, ends of reeled conductors factory sealed. Deliver large multicomponent assemblies in sections that facilitate field handling and installation.

B. Handling

Contractor shall unload and handle materials and equipment in accordance with manufacturer's recommendations. Lift large or heavy items only at the points designated by the manufacturer. Use padded slings and hooks for lifting as necessary to prevent damage.
C. **Storage**

Store electrical equipment and material in accordance with the manufacturer’s requirements. Where enclosures are specified to be provided with space heaters, Contractor shall furnish temporary power to equipment space heaters to prevent condensation until the equipment is installed and energized.

Unless designed for outdoor exposure, store electrical materials off the ground and under cover to prevent corrosion, contamination, or deterioration.

### 1.06 COORDINATION OF WORK AND TRADES

A. Electrical work shall conform to the construction schedule and progress of other trades. The electrical construction shall be performed in cooperation with all other trades so that a neat and orderly arrangement of the work as a whole shall be obtained.

B. Electrical components on all equipment shall be handled, set in place, connected, checked out, serviced, and placed in readiness for proper operation to the satisfaction of the District all within the scope of work intended under this Section.

C. Before any work is commenced, Contractor shall verify with the equipment manufacturers that equipment dimensions and arrangements will allow for equipment installation in the spaces provided for on the Drawings, including, but not limited to: all switchboards motor control centers, variable frequency drives, panelboards, control panels, terminal cabinets, transformers, and other items of electrical equipment or apparatus; and that the installation spaces indicated will provide for all required ventilation, clearances, access, and work space.

D. Before installing any equipment, conduit, or materials, the Contractor shall examine the complete set of Contract Documents (Drawings and Specifications) and approved shop drawings, and confirm all dimensions and space requirements.
1.07 COORDINATION OF THE ELECTRICAL SYSTEM

A. Contractor shall verify all actual equipment and motor full-load and locked rotor current ratings. The necessary minimum equipment, conductors, and conduit sizes are indicated on the Drawings. If the Contractor furnishes equipment of different ratings, the Contractor shall coordinate the actual current rating of equipment furnished with the branch circuit conductor size, the controller size, the motor starter, and the branch circuit over current protection. The branch circuit conductors shall have a carrying capacity of not less than 125% of the actual full-load current rating. The size of the branch circuit conductors shall be such that the voltage drop from the overcurrent protection devices up to the equipment shall not be greater than 2% when the equipment is running at full load and rated voltage. Conductor ampacities shall be derated in accordance with NEC, Table 310-16 for ambient temperatures of 114-122°F.

B. Unless specified otherwise, the motor running solid state overcurrent protection devices shall be ambient temperature compensated for 50°C and be rated or selected to trip at no more than 125% of the motor full-load current rating for motors marked to have a Class B temperature rise not over 80°C or motors marked with a service factor not less than 1.15, and at no more than 115% for all other types of motors.

C. Unless specified otherwise, the motor branch circuit overcurrent protection device shall trip open in 10 seconds or less on locked-rotor current of the motor. This device shall also protect the motor branch circuit conductors and the motor control apparatus against overcurrent due to short circuits or ground faults. The motor control circuits shall have overcurrent protection of the type specified in the Specifications, or indicated on the Drawings.

1.08 RELATED WORK SPECIFIED ELSEWHERE

A. The Contract Documents are a single integrated document, and as such all Specification Divisions and Sections apply. It is the responsibility of the Contractor and its Subcontractors to review all sections to ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment and/or systems requiring electrical power and/or control.

2. Division 16 – Electrical

3. Division 17 – Instrumentation and Controls
1.09 PERMITS

Contractor shall obtain and pay for all permits, licenses, and inspections required for electrical construction work by public agencies and utility companies having jurisdiction, except as otherwise specified.

1.10 OUTAGES

A. Contractor shall keep equipment system power outage periods to the minimum time feasible, and only for such times and durations as may be approved by the District. Contractor shall submit any request for an equipment system power outage (shutdown) in writing to District for approval at least 10 working days in advance of said shutdown. The written request shall include the date, time, location, affected equipment and systems, and proposed duration of the shutdown. Contractor shall bear all overtime costs for outages required to be performed during non-working hours.

B. Contractor shall keep facility power outage periods to the minimum time feasible, and only for such times and durations as may be approved by the District and SCE. Contractor shall submit request for a facility power outage (shutdown) in writing to District for approval at least 45 working days in advance of said shutdown. The written request shall include the date, time, location, and proposed duration of the shutdown. If the proposed facility shutdown is approved by the District, Contractor shall provide all necessary coordination with SCE and the District throughout the planning and shutdown period. Contractor shall bear all overtime costs for facility outage required to be performed during non-working hours.

1.11 AREA CLASSIFICATION DESIGNATIONS

A. General

For purposes of defining electrical enclosure and electrical installation requirements, certain areas have been classified in this Section, other Specification Sections, or indicated on the Drawings. Electrical equipment, materials, and installations within these areas shall conform to the equipment standards and code requirements for the areas involved.

B. Indoor Locations

Unless specified otherwise, electrical work installed in indoor, dry, non-corrosive areas that are not subject to wash down and not specifically classified shall be general purpose locations. Enclosures for instruments, control panels, controllers, terminal cabinets, junction boxes, devices, etc., in general purpose locations shall be rated NEMA 12. Enclosures for motor control centers, switchboards, panelboards, and variable frequency drives in general purpose locations shall be rated NEMA 1A (gasketed).
C. **Outdoor Locations**

Unless specified otherwise, electrical work installed in indoor areas subject to wash down or installed in outdoor areas shall be classified as wet locations. Enclosures for instruments, control panels, controllers, terminal cabinets, junction boxes, devices, etc., in wet locations shall be rated NEMA 4X. Enclosures for motor control centers, switchboards, panelboards, and variable frequency drives in wet locations shall be rated NEMA 3R (weatherproof). Wherever possible, outdoor enclosures shall be gasketed, and shall be provided with hinged and padlockable doors.

D. **Corrosive Locations**

Unless specified otherwise, electrical work installed in indoor or outdoor areas with exposure or potential exposure to chemical liquids, chemical gases, sewage, or sludge shall be classified as corrosive locations. Enclosures for instruments, control panels, controllers, terminal cabinets, junction boxes, devices, etc., in corrosive locations shall be rated NEMA 4X. Wherever possible, NEMA 4X enclosures shall be constructed of Type 316 stainless steel, and shall be provided with hinged and padlockable doors.

E. **Hazardous Locations**

Unless specified otherwise, electrical work installed in indoor or outdoor areas with exposure or potential exposure to flammable gases or vapors, or combustible dusts shall be classified as hazardous locations. Enclosures for instruments, control panels, controllers, terminal cabinets, junction boxes, devices, etc., in hazardous (classified) locations shall be provided in accordance with NEC Articles 500 through 504.

### 1.12 WARNING SIGNS

A. Unless specified otherwise, permanent warning and caution signs shall be mounted at the site and on all mechanical equipment which may be started automatically or from remote locations for personnel safety. Signs shall be fabricated in accordance with Porcelain Enamel Institute Specification S-103 and shall be suitable for exterior use. Mounting details shall be in accordance with the manufacturer's recommendations. Signs shall be located as approved by District. Provide a minimum of one (1) sign at each equipment location.

B. Warning signs shall be 7 inches high by 10 inches wide, colored yellow and black, on not less than 18 gauge vitreous enameling stock. Sign shall read:

```
CAUTION
THIS EQUIPMENT STARTS
AUTOMATICALLY
BY REMOTE CONTROL
```
C. Where specified, provide a minimum of one (1) sign mounted on the entrance door of generator, blower, or compressor rooms. Sign shall read:

**CAUTION**
**HEARING PROTECTION**
**SHALL BE WORN IN THE AREA**

D. Permanent and conspicuous warning signs shall be mounted on all equipment and doorways to equipment rooms where the voltage exceeds 600 volts.

E. Where specified, provide a minimum of one (1) sign mounted on the door of pump or electrical rooms. Warning signs shall be 7 inches high by 10 inches wide, colored red and white, on not less than 18 gauge vitreous enameling stock. Sign shall read:

**WARNING**
**HIGH VOLTAGE**
**AUTHORIZED PERSONNEL ONLY**

1.13 GUARANTEE AND WARRANTY

Contractor shall guarantee all work of Division 16 in accordance with the General Conditions. With respect to equipment, guarantee shall cover (1) faulty or inadequate design; (2) improper assembly or erection; (3) defective workmanship or materials; and (4) incorrect or inadequate operation, or other failure. For equipment bearing a manufacturer's warranty in excess of one (1) year, furnish a copy of the warranty to the District, who shall be named as beneficiary.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

Contractor shall provide new materials and equipment as required to complete all indicated and specified electrical work, including incidental items inferable from the Contract Documents that are necessary to complete the work. Provide materials and equipment of latest design, standard products of established manufacturers. Custom products shall be provided where required to comply with specified performance requirements or special features and capabilities.

For uniformity, only one manufacturer is acceptable for each type of product. Manufacture individual parts to standard sizes and gages so repair parts can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not be placed in service at any time prior to delivery, except as required for factory or shop tests.
A. **Prohibited Materials**

Aluminum conductors are not acceptable.

B. **Damaged Products**

Notify the District in writing if any equipment or material is damaged. Do not repair damaged products without prior written approval.

C. **Factory Finishes**

Unless specified otherwise in other Division 16 Sections or in the Special Conditions, the sheet metal surfaces of equipment enclosures shall be phosphatized and coated with a rust resisting primer. Over the primer, apply a corrosion resistant baked enamel finish on the interior and exterior metal surfaces. The exterior color shall be ANSI No. 49 medium light gray. The interior color shall be white. Hardware shall have a corrosion resistant finish. Sheet metal enclosures and lighting fixtures, in corrosive areas, shall have an outer coating of corrosion resistant epoxy.

### PART 3 - EXECUTION

#### 3.01 GENERAL

Contractor shall install electrical work in accordance with the codes and standards specified, except where more stringent requirements are indicated or specified. Prior to commencing construction, Contractor shall verify that equipment and materials properly fit the installation space with clearances conforming to the codes and standards specified, except where greater clearance is indicated. Contractor shall perform work as required to correct improper installations, at no additional cost to the District.

#### 3.02 ELECTRICAL SUPERVISION

In addition to supervision required under the General Conditions, Contractor shall assign a competent representative to supervise the electrical construction work from beginning to completion and final acceptance.

#### 3.03 INSPECTION

Contractor shall inspect each item of equipment and material for damage, defects, completeness, and correct operation before installing. In addition, Contractor shall inspect previously installed related work and verify that it is ready for installation of electrical work.
3.04 PREPARATION

Prior to installing electrical work, Contractor shall ensure that installation areas are free of debris and clean. Contractor shall maintain the areas in a broom-clean condition during installation operations. Contractor shall clean, condition, and service equipment in accordance with the manufacturer's instructions, approved submittals, and other requirements indicated or specified.

3.05 WORKMANSHIP

Contractor shall employ skilled craftsmen experienced in installation of the types of electrical equipment and materials specified. Contractor shall use specialized installation tools and equipment as applicable. Contractor shall construct acceptable installations free of defects. Refer to Part 1.02 herein.

3.06 PROTECTIVE DEVICE ADJUSTMENTS

Contractor shall adjust all protective devices in accordance with tabulated settings listed in the approved coordination study per Section 16040. In addition, adjustments shall conform to SCE requirements and IEEE Standard 242. No equipment shall be operated prior to said adjustments being properly completed and field verified/tested.

3.07 JOB SITE CONDITIONS AND ELECTRICAL DRAWINGS

A. Job Site Conditions and Drawings

1. The Drawings indicate diagrammatically the desired location and arrangement of outlets, conduit runs, equipment, and other items. Exact locations shall be determined in the field based on the physical size and arrangement of equipment, finished elevations, and obstructions. Locations indicated on the Drawings, however, shall be adhered to as closely as possible.

2. All equipment and conduit shall be installed in such a manner as to avoid all obstructions, preserving headroom, and keeping openings and passageways clear. Lighting fixtures, switches, convenience outlets, and similar items shall be located within finished rooms as indicated on the Drawings. Where these Drawings do not indicate exact locations, Contractor shall propose locations to the District for final approval by District prior to installation. Where equipment is installed without approval and must be moved (as determined by the District), it shall be moved without additional cost to the District.
3. Allowance has been made in the design for the number of conduits, conductors and cables, which the District considers adequate for feeding various equipment and drives. These circuits and diagrams are based on available data pertaining to a particular design of equipment and portray the systems which the District has chosen to effect the required operation and level of control. Equipment provided by the Contractor (even though of the make and model specified) may differ in detail, arrangement, connections or form from that indicated on the Drawings. If the Contractor uses equipment which differs from the equipment shown in major aspects and requires modifications to power, control or other electrical systems (including, but not limited to, size and quantity changes to conductors, conduits, starters, circuit breakers, control devices, etc.), the District's acceptance of the equipment will be based upon the Contractor providing the modification required, and they shall be of the same quality as shown and shall be provided at no additional costs to the District.

4. The Drawings do not, and are not intended to, show all required equipment, such as pull boxes, junction boxes, etc. nor to indicate all mechanical or structural difficulties that may be encountered which would necessitate routing alteration, or fittings. Items not specifically mentioned in these Specifications or noted on the Drawings or approved shop drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.

5. Discrepancies shown on different Drawings, between Drawings and actual field conditions, or between Drawings and Specifications shall be promptly brought to the attention of the District for direction.

6. The equipment alignment and conduit shall be varied due to architectural changes, or to avoid work of other trades, without extra expense to the District.

B. Protection of Existing and New Facilities

1. Contractor shall hand dig or otherwise cautiously dig the trenches for the underground lines in areas where interferences are possible or where electric lines must pass or cross below or above existing facilities.
2. Contractor shall protect electrical equipment and materials until final acceptance by the District. Contractor shall protect factory painted surfaces from impact, abrasion, discoloration, and other damage. Contractor shall keep electrical equipment, materials, and insulation dry at all times. Contractor shall maintain heaters in equipment connected and operating until equipment is placed in operation. If partial dismantling of equipment is required for installation, box or wrap the removed parts until reinstalled. Contractor shall repair or replace damaged work as directed by the District, and at no additional cost to the District.

3.08 FIELD TESTING AND QUALITY CONTROL

A. General

1. Prior to testing equipment including wiring and cables, the equipment shall be installed and anchored in accordance with the manufacturer's recommendations and the Contract Documents. A minimum of ten (10) working days in advance of testing, Contractor shall provide written notice to the District for installation inspection. District's and equipment manufacturer's acceptance of installation shall be obtained prior to the commencement of any testing.

a. The District intends to observe all testing, thus, the Contractor shall prepare a testing schedule showing daily work and projecting same for a minimum of three (3) weeks. Contractor shall maintain a current testing schedule and submit updated schedules to the District on weekly intervals.

b. Contractor shall provide a minimum of ten (10) working days advance notice to the District for the scheduling of any testing.

c. Contractor shall provide the manufacturers' documentation for testing for all equipment.

d. In the event a retest is required due to equipment failure, adverse testing conditions, or installation deficiency, Contractor shall schedule the retest. Any impact to project schedule or testing schedule shall be borne by the Contractor.

2. Inspection and test records shall be submitted to the District no later than thirty (30) days after completion of the individual test and prior to energizing of equipment.

3. All tests shall be performed with the equipment or material de-energized, except where otherwise specifically required by the nature of the test.
4. All items not in conformance with the requirements of these Specifications shall be corrected by the Contractor.

5. Upon completion of various phases of the project, electrical equipment and wiring and cabling systems shall be inspected and tested in accordance with this Specification. All testing shall be in accordance with the applicable ANSI, IEEE, NETA, NEMA, or other national standard, and in accordance with the specific manufacturer's instruction bulletins or other literature supplied with the equipment to be tested, and the test equipment manufacturer's operating instructions. All tests that are required to be performed, whether performed by the Contractor or by the Testing Consultant (refer to Part 3.08E herein) shall be in accordance with NETA Standard for Acceptance Testing Specifications.

6. No equipment shall be energized until the testing and setting of protective devices per Section 16040 and testing as specified herein has been completed and accepted by the District.

7. Contractor shall provide all test data in tabulated form as approved by the District. Insulation testing (high potential testing) and continuity testing data shall include conductor number, size, test value, and expected value for each conductor.

8. Contractor shall check all equipment for proper mechanical adjustment and freedom of operation. All electrical equipment, both pre-wired and field-wired shall be field-tested for functional operation, including all intended modes and sequences of operation. This shall include switches, relays, non-adjustable circuit breakers, contractors, etc., including control interlock and sequence circuits. All necessary adjustments shall be made on apparatus in accordance with the manufacturer's instructions and design requirements. Alarm systems and circuits shall be tested by manually operating initiating devices. Relays and control components that may prove to be functioning incorrectly or otherwise appear to be unreliable shall be repaired or replaced as necessary. An electrical system will not be accepted until it is tested in its entirety and the results reported to and accepted by the District.
9. Each equipment manufacturer shall furnish the services of an authorized representative especially trained and experienced in the installation of his equipment to: (1) supervise the equipment installation in accordance with the Contract Documents, approved submittals, and manufacturer's instructions; (2) inspect, check, adjust as necessary, and approve the installation prior to start up; (3) submit certification that equipment is ready to start-up and test; (4) be present when the equipment is placed into operation and tested; (5) repeat the inspection, checking, adjusting, and testing until all trouble or defects are corrected and the equipment installation and operation are acceptable; and (6) prepare and submit the specified Manufacturer's Certified Report (refer to Part 1.04F herein). Contactor shall include all costs for manufacturer representatives' services in the Contract Price.

10. All costs associated with equipment and material testing and retesting (if required) shall be paid by the Contractor.

B. Testing Power, Control, and Lighting Circuits - 600 V and Below

Contractor shall perform continuity checks of all power, control and lighting conductors and cables, including each conductor of multi-conductor and multi-pair cables. Continuity checks shall be performed prior to termination of conductors and cables, and any testing by the Testing Consultant.

1. Contractor shall visually check all conductor and cable connections, verify conductor numbers, and verify that the actual wiring conforms to the Drawings and shop drawings.

2. Each power conductor shall be tested to ensure proper phase identification.

3. The conductor ends shall be cleaned and guarded for personnel safety during testing. Circuits in the immediate vicinity that are not under test shall be grounded.

4. Contractor shall perform insulation resistance tests on all 600 V rated power conductors. Each conductor shall be tested against ground with the conduit and/or all other conductors connected to ground. Motor feeder circuits shall be tested with motors disconnected and the controller open. Lighting panelboard main feeder circuits, including lighting panelboard and transformer, shall be tested with the branch circuit breakers open. Testing shall be for one minute using 1000 V DC. Values of insulation resistance less than 50 megohms shall not be acceptable.

5. Control and lighting circuits require only functional tests.
General Electrical Requirements
Section 16010 – 22

6. Branch lighting circuits containing light fixtures and receptacles require only functional tests.

7. Contractor shall check all AC and DC control circuits for short circuits and extraneous grounds.

8. Contractor shall perform functional tests of all power, control, and lighting circuits. Alarm conditions shall be simulated for each alarm and control point, and alarm indicators shall be checked for proper operation. All control circuits shall function as intended by the Contract Documents. Metering and indication lights for motors shall be checked for proper operation. All lighting panels, circuits, lighting fixtures, and receptacles shall be tested for proper operation.

9. The District shall be notified if minimum insulation resistance values are not obtained and if any functional tests fail.

C. Testing Instrumentation, Signal, and Alarm Circuits - 300 V and Below

1. Contractor shall perform continuity checks of all instrumentation, control, signal, and alarm conductors and cables, including each conductor of multi-conductor and multi-pair cables. Continuity checks shall be performed prior to termination of conductors and cables.

2. Contractor shall visually check all conductor and cable connections, verify conductor numbers, and verify actual wiring conforms to the Drawings.

3. Performing insulation resistance tests on conductors and cables will not be required, but functional tests shall be performed.

4. All signal and alarm conditions shall be simulated for each status, alarm and control point, and status/alarm indicators checked for proper operation, similar to that required for control circuits.

5. Contractor shall check all AC and DC instrumentation, signaling and alarm circuits for short circuits and extraneous grounds.

6. The District shall be notified if any functional tests fail.
D. **Motor Testing Prior to Energization**

The following tests shall be conducted prior to starting motors for all motors 5 horsepower and larger:

1. Compare equipment nameplate with the Contract Documents and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding.
4. Perform insulation resistance tests in accordance with IEEE 43 of all motor windings before connecting power conductors to motors. Test duration shall be one minute. Insulation resistance shall be a minimum of 50 megohms at 20°C at test voltage of 1000 V DC.
5. Inspect bolted electrical connections for high-resistance using the calibrated torque-wrench method in accordance with manufacturer's published data.
6. Check all bearings to see if they are properly filled with oil or grease.
7. Check coupling alignment and shaft end play.
8. Rotate the motor shaft by hand or bar to ensure it is free to rotate.

E. **Tests Required to be Performed by Independent Testing Consultant (Testing Consultant)**

1. Subsequent to acceptance of equipment installation by the District, the Contractor shall provide a minimum of ten (10) working days written notice of independent third party testing. All terminations required for NETA testing shall be complete. Energizing of tested equipment is at the discretion of the District and will not take place until passed and documented by the Testing Consultant and reviewed by the District. The entire electrical system shall be tested before energization. If functional testing requires power, the Contractor shall provide temporary power for that purpose. All testing shall be completed prior to equipment start up.

2. All references to NETA in this Section are referring to NETA Standard for Acceptance Testing Specifications.

3. The Testing Consultant shall provide a detailed report on all testing per NETA and Section 16040 for District's approval.
In addition to and in conjunction with testing and protective device setting per Section 16040, the following tests shall be performed by the Testing Consultant and witnessed by the Contractor and District:

a. Switchboard and Switchgear Assemblies

Perform all inspections and tests, including all optional tests, listed in Section 7.1 of NETA on all Medium-Voltage Switchboards and Switchgear, and Low-Voltage Switchboards and Switchgear.

b. Transformers, Dry-Type, Air-Cooled

Perform all inspections and tests, including all optional tests, listed in applicable Section 7.2.1.1 or 7.2.1.2 of NETA on all dry type transformers.

c. Transformers, Liquid-Filled

Perform all inspections and tests, including all optional tests listed in Section 7.2.2 of NETA on all liquid-filled transformers.

d. Conductors and Cables, Low-Voltage and Medium-Voltage

Perform all inspections and tests, including all optional tests, listed in Sections 7.3.2 and 7.3.3 of NETA on all low-voltage (600 V maximum) and medium-voltage conductors and cables.

e. Circuit Breakers, Insulated-Case/Molded-Case

Perform all inspections and tests (not including optional tests), listed in Section 7.6.1.1 of NETA on all insulated-case/molded-case circuit breakers 100 A frame and higher.

f. Circuit Breakers, Vacuum, Medium-Voltage

Perform all inspections and tests, including all optional tests, listed in section 7.6.3 of NETA on all medium-voltage circuit breakers.

g. Protective Relays, Electromechanical and Solid-State

Perform all inspections and tests, including all optional tests, listed in Section 7.9.1 of NETA on all electromechanical and solid-state protective relays.
h. Protective Relays, Microprocessor-Based

Perform all inspections and tests listed in Section 7.9.2 of NETA on all microprocessor-based protective relays.

i. Metering Devices, Microprocessor-Based

Perform all inspections and tests listed in Section 7.11 of NETA on all metering devices including power monitors.

j. Grounding Systems

Perform all inspections and tests listed in Section 7.13 of NETA on all grounding systems.

k. Ground-Fault Protection Systems, Low-Voltage

Perform all inspections and tests listed in Section 7.14 of NETA on all ground fault protection systems.

l. Rotating Machinery, AC Induction Motors and Generators

Perform all inspections and tests, including all optional tests, listed in Section 7.15.1 of NETA on all low-voltage AC motors and generators 20 HP and larger.

m. Motor Control, Motor Starters, Low-Voltage

Perform all inspections and tests, including all optional tests, listed in Section 7.16.1.1 of NETA on all motor starters. For item 7.16.1.1.6 "Perform operational tests by initiating control devices," the starter control devices (selector switches, pushbuttons, relays, pilot lights, etc.) and motor control wiring shall be tested by simulating field device controls or signals at starter terminal blocks to simulate actual control functionality. Control functionality shall also be checked during field operation testing as described herein, and in accordance with other Sections of the Detailed Provisions.

n. Motor Control, Motor Control Centers, Low-Voltage

Perform all inspections and tests, including all optional tests, listed in Section 7.16.2.1 of NETA on all MCCs.
o. Variable Frequency Drives

Perform all inspections and tests, including all optional tests, listed in Section 7.17 of NETA on all Variable Frequency Drives, except for Section 7.17.2.7 which shall be performed by the manufacturer. For item 7.17.2.8 "Perform operational tests by initiating control devices, the VFD control devices (selector switches, pushbuttons, relays, pilot lights, etc.) and motor control wiring shall be tested by simulating field device controls or signals at starter terminal blocks to simulate actual control functionality." Control functionality shall also be checked during field operation testing as described herein, and in accordance with other Sections of the Detailed Provisions.


Perform all inspections and tests listed in Section 7.22.3 of NETA on all Automatic and Manual Transfer Switches, and Manual Bypass Switches.

q. Setting and Testing of Adjustable/Programmable Protective Devices

The Testing Consultant shall set/program and test the adjustable/programmable protective devices in the field according to applicable NETA and manufacturer's requirements and per Section 16040. Contractor shall provide all software and hardware required to set or program devices. The protective devices shall be tested for operation after completion of device setting and programming.

5. In conjunction with the NETA inspections and tests specified above, each bolted connection shall receive Dykem Orange Torque-Seal, or equal, following verification of proper bolt-torque level.

F. Operational Demonstration Testing

Contractor shall demonstrate that the performance of installed electrical materials and equipment complies with requirements specified in Division 16. Operate equipment through entire no-load to full-load range for not less than 4 hours unless a longer period is specified elsewhere. Immediately correct defects and malfunctions with approved methods and materials in each case, and repeat the demonstration. Operational demonstration testing shall conform to the approved demonstration testing plan.
G. **System Validation Testing**

Unless specified otherwise, test all electrical systems for not less than 7 days (168 hours), with no interruptions except for normal maintenance. System validation testing shall conform to the approved test plan. Coordinate testing with equipment validation testing required under Divisions 11 and 16, and under the Special Conditions.

1. **Testing Materials and Equipment**

Contractor shall furnish all labor, equipment, and materials for required tests, including all instruments, recorders, gauges, chemicals, power, etc.

2. **Testing Methods**

Contractor shall perform field tests on equipment as specified in the Special Conditions and/or Specification Sections for the specific equipment. Unless specified otherwise, operate systems continuously (24 hours per day) under constant supervision of trained operators and/or field service engineers. Cause variable speed equipment to cycle through the applicable speed range at a steady rate of change. Induce simulated alarm and distressed operating conditions, and test controls and protective devices for correct operation in adjusting system functions or causing system shutdown. Perform other system validation tests as may be required under other Sections of Division 11 and 16, and under the Special Conditions.

3. **Defects**

Contractor shall immediately correct all defects and malfunctions disclosed by tests. Contractor shall use new parts and materials as required to perform corrective work, as approved by the District. The specified total test period shall be extended by the interruption time for corrective work.

4. **Test Records**

Contractor shall continuously record all function and operation parameters during the entire test period. Contractor shall submit complete, well organized, and clearly labeled test data to the District for review and approval.

**END OF SECTION 16010**
SPECIFICATIONS - DETAILED PROVISIONS
Section 16040 – Short-Circuit/Coordination Study
and Arc-Flash Hazard Study

CONTENTS

PART 1 - GENERAL

1.01 SUMMARY

1.02 DESCRIPTION OF THE WORK

1.03 RELATED SECTIONS

1.04 REFERENCE STANDARDS AND CODES

1.05 SUBMITTALS

1.06 QUALIFICATIONS

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

2.02 DATA COLLECTION

2.03 SINGLE LINE DIAGRAM

2.04 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

2.05 PROTECTIVE DEVICE COORDINATION STUDY

2.06 ARC-FLASH HAZARD STUDY

2.07 STUDY DATA

2.08 IMPLEMENTATION OF STUDY RESULTS

2.09 ARC-FLASH AND SHOCK HAZARD LABELS

PART 3 - EXECUTION

3.01 PROTECTIVE DEVICE SELECTION AND SETTING

3.02 ARC-FLASH AND SHOCK HAZARD LABEL INSTALLATION

3.03 FIELD REPORT

ARC-FLASH LABEL EXAMPLES
SECTION 16040  
SHORT-CIRCUIT/COORDINATION STUDY AND 
ARC-FLASH HAZARD STUDY

PART 1 - GENERAL

1.01  SUMMARY

A. Contractor shall provide a Short-Circuit and Protective Device Evaluation Study, a Protective Device Coordination Study, and an Arc-Flash Hazard Study, as specified herein.

B. The studies shall be performed for the purposes of estimating the worst case available short-circuit current values and arc-flash incident energy. The studies shall be generated based on information obtained from electrical equipment submittals, actual conductor sizes and lengths for all feeders, utility short circuit current value at the main service switchboard, and information obtained from field reconnaissance of existing equipment/material (if applicable).

C. Contractor shall obtain the short circuit current value at the main service switchboard for the specific project location from the utility. Contractor shall bear all costs associated with obtaining the available short circuit current value.

D. Contractor shall adjust all required protective device settings based on the results of the Protective Device Coordination Study and Arc-Flash Hazard Study.

E. Contractor shall install Arc-Flash and Shock Hazard labels on all electrical equipment, as specified herein.

1.02  DESCRIPTION OF THE WORK

A. Short-Circuit and Protective Device Evaluation Study

1. Contractor shall provide a Short-Circuit and Protective Device Evaluation Study to verify the proposed equipment ratings and protective device ratings.
2. Unless specified otherwise, the scope of the study shall include all proposed distribution equipment supplied under this Contact, as well as all directly affected existing distribution equipment at the District's facility. The study shall include all portions of the existing and proposed electrical distribution system from the electric utility power source(s) and emergency power source(s) down to and including each switchboard, distribution panel, transfer switch (automatic or manual), motor control center, variable frequency drive, distribution panelboard, branch circuit panelboard, busway, enclosed circuit breaker and fused disconnect switch.

B. Protective Device Coordination Study

1. Contractor shall provide a Protective Device Coordination Study to determine and coordinate the selective tripping of protective devices for the proposed equipment.

2. Unless specified otherwise, the scope of the study shall include all proposed distribution equipment supplied under this Contact, as well as all directly affected existing distribution equipment at the District's facility. The study shall include all portions of the existing and proposed electrical distribution system from the electric utility power source(s) and emergency power source(s) down to and including the smallest adjustable trip circuit breaker and fused disconnect switch in the system.

C. Arc-Flash Hazard Study

1. Contractor shall provide an Arc-Flash Hazard Study to determine potential arc-flash incident energies, arc-flash boundaries, shock hazard boundaries; required personal protective equipment (PPE) for all energized electrical equipment; and arc-flash and shock hazard warning labels.

2. Unless specified otherwise, the study shall include all electrical circuits from the electric utility power source(s) and emergency power source(s) to and including all electrical equipment and panelboards rated 208 V and greater.

3. Wherever possible, the proposed electrical equipment shall be designed, manufactured, and supplied to limit the potential arc-flash incident energy to 8 cal/sq cm or less (PPE Category 2). The firm performing the studies shall coordinate with Contractor, the District, and the electrical equipment manufacturers to assist in achieving this requirement.
D. Field Verification

Contractor shall provide the services of an independent testing consultant or firm performing the studies to field verify that all protective devices are set in accordance with the accepted short-circuit/coordination study requirements and recommendations. In addition, the consultant or firm shall verify that all arc-flash and stock hazard labels have been installed.

1.03 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all Sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Division 11 – Equipment

2. Division 16 – Electrical

1.04 REFERENCE STANDARDS AND CODES

Unless specified otherwise, all calculations, analyses, and studies, including application of same to equipment and settings shall meet or exceed the applicable requirements of the following standards and codes (latest edition):

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE 141 – Recommended Practice for Electric Power Distribution for Industrial Plants

2. IEEE 142 – Recommended Practice Grounding of Industrial and Commercial Power Systems


4. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

5. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
6. IEEE 551 – Recommended Practice for Calculating Short-Circuit Currents in Industrial and Commercial Power Systems
7. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems

B. **American National Standards Institute (ANSI):**
   1. ANSI C37.010 – Standard Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
   2. ANSI C37.13 – Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
   4. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

C. **Code of Federal Regulations:**

D. **The National Fire Protection Association (NFPA):**
   1. NFPA 70 - National Electrical Code, latest edition
   2. NFPA 70E – Standard for Electrical Safety in the Workplace
1.05 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Computer Software Information

Submit product literature/brochure for computer software to be utilized for the studies. Submit computer software statement of compliance with IEEE, ANSI, and NFPA 70E standards and requirements.

B. Qualification Information

Submit qualification information for firm and individual(s) specified in Part 1.06 herein.

C. Utility Information

Submit letter from utility with available short circuit current value at the main service switchboard. As a minimum, the utility letter shall include the following: project address, service voltage and configuration, main service switchboard amperage, short circuit current (3-phase and phase-ground), 3-phase and phase-ground X/R ratios, service transformer kVA and impedance, and service conductor size, number, and length.

D. Study Results and Report

The results of the Short-Circuit and Protective Device Evaluation Study, Protective Device Coordination Study, and Arc-Flash Hazard Study shall be summarized in a well-organized, comprehensive report. The report shall address all study requirements specified in Part 2 herein. A sample outline for the report is provided below:

1. Section 1 - Executive Summary

2. Section 2 - Short-Circuit and Protective Device Evaluation Study

   2.1 Short-Circuit Analysis Objectives
   2.2 System Modeling
   2.3 Short-Circuit Results
   2.4 Equipment, Material, and Protective Device Evaluation
3. Section 3 - Protective Device Coordination Study
   3.1 General Description and Protection Philosophy
   3.2 Codes and Standards
   3.3 Coordination Objectives
   3.4 Coordination Results
   3.5 Coordination Recommendations
   3.6 Time-Current Characteristic Plots

4. Section 4 - Recommended Protective Device Settings

5. Section 5 - Short-Circuit Analysis Computer Reports
   5.1 Report Interpretation
   5.2 Short-Circuit Input Data Report
   5.3 Short-Circuit Analysis Results Report - Utility Source
   5.4 Short-Circuit Analysis Results Report - Generator Source
   5.5 Short-Circuit Analysis Results Report - Single-Phase

6. Section 6 - Arc-Flash Hazard Study
   6.1 General Description
   6.2 Analysis Procedure
   6.3 Arc-Flash Analysis Results
   6.4 Arc-Flash Analysis Recommendations
   6.5 Arc-Flash Labels and Location Drawings

7. Section 7 - Single Line Diagrams
   7.1 Power System Study Diagram
   7.2 Reference Drawing Single Line Diagrams

Unless specified otherwise, Contractor shall provide all computer software project study files to the District in electronic format. In addition, a copy of the computer analysis software viewer program shall be provided with the electronic project files, to allow the District to review all aspects of the project and print single line diagrams, arc-flash labels, etc.
E. Coordination of Studies and Equipment Submittals

The Short-Circuit and Protective Device Coordination Studies shall be submitted to the District prior to receiving final acceptance of the related equipment shop drawings and prior to equipment fabrication. If formal completion of the studies may cause delay in equipment fabrication and delivery, approval from the District may be obtained for preliminary submittal of sufficient study data to ensure that the proposed equipment ratings and protective device selection/characteristics will be satisfactory.

1.06 QUALIFICATIONS

A. The firm and individual(s) performing the specified studies shall be experienced in the application of computer software used for power system studies, and shall have performed studies of similar magnitude on electrical systems using similar equipment and devices.

B. The short-circuit, protective device coordination, and arc-flash hazard studies shall be conducted under the direct supervision and control of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. Each study report shall be signed and stamped by the Registered Professional Electrical Engineer.

C. Credentials and background of the firm and individual(s) performing the study shall be submitted to the District for approval prior to commencing the work. A minimum of five (5) years of experience in power system analysis is required for the engineer in charge of the project.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Short-Circuit and Protective Device Evaluation Study, Protective Device Coordination Study, and Arc-Flash Hazard Study shall be performed by the same entity.

B. The studies shall be submitted to the District prior to fabrication of any electrical distribution equipment. District's written approval will be required prior to equipment fabrication.

C. Contractor shall be responsible for supplying pertinent electrical system information for proposed equipment/material and existing equipment/material (if applicable).
D. The studies shall include all portions of the electrical system including the electric utility power source and emergency power sources, and contributions from inductive loads on the medium voltage (if applicable) and low voltage (480V) distribution system.

E. All induction motors greater than 50 HP shall be included individually with associated starters and feeder impedance. Unless specified otherwise, all induction motors 50 HP or less and fed from the same bus may be grouped together.

F. Normal system connections and those which result in maximum fault conditions shall be adequately evaluated in the studies.

G. The studies shall be performed using the latest version of the SKM Systems Analysis software (no substitutes). Software shall comply with all applicable IEEE, ANSI, and NFPA 70E standards and requirements.

2.02 DATA COLLECTION

A. Contractor shall be responsible to collect all data as required for the power system studies.

B. The firm performing the system studies shall furnish the Contractor with a listing of the required data immediately after award of the contract and the Contractor shall expedite collection of the data to assure completion of the studies prior to final approval of the distribution equipment shop drawings and/or release of the equipment for manufacture.

C. As a minimum, the following input data shall be collected and tabulated:

1. Product data for overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment names/tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. **Minimum and maximum** fault contribution, impedance, and \(X/R\) ratio of the electric power utility service transformer. Rating, type, and settings of the primary overcurrent protective device that protects the service transformer. Conductor data from the protective device to the service transformer. Contractor shall obtain the required electrical service information directly from the electric power utility. Contractor shall be responsible for all coordination and costs associated with obtaining the utility information.

3. Ampacity and interrupting rating in amperes RMS symmetrical for all switchboards, motor control centers, and panelboards.

4. Circuit breaker and fuse current ratings and types within each switchboard, motor control center, panelboard, variable frequency drive, and equipment control panel.

5. 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.

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

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

8. Distribution system transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

9. Standby generator kVA, size, voltage, source impedance, and thermal-damage curve.

10. Conductors: conduit material, sizes of conductors, number of conductors per phase, conductor material, insulation, and length.

11. Motor horsepower and code letter designation according to NEMA MG 1. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.

D. Contractor shall obtain required existing equipment data as necessary to satisfy the study requirements.
2.03 SINGLE LINE DIAGRAM

A. A single line diagram of the electrical distribution system shall be prepared in hard-copy and electronic-copy formats.

B. As a minimum, the single line diagram shall show the following:

1. All individual switchboard, switchgear, motor control center, and panelboard equipment buses with voltage, bus ampere ratings, and short-circuit current ratings.

2. Circuit breaker and fuses with current ratings, amperes interrupting ratings, and types.

3. Motors labeled with horsepower and code letter designation according to NEMA MG 1.

4. Conductor and bus connections between the equipment.

5. Conductor sizes, number of conductors per phase, conductor material and insulation, conductor length, and conduit material.

6. Transformers labeled with size (kVA), voltage, configuration, impedance, and X/R ratio.

7. Generators labeled with size (kVA), voltage, and source impedance.

8. Transfer switches labeled with ampere rating and short-circuit current rating.

2.04 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard 141.

B. Transformer design impedances shall be used when test impedances are not available.

C. As a minimum, provide the following:

1. Calculation methods and assumptions

2. Selected base per unit quantities
3. Source impedance data, including electric power utility system and motor fault contribution characteristics

4. Tabulations of input data per Part 2.02 and calculated quantities, including fault impedance, X/R ratios, asymmetry factors, motor contributions, generator contributions (if applicable), and symmetrical and asymmetrical fault currents

5. Single line diagram of the system being evaluated with available fault at each bus, and interrupting rating of devices noted

6. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric power utility’s supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear and/or switchboard
5. Motor control center
6. Distribution panelboard
7. Branch circuit panelboard
8. Variable frequency drive
9. Standby generator and automatic transfer switch
10. Equipment control panels
11. Other significant locations throughout the system.

E. 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.
F. Equipment, Material, and Protective Device Evaluations:

1. Evaluate equipment and protective devices and compare to proposed short-circuit ratings.

2. Evaluate adequacy of switchgear, switchboard, motor control center, and panelboard bus bars/bracing to withstand short-circuit stresses.

3. Evaluate adequacy of transformer windings to withstand short-circuit stresses.

4. Evaluate conductors and busways for ability to withstand short-circuit heating.

5. Identify any existing circuit protective devices improperly rated for the calculated available fault current.

6. Tabulate all evaluation results.

2.05 PROTECTIVE DEVICE COORDINATION STUDY

A. Perform the protective device study using the approved computer software program. Utilize the results of the short-circuit analysis. Coordination study shall be performed in compliance with IEEE 399.

1. Model 1/2 cycle network (sub-transient network), 1.5 to 4 cycle network (transient), and 30 cycle network (steady-state network). Calculate 1/2 cycle, 1.5 to 4 cycle, and 30 cycle balanced and unbalanced faults for 3-phase, L-G, L-L, and L-L-G.

2. Calculate the maximum and minimum 1/2 cycle short-circuit currents.

3. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.

4. Calculate the maximum and minimum ground-fault currents.

B. Fault currents and time intervals shall comply with IEEE 241 recommendations.
C. Protect conductors against damage from fault currents according to Insulated Cable Engineers Association (ICEA) Publication P-32-382, ICEA P-45-482, and conductor melting curves 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.

D. Protect transformers against damage from through-fault currents according to ANSI C57.109, IEEE C57.12.00, and IEEE 242.

E. Provide computer software generated time-current characteristic (TCC) plots of all overcurrent protective devices on log-log sheets graphically indicating the coordination for all of the key systems.

F. Perform a sequence of operation that evaluates, verifies, and confirms the operation and selectivity of the protective devices for various types of faults via normalized TCC plots and the single-line diagram. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

G. Establish settings and/or ratings of overcurrent protective devices to achieve selective coordination between devices. Graphically illustrate that adequate time separation exists between devices installed in series, including electric power utility's upstream devices. Prepare separate sets of plots for the switching schemes and for emergency periods where the power source is via the emergency standby generator(s).

H. On each TCC plot, include reference voltage, a complete title, and single line diagram with legend identifying the specific portion of the system covered.

I. Identify the device associated with each curve by device designation/tag, manufacturer, type, and function. Terminate the protective device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device will be exposed.

J. The electric power utility's relay, fuse, or protective device shall be plotted with all load protective devices at the same voltage.

K. Transformer primary protective device, transformer magnetic inrush, transformer ANSI withstand points, secondary voltage fuse or circuit breaker and largest feeder fuse or circuit breaker shall be plotted at the secondary voltage.

L. Fuse curves shall include no damage, melting, and clearing curves as applicable.
M. Circuit breaker curves shall include complete operating bands, terminating with the appropriate available short-circuit current.

N. When the main circuit breaker is provided with an arc-flash reduction maintenance system to reduce the arc fault level, both settings shall be included in the study.

O. Low voltage circuit breakers with adjustable overcurrent protection shall have instantaneous, short delay, and long-time pick-up identified on the plot. Low voltage circuit breakers with ground fault protection shall have ground fault trip settings, ground fault ampere, and time delay settings identified on the plot. Sensor or monitor rating shall be stated for each circuit breaker. All regions of the circuit breaker curve shall be identified.

P. Feeder circuit breakers shall have the time-damage curve of the feeder conductors plotted to indicate protection of the conductor insulation at the total clearing time of the circuit breaker or fuse. This time-damage point shall be calculated for the specific parameters of conductor insulation used, with average 3 phase RMS asymmetrical amperes at 1/2 cycle calculated using actual resistance and reactance values of the source plus all motor contributions which exist at the load end of the feeder conductors. Conductor initial temperature and conductor maximum transient temperature for short-circuits, as recommended by ICEA, shall be indicated.

Q. The coordination plots shall include significant motor starting characteristics and large motor protective devices.

R. As a minimum, TCC coordination plots shall be provided for the following:

1. Electric power utility’s overcurrent protective device
2. Medium voltage equipment overcurrent relays
3. Medium and low voltage fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands
4. Low voltage circuit breakers and fuses, including manufacturer’s tolerance bands
5. Transformer full-load and 150, 400, or 600 percent currents, magnetizing inrush current, and ANSI through-fault protection curves
6. Conductor damage curves
7. Ground fault protective devices, as applicable

8. Pertinent motor starting characteristics and motor damage points. For motor control circuits, show motor control center full-load current plus symmetrical and asymmetrical of the largest motor starting current and time to ensure protective devices will not trip during major or group start operation.

9. Pertinent generator short-circuit decrement curve and generator damage point, where applicable. Provide phase and ground coordination of the generator protective devices. Obtain the required input information from the generator manufacturer and include the generator actual impedance value, time constants, and current boost data in the study. Do not use typical values for the generator.

10. Other system load protective devices, including branch circuits and feeder circuit breakers in each motor control center, and main circuit breaker in each branch panelboard.

S. A summary tabulation shall be provided listing the designation/tag, manufacturer, and type for all overcurrent and ground fault protective devices, and all recommended settings of each adjustable band included for each device.

T. Provide an evaluation of the degree of system protection and service continuity possible with the overcurrent devices supplied.

### 2.06 ARC-FLASH HAZARD STUDY

A. The arc-flash hazard study shall be performed according to the IEEE 1584 guidelines and equations presented in NFPA 70E-2015, Annex D. The analysis shall be performed in conjunction with the Short-Circuit and Protective Device Evaluation Study, and the Protective Device Coordination Study.

B. The flash-protection boundary and the incident energy shall be calculated at all equipment locations in the electrical distribution system where work could be performed on energized parts, including, but not limited to, the following: switchboards, switchgear, motor control centers, panelboards, busway and splitters, and equipment control panels.

C. The Arc-Flash Hazard Study shall include all medium voltage, locations, all 480V locations, and all 240V and/or 208V locations. In addition, the Arc-Flash Hazard Study shall include all DC locations of 50V or greater.
Safe working distances shall be based upon the calculated arc-flash boundary considering an incident energy of 1.2 cal/sq cm.

When appropriate, the short-circuit calculations and the clearing times of the overcurrent protective devices shall be retrieved from the short-circuit and protective device coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios shall be compared, and the greatest incident energy shall be uniquely reported for each equipment location. Calculations shall be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation shall assume that the electric power utility contribution is at a minimum and shall assume a minimum motor contribution (all motors off). Conversely, the maximum calculation shall assume a maximum contribution from the electric power utility and shall assume the maximum amount of motors to be operating under full-load conditions. Calculations shall take into consideration the parallel operation of synchronous generators with the electric power utility, where applicable.

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

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash-protection boundary shall include both the line and load side of the main breaker.
I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions shall be included in the fault calculation.

J. Mis-coordination shall be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation shall utilize the fastest device to compute the incident energy for the corresponding location.

K. Arc-flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584, Section B.1.2. Where it is not physically possible to move outside of the flash-protection boundary in less than 2 seconds during an arc-flash event, a maximum clearing time based on the specific location shall be utilized.

L. Determine incident energy and arc-flash PPE requirements for each equipment location. For main circuit breakers with arc-flash reduction maintenance systems, determine two (2) incident energies (one for normal duty and one for maintenance duty).

M. Calculate shock hazard approach boundaries (limited approach boundary and restricted approach boundary) for each equipment location.

N. Provide recommendations to reduce arc-flash hazard energy and exposure.

O. Coordinate with manufacturers/suppliers of the electrical equipment.

2.07 STUDY DATA

The results of all study calculations, analyses, evaluations, and determinations specified in Part 2 herein shall be presented in a detailed, comprehensive report. In addition, data from the computer software analyses shall be included in the study report along with data evaluation and recommendations. Computer analysis data, data evaluation, and recommendations shall include, but not be limited to, the following:

A. Study Input Data

1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum).

2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, percent taps and phase shift.
3. Reactor data, including voltage rating, and impedance.

4. Generation contribution data, (synchronous generators and electric power utility), including short-circuit reactance (X”d), rated MVA, rated voltage, three-phase and single-line to ground contribution (for electric power utility sources) and X/R ratio.

5. Motor contribution data (induction motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio.

B. Short-Circuit Study

1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage (600V and less)
   b. Calculated fault current magnitude and angle
   c. Fault point X/R ratio
   d. Equivalent impedance

2. Momentary (First Half-Cycle) Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
   a. Voltage (greater than 600V)
   b. Calculated symmetrical fault current magnitude and angle
   c. Fault point X/R ratio
   d. Calculated asymmetrical fault currents
      • Based on fault point X/R ratio
      • Based on calculated symmetrical value multiplied by 1.6
      • Based on calculated symmetrical value multiplied by 2.7
   e. Equivalent impedance
3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:

a. Voltage (greater than 600V)
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.

C. Protective Device Coordinating Study:

1. Recommendations for Phase and Ground Relays:
   a. Current transformer ratio
   b. Current setting
   c. Time setting
   d. Instantaneous setting
e. Recommendations on improved relaying systems, if applicable.

2. Recommendations for Circuit Breakers:
   a. Adjustable pickups and time delays (long time, short time, ground)
   b. Adjustable time-current characteristic
   c. Adjustable instantaneous pickup
d. Recommendations on improved trip systems, if applicable.
D. **Arc-Flash Hazard Study:**

1. **Incident Energy Calculations:**
   a. Arcing fault magnitude
   b. Protective device clearing time
   c. Duration of arc
   d. Incident energy

2. **Arc-Flash Protection Boundary Calculations and Recommendations:**
   a. Arc-flash boundary
   b. Shock hazard approach boundaries
   c. Personal protective equipment
   d. Recommendations for arc-flash energy reduction.

**2.08 IMPLEMENTATION OF STUDY RESULTS**

Prior to fabrication, Contractor shall coordinate the study results with the manufacturers and suppliers of electrical equipment to incorporate the recommendations and modifications therein.

**2.09 ARC-FLASH AND SHOCK HAZARD LABELS**

A. **General**

1. Labels shall be 4" x 6" thermal transfer type labels of UV resistant high adhesion polyester. Labels shall be machine printed, with no field markings.

2. Labels shall comply with the requirements of the NEC, NPFA 70E, and ANSI Z535.4.

3. All labels shall be based on recommended overcurrent protective device settings and shall be provided after the results of the analyses have been accepted by the District and after any system changes, upgrades or modifications have been incorporated into the system.
4. In general, the arc-flash labels shall be based on the maximum calculated incident energies for the worst case operating scenario. However, where arc-flash reduction maintenance systems are specified, provide two (2) sets of arc-flash labels (one for normal duty and one for maintenance duty).

5. The firm performing the Study shall provide all labels. Equipment elevations drawings showing the location of each label shall be prepared by the firm performing the Study.

6. For outdoor electrical panels with interior enclosures and outer NEMA 3R wrappers, labels shall be provided on both outer and inner doors, as follows:
   a. For incident energy levels less than 40 cal/sq cm, each outer door section shall be provided with a warning label stating "WARNING, ARC-FLASH AND SHOCK HAZARD, APPROPRIATE PPE REQUIRED". The label color scheme shall match the inner arc-flash warning label.
   b. For incident energy levels greater than 40 cal/sq cm, each outer door section shall be provided with a danger label stating "DANGER, ARC-FLASH AND SHOCK HAZARD, NO SAFE PPE EXISTS, ENERGIZED WORK PROHIBITED". The label color scheme shall match the inner arc-flash danger label.
   c. Inner doors shall be provided with arc-flash labels as specified in Parts B and C below.

7. Labels shall be provided for each switchboard, distribution panel, transfer switch (automatic or manual), motor control center, variable frequency drive, distribution panelboard, branch circuit panelboard, busway, enclosed circuit breaker and disconnect switch in a readily visible location in accordance with NEC and OSHA requirements.

8. Where incident energy levels vary across a panel line-up, such as a motor control center, a separate label shall be provided for each section or compartment with a different incident energy level. As a minimum, labels shall be installed every four feet.

B. Warning Labels

1. Warning labels shall be white with an orange stripe and black letters. A sample warning label is presented at the end of this Section.
2. Warning labels shall include the following information:

   a. "WARNING, ARC-FLASH AND SHOCK HAZARDS, APPROPRIATE PPE REQUIRED".

   b. Arc-flash hazard boundary.

   c. Available incident energy (cal/sq cm) and working distance.

   d. Recommended (minimum) PPE from NFPA Table 70E H.3(b)

   e. Maximum available fault current (Isc).

   f. Shock hazard when cover is removed.

   g. Glove class.

   h. Limited approach distance.

   i. Restricted approach distance.

   j. Equipment description and location.

   k. Protective device description.

   l. Operating scenario.

   m. Firm identification (prepared by).

   n. Label preparation date.

C. **Danger Labels**

   1. Danger labels shall be white with a red warning stripe and black letters. A sample danger label is presented at the end of this Section.

   2. Danger labels shall include the following information:

   a. "DANGER, ARC-FLASH AND SHOCK HAZARDS, ENERGIZED WORK PROHIBITED".

   b. Arc-flash hazard boundary.

   c. Available incident energy (cal/sq cm) and working distance.
d. No safe PPE exists – Do not work on equipment while energized.

e. Available fault current (Isc).

f. Shock hazard when cover is removed.

g. Glove class.

h. Limited approach distance.

i. Restricted approach distance.

j. Equipment description and location.

k. Protective device description.

l. Operating Scenario.

m. Firm identification (prepared by).

n. Label preparation date.

PART 3 - EXECUTION

3.01 PROTECTIVE DEVICE SELECTION AND SETTING

A. Field setting of the protective devices shall be performed as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study, and protective device coordination study. Confirmation of protective device selection and performance of device field setting shall be witnessed and verified by the testing consultant performing electrical system testing (reference Specification Section 16010) or by the firm performing the studies.

B. Contractor shall set all relays, overcurrent devices and ground fault protection devices, and confirm selection of fuse overcurrent devices as follows:

1. Relays: Reset all adjustable relay settings from factory defaults settings to the settings recommended in the studies specified herein.

2. Circuit Breakers: Reset all adjustable trip settings from factory default settings to the settings recommended in the studies specified herein.
3. **Ground Fault Protection Devices:** Reset all adjustable device settings from the factory defaults settings to the settings recommended in the studies specified herein.

4. **Fuses:** Confirm that fuse types installed on the project are as recommended in the studies specified herein.

C. Necessary field adjustments of devices and minor modifications to equipment to accomplish conformance with the approved studies shall be performed at no additional cost to the District.

D. Contractor shall verify the proper short-circuit duty and amperage rating of all protective devices and bussing. Equipment short-circuit duty and amperage ratings shall be in accordance with the Drawings and equipment specifications, and shall meet or exceed the ratings recommended in the studies specified herein.

### 3.02 ARC-FLASH AND SHOCK HAZARD LABEL INSTALLATION

A. Affix arc-flash and shock hazard labels to all electrical equipment as required by NFPA 70 and NFPA 70E.

B. Install labels in accordance with the approved label location drawings and as specified herein.

### 3.03 FIELD REPORT

The firm witnessing the confirmation of protective device selection and performance of device field setting shall provide a detailed report showing that selections and settings of protective devices are in compliance with the studies and requirements specified herein. In addition, the report shall include a photographic record of all installed arc-flash labels, including locations. The report shall be submitted to the District for acceptance as a submittal document.
ARC-FLASH LABEL EXAMPLES

WARNING

Qualified Persons Only

Arc-Flash and Shock Hazards
Appropriate PPE Required

REVIEW SAFE WORK PRACTICES PRIOR TO WORK

44 in  Arc-Flash Hazard Boundary
7.1 cal/cm²  Arc-Flash Incident Energy at Work Distance: 18 inches
5.85 kA  Maximum Available Fault Current

Recommended (Minimum) PPE:  Arc-rated long sleeve shirt and arc-rated pants, or arc-rated coverall and/or arc-flash suit.  Arc-rated arc-flash suit hood, arc-rated gloves, arc-rated jacket, parka, or rainwear.  Hard hat, arc-rated hard hat liner, safety glasses, hearing protection, arc-rated gloves, and leather footwear.

480 VAC  Shock Hazard when Cover is Removed
00  Glove Class

42 in  Limited Approach
12 in  Restricted Approach

Equipment/Device Name:  MCC-2A
Feed From:  MDP-1
Scenario 2 - Normal Power

Study Performed by:  ACME Flash, Inc.
Prepared:  02/12/16

DANGER

Arc-Flash and Shock Hazards
Energized Work Prohibited

207 in  Arc-Flash Hazard Boundary
65 cal/cm²  Arc-Flash Incident Energy at Work Distance: 18 inches
43.8 kA  Maximum Available Fault Current

Recommended (Minimum) PPE:  No Safe PPE Exists - Do Not Work On Equipment While Energized!

480 VAC  Shock Hazard when Cover is Removed
00  Glove Class

42 in  Limited Approach
12 in  Restricted Approach

Equipment/Device Name:  Main CB
Feed From:  Service Switchboard
Scenario 2 - Normal Power

Study Performed by:  ACME Flash, Inc.
Prepared:  02/12/16

END OF SECTION
Short-Circuit/Coordination Study
and Arc-Flash Hazard Study
Section 16040 - 26

[PAGE LEFT INTENTIONALLY BLANK]
PART 1 - GENERAL

1.1 DESCRIPTION
This section outlines the wiring requirements for the electrical work, and forms a part of all other Sections of these specifications unless otherwise specified.

A. Related Work Not Included in this Section

1. Induction Motors
2. Service and Distribution
3. Lighting
4. Electrical Controls
5. PLC/RTU
6. Variable Frequency Drives

1.2 SUBMITTALS
Submit for the District's approval material lists, shop drawings, factory test reports and technical data to the extent required in this Section, Section 16010, and the General Conditions.

1.3 WIRING
Wiring for furnished equipment shall include the following:

A. Wiring for Furnished Equipment (other than Division 17 equipment). The wiring from electrical panels and control centers to the furnished equipment shall include all the required materials and installations to complete the wiring as shown on the drawings, specified and required. For a complete and operable electrical system.
PART 2 - PRODUCTS

2.1 GENERAL
Provide basic materials and all wiring installations as indicated, specified and required.

2.2 METAL CONDUITS
Conduits shall be aluminum or, hot-dipped galvanized steel and equipped with couplings and thread protector caps. The surfaces and threads shall be corrosion-resistant coated. Conduits shall be in ten-foot lengths and manufactured by Triangle, Republic, Youngstown, Allied, or equal. Supports shall be provided for all conduits.

A. Rigid Steel Conduit. Rigid steel conduit shall be provided for all concealed installation unless otherwise indicated and/or specified. For underground installations, steel conduit shall be a minimum size of 3/4 inch and stubbed up to finished grade, wrapped with 33 mil tape.

B. PVC-Coated Rigid Steel Conduit. PVC-Coated Rigid Steel Conduit shall be used for all above grade conduit installations. The conduit shall be rigid steel. Before the PVC coating is applied, the hot-dip galvanized surfaces shall be coated with a primer to obtain a bond between the steel substrate and the coating. The PVC coating shall be bonded to the primed outer surface of the conduit. The bond on conduit and fittings shall be stronger than the tensile strength of the PVC coating. The thickness of the PVC coating shall be at least 40 mils [1000 µm].

2.3 NONMETALLIC CONDUITS
Nonmetallic conduits shall be Triangle high impact styrene, Triangle, Carlon polyvinyl chloride, or approved equal. All the conduit shall be of one type, and low temperature, corrosion, and moisture resistant. PVC Sch.40 or Sch.80.

A. Nonmetallic Conduit. Nonmetallic conduit may be installed for underground conduit runs which are outside of the buildings and structures and run between buildings and structures. Rigid steel bends and risers shall be used with nonmetallic conduit wherever conduit rises to above grade equipment and to be left flush with floor, wrapped with 33 mil tape. Each nonmetallic conduit shall contain a code sized grounding conductor. All changes in direction in underground conduit installation shall be rigid conduit.
2.4 FLEXIBLE CONDUIT
Liquidtight flexible metal conduit shall be provided for short connections to equipment as shown on the drawings and as required which withstand temperatures from -50°F to +220°F.

A. **Liquidtight Conduit.** Liquidtight conduit shall have an interlocked flexible galvanized steel core with a permanently bonded exterior gray polyvinyl chloride jacket.

B. **Flexible Conduits, 1-1/4 Inch and Smaller.** Conduits, 1-1/4 inch and smaller, shall have an internal copper bonding conductor wound spirally in the space between each convolution for the equipment ground provided by the manufacturer.

C. **Separate Ground Conductor.** Separate ground conductors shall be provided by the Contractor in liquidtight flexible conduits that do not have the internal copper bonding conductors included by the manufacturer.

D. **Manufacturers.** Manufacturers for liquidtight flexible conduit shall be Anaconda, Electri-Flex, Universal or equal.

2.5 FLEXIBLE COUPLINGS
Provide the explosion-proof flexible couplings for wiring connections to equipment located in Class 1, Division 1, hazardous areas as indicated, specified and required.

A. **Explosion-proof Couplings.** Explosion-proof couplings shall have a flexible brass inner core and outer bronze braid covering attached to threaded fittings. The metallic braid and fittings shall be shipped completely factory assembled.

B. **Couplings.** The couplings shall be capable of withstanding internal explosive pressures. Couplings shall have conductivity on a similar length basis, equal to rigid steel conduit.

C. **Manufacturers.** Manufacturers for flexible couplings shall be Crouse-Hinds, Appleton, Pyle-National, or equal.

2.6 CAST METAL BOXES AND FITTINGS
Provide conduit outlet bodies, boxes, fittings, gaskets and covers for exposed conduit installations as indicated and required. The outlet bodies, boxes, fittings, and covers shall be cast copper free aluminum iron alloy with threaded hubs, and of sufficient size to provide free space for all conductors that shall be enclosed.
Basic Electrical Materials and Methods  
Section 16050 – 4

The materials shall be manufactured by Killark, Appleton, Pyle-National, or approved equal.

A. **Covers and Gaskets.** Covers and gaskets shall be provided for all conduit outlet bodies, boxes and fittings. The covers shall be cast copper free aluminum iron alloy and equipped with neoprene gaskets. Explosion-proof boxes shall have externally threaded surface covers.

B. **Seal Fittings.** Seal fittings shall be provided as required in hazardous area conduit installations. The seal fitting shall prevent gases and flames to pass from one area to another through the conduit system. Chico X-Fiber product and water soluble compound shall be provided inside the fitting to complete the seal.

C. **Plastic Fittings.** Plastic fittings shall be solvent weld type, and shall match the conduit to which they shall be connected.

D. **Thread Lubricant.** Thread lubricant shall be provided for all metal conduit threads. The lubricant shall inhibit corrosion and maintain grounding continuity, and shall be Crouse-Hinds STL, Thomas and Betts "Koper-Shield", or equal.

E. **Couplings and Elbows.** Couplings and elbows shall be of the same type as the conduit to which they shall be connected. For metallic conduits, the couplings and elbows shall be threaded and one-piece. For plastic conduits, couplings and elbows shall have plain ends for tight weld fits, which form watertight joints.

### 2.7 STEEL BOXES AND FITTINGS

Provide the steel boxes and fittings as indicated and required.

A. **Pull Boxes.** Pull boxes shall be of sufficient size to accommodate the connected conduits and enclosed conductors. Boxes 24 inches square and smaller shall have gasketed screw type covers. Larger boxes shall have bi-parting gasketed hinged doors with latch mechanisms, handles and cylinder locks complete. Provide two keys for each lock. Pull boxes shall be painted as specified in Section 16010. The pull boxes shall be Hoffman, Boss, Circle A-W, or approved equal.

B. **Outlet boxes and fittings** shall be provided for connections to concealed steel electrical metallic tubing (EMT) in hollow walls and furred ceilings.
The boxes shall be galvanized steel square and octagonal, and of sufficient size to accommodate all the required conductors enclosed in the box. Box extensions and covers shall fit. Outlet boxes and fittings shall be Appleton, Bowers, Steel City, or approved equal.

2.8 WATER SEAL FITTINGS
Provide the malleable iron water seal fittings connected to rigid steel conduits as indicated, specified and required.

   A. **Sealing Bushings.** Sealing bushings shall be provided on the ends of exterior underground conduits that terminate at indoor equipment. The bushing shall consist of a thick neoprene sealing ring secured between two metal plates by socket head screws. When the conduit sealing bushing is in place and the screws are tightened, the neoprene shall become compressed between the metal plates and be forced against the conduit inside wall and also against the conductor insulation to form a watertight seal inside the conduit.

   B. **Wall and Floor Seals.** Wall and floor seals shall be provided to completely seal the areas around the conduits that pass through concrete walls and floors. Seals shall have a neoprene grommet between two pressure rings, which provides a watertight seal on the outer surface of the entering conduits.

2.9 CONDUIT FITTINGS
Provide all the hot-dip galvanized steel, aluminum, and iron conduit fittings required to complete the wiring installation.

   A. **Liquidtight Conduit Fittings.** Liquidtight conduit fittings shall be Types LT, ST, CT as manufactured by Crouse-Hinds, Appleton, Pyle-National, or approved equal.

   B. **EMT Fittings.** EMT fittings shall be provided to connect electrical metallic tubing together, and to boxes and equipment. The couplings and connectors shall have steel bodies and malleable iron nuts as manufactured by Thomas and Betts, Efcor, Appleton, or equal.

   C. **Union.** Union shall be provided, as required, for conduit connections to threaded outlet bodies, boxes, and equipment, and for connecting two steel conduits together. Union shall be Appleton, Crouse-Hinds, Pyle-National, or equal.
D. **Bushing Reducers.** Bushing reducers shall be provided in conduit fitting hubs for connections to smaller conduits. Reducers shall be Appleton, Thomas and Betts, Efcor, or equal.

E. **Conduit Enlargers.** Conduit enlargers shall be provided for connecting two conduits of different sizes together. The enlargers shall be Appleton, Thomas and Betts, Efcor, or equal.

F. **Locknuts.** Locknuts shall be provided on the threads of conduits that enter through close fitting openings in enclosures. Locknuts shall have notches all around for tightening with a screwdriver. Locknuts shall be Appleton, O-Z, Thomas and Betts, or equal.

G. **Metallic Insulated Bushings.** Metallic insulated bushings with ground terminals shall be provided on the ends of threaded metal conduits and nipples that terminate through openings in sheet steel enclosures. The malleable iron grounding bushings shall have smooth and well-rounded surfaces to protect the conductor insulation. The conduit threads shall be deep, clean and easily attached to the conduits. The bushings shall be O-Z, Efcor, Thomas and Betts, or equal.

H. **Plugs.** Plugs shall be the recessed type and installed in all unused conduit fitting hubs and couplings. Plugs shall be Appleton, Crouse-Hinds, or equal.

I. **Interchangeable Hubs.** Interchangeable hubs shall be provided for rigid metal conduit connections to sheet steel enclosures. The interchangeable hub shall have an insulated throat, sealing ring and vibration-proof nut. Machined serrations on hub and nut shall bite into the metal enclosure assuring an equipment ground. The hubs shall be Myers "Scru-Tite", Efcor "Space-Saver", or equal.

2.10 **CONDUCTORS AND CABLES**

Conductors and cables shall be new, single conductor, copper, not smaller than #12 AWG (except fixture wire) unless otherwise indicated, and as shown on the drawings.

A. **Conductors 250 MCM and Larger.** Conductors 250 MCM and larger shall be stranded, 500 volts, and Type XHHW. Conductors shall be Okonite, General Electric, Rome, XLP, or approved equal.

B. **Conductors Smaller than 250 MCM.** Smaller than 250 MCM conductors shall be stranded, 600 volt and Type THWN 75°C unless otherwise noted. Conductors shall be Rome, General Electric, or approved equal.
C. **High Temperature Conductors.** High temperature (90°C) conductors shall be provided in areas where indicated. Conductors shall be stranded, 600 volt and Type THHN. Conductors shall be General Electric, Rome, or approved equal.

D. **Ground Conductors.** Ground conductors shall be provided for the required ground wiring. The conductors shall be stranded copper, 600 volt and Type THWN Neutral conductors shall be identified by continuous white or natural gray insulation color. Equipment and structural ground conductors shall be identified by a continuous green insulation color or a continuous green insulation color with one or more yellow stripes. Ground conductors shall be Rome, Anaconda, or approved equal.

E. **Instrumentation Signal Cables.** Instrumentation signal cables shall be single twisted pair or multi-twisted pairs of stranded, 600 volt, copper cables with 15 mil polyvinyl chloride insulation over each conductor, overall aluminum-mylar tape shield, overall tinned copper drain wire and 45 mil minimum polyvinyl chloride jacket overall. Twisted pair cables that are required to be shielded, shall have aluminum-mylar tape shields and tinned copper drain wires over individual twisted pairs of cable. Single twisted pair cables shall be #16 AWG minimum. Cables shall be Okonite "Okoseal-N-Type TC", Belden, or approved equal.

F. **Wire Lubricant.** Wire lubricant shall be provided to ease the pulling of cables and conductors in conduits. The lubricant shall be Burndy "Slikon", Holub "Hi-Green", Ideal "Yellow 77", or equal.

G. **Identifications.** Identifications on the conductors and cables shall be continuous and include the type, voltage, manufactured date and name of the manufacturer. All 120/208 volt conductors shall be color coded as follows: Phase A-black, Phase B-red, Phase C-blue. All 277/480 volt conductors shall be color coded as follows: Phase A-Brown, Phase B-Orange, Phase C-Yellow.

H. **Welding Cable.** Welding Cable shall not be used whether factory installed or field installed.

### 2.11 WIRE CONNECTORS
Connectors shall be provided for splices and terminal connections of all copper conductors and cables. The connector shall fit the conductor to which it shall be connected, and the assembly shall have joint contact surfaces not less than 50 percent.
A. **Compression Connectors.** Connectors for No. 8 AWG and larger shall be copper lugs for terminal connections, and two-way copper sleeves and taps for splice connections. A crimping tool shall be provided to make tight and neat compression connections. The connectors and crimping tool shall be Anderson-Square D, Thomas and Betts, Buchanan, or equal.

B. **Tapered Spring Connectors.** Connectors shall have live springs attached to inner steel housings and enclosed with plastic insulators. Connectors shall be provided for No. 10 AWG conductors and smaller, and shall be Buchanan Type B2, Scotchlok Type B, Thomas and Betts Type PT, or equal.

C. **Ground Clamps.** Ground clamps shall be provided for cable connections to ground rods and metal pipes as shown on the drawings. Clamps shall be copper alloy, heavy duty, corrosion resistant and consist of U-bolts and saddles with bolted cable connections. The ground clamps shall be O-Z, Thomas and Betts, Burndy, or equal.

D. **Electrical Tape.** Tape shall be plastic, 0.007 inches thick, and resistant to abrasion, alkalies, acids, corrosion, moisture, low and high temperatures. The tape shall be Scotch No. 33 Plus, Plymouth Premium Black No. 4453, or equal.

E. **Wire Markers.** Markers shall be provided to identify conductors and cables at equipment terminals, and in boxes, and handholes. The markers shall be adhesive and manufactured by Thomas and Betts, Brady, or equal.

---

2.12 **PANELBOARDS**

Panelboards shall be factory assembled, metal enclosed, dead front and equipped with thermal-magnetic molded case circuit breakers as shown on the drawings.

A. **Circuit Breakers.** Circuit breakers shall be molded case, toggle type, quick-make, quick-break, trip free, single and multipole, and bolted type. Each circuit breaker shall have clear visual indications for "ON", "OFF", and "TRIP" positions. The minimum interrupting capacity shall be 10,000 symmetrical amperes at 240 volts. As indicated, provide devices to lock the branch circuit breaker in the "ON" and "OFF" positions.
B. **Copper Bus.** Plated Copper bus shall be provided for single phase (120/240 volt) and three phase (120/208 volt) panelboards and be rated as shown on the Drawings.

C. **Bussing.** Panelboards, shall be bussed so that any adjacent single-pole breakers shall be connected to different phases (distributed phase). A single handle two-pole breaker or three-pole breaker can be installed at any location.

D. **Terminals and Connectors.** Terminals and connectors shall be provided for the feeder, neutral and branch conductors shown on the drawings.

E. **Circuit Numbers.** Circuit numbers shall start at the top of the panelboard. Odd numbers shall be assigned in sequence on the left side, and even numbers shall be in sequence on the right side of the panelboard.

F. **Cabinet.** The cabinet shall enclose the bus and breaker assembly, and shall be steel fabricated and coated with corrosion-resistant finish as specified in Section 16010 2.01.D The front of the panelboard shall include a trim, hinged door, flush cylinder lock with catch. The lock shall be furnished with two keys, and all locks shall be keyed alike. Fronts shall not be removable when the door is in the locked position.

G. **Circuit Directory.** The circuit directory frame and card with clear plastic covering shall be provided on the inside of the door. The directory card shall provide a space at least 1/4-inch high and 3 inches long for each branch circuit. The card shall be completely typed to identify each connected and spare circuit.

H. **Manufacturers.** Lighting panelboards and transformers shall be manufactured by Eaton/Cutler-Hammer, Schneider/Square D, or General Electric (no substitutes).

### 2.13 MOTORS AND CONTROLS

The motors shall be furnished and installed with the driven equipment as indicated and specified in Divisions 11, 13, 15, and Section 16150.

A. **Motor Wiring.** Motor wiring shall be provided as shown on the drawings.
2.14 OVERCURRENT PROTECTION

Circuit breakers, fuses, relays and other protective devices that protect the conductors and equipment against overload currents and short circuit currents shall be provided as indicated, specified and required.

A. **Circuit Breakers.** Circuit breakers shall be molded case type unless otherwise indicated. Breakers shall be quick-make and quick-break on manual or automatic operation. The drawings shall indicate the number of poles and ampere trip ratings. The handle mechanism shall be trip-free which prevents holding the contacts against overload or short circuit conditions.

1. The thermal device shall provide time-delay tripping on overloads, and the magnetic device shall provide instantaneous tripping on short circuits. The instantaneous magnetic trip shall be adjustable and accessible from the front of the circuit breaker on frame sizes above 100 amperes.

   Non-automatic breakers shall have no tripping devices, and shall be used for manual switching of circuits. Molded case thermal-magnetic circuit breakers shall have at least the following interrupting capacities in symmetrical amperes at 480 volts unless otherwise indicated.

   - 100 Ampere Frame - 18,000
   - 225 Ampere Frame - 25,000
   - 400 Ampere Frame - 30,000

2.15 WIRING DEVICES

Receptacles and switches shall be specification grade, heavy duty and provided in cast metal boxes with gasketed covers as identified and located on the drawings. Unless otherwise indicated, the device phenolic color shall be ivory for all duplex receptacles and localswitches.

A. **Convenience Receptacles.** Convenience receptacles for interior installations, shall be duplex, grounding type, polarized, NEMA 5-20R, rated 20 amperes and 125 volts AC, and shall have double sided screw terminals for copper wire unless otherwise indicated. The receptacles shall be #5362 ivory and manufactured by Hubbell, Arrow, Bryant, or approved equal.
B. **Local and Weatherproof Switches.** Switches shall be toggle type, rated 20 amperes and 120-277 volts AC, and equipped with side screw terminals for copper wire. Single pole switches shall be #1221, #1991, #4901 ivory. Three-way switches shall be #1223, #1993, #4903 ivory. The switches shall be manufactured by Hubbell, Arrow, Bryant, or approved equal.

### 2.16 DISCONNECT SWITCHES

Provide the fusible disconnect switches, or non-fusible as indicated, specified and required.

A. **Switches** shall be steel enclosed, heavy duty, NEMA 1 and NEMA 3R and NEMA 12 as required, 2-pole and 3-pole, 250 volt and 600 volt, ampere rating as indicated, and finished as specified in Section 16010. On the front of the enclosure, attach a plastic nameplate that identifies the load. Disconnect switches shall be Square D Type RB, Westinghouse Type H-600, I-T-E "Vacu-break", or approved equal.

B. **Mechanisms.** Mechanisms shall have quick-make and quick-break operating handles and provisions for padlocking in the "OFF" position. The switch shall have an interlock to prevent unauthorized opening of the hinged cover when the switch is in the "ON" position, and an interlock to prevent closing the switch mechanism with the hinged cover open.

C. **Copper Lugs.** Copper lugs shall be included for the copper wire connections. The lug shall fit the conductor which shall be connected to the lug.

### 2.17 SUPPORTS

Provide the galvanized metal channels, fittings, stanchions, clamps, hangers, and required hardware to support all conduit and equipment as required. Refer also to earthquake restraint provisions of Section 11005.

A. **Channels.** The channels shall be steel and cold rolled. One side of the channel shall have a continuous slot. On both sides of the slot, the edges turn inward and form a guide for the spring nuts. The fittings shall be fabricated from steel and attached to the channel with bolts and spring nuts. The channel, fittings, and hardware shall be hot-dipped galvanized and manufactured by Unistrut, Power-Strut, Kindorf, or equal.
B. **One-hole Clamps.** Clamps shall be malleable iron, galvanized for steel conduits and equipped with clamp-backs. The clamps shall be Efcor, Thomas and Betts, Appleton, or equal.

C. **Beam Clamps.** Clamps shall be malleable iron, galvanized, right angle and parallel types. The clamps shall be manufactured by Efcor, Thomas and Betts, Appleton, or equal.

D. **Spacers.** Spacers shall be plastic and provided to support underground conduits for concrete encasements. The spacers shall be Carlon, Johns-Manville, Underground Products, or equal.

E. **Steel Anchors.** Steel anchors shall be sleeve and stud types for securing equipment to concrete foundations, floors, and walls. The anchors shall be Phillips "Red Head", Diamond, or equal.

F. **Toggle Bolts.** Toggle bolts shall be steel, spring wing type for securing equipment to hollow walls and ceilings. Toggle bolts shall be Phillips "Red-Head", Diamond, or equal.

G. **Stanchions.** Stanchions shall be structural steel as shown on the drawings, shop fabricated, coated with a rust inhibiting primer and finished with a corrosive-resistant gray enamel as specified in Division 9.

H. **Conduit Hangers.** Conduit hangers shall be heavy gauge formed steel, galvanized and equipped with carriage bolts, 1/4-inch rods and nuts. The hangers shall be Efcor, Kindorf, Appleton, or equal.

I. **U-Bolts.** U-bolts shall be heavy gage steel, galvanized and equipped with two hexagon steel nuts. The U-bolts shall be Efcor, Kindorf, or equal.

**Fixture Hangers.** Fixture hangers shall be cast iron alloy, cushion type, equipped with cover, screw terminal blocks, and permits the pendant to swing 20 degrees from perpendicular in any direction.

Hangers shall be Crouse-Hinds Type ALT, Appleton Type ALT, Pyle-National Type A-2152M, or equal.

J. **Hardware.** Hardware shall be provided to securely attach all equipment and materials.
2.18 NAMEPLATES
Plastic nameplates shall be provided for switchboards, motor control centers, panelboards, receptacles, local switches, and individually enclosed circuit breakers, disconnect switches, magnetic starters, relays, manual starters and control stations unless otherwise indicated.

All nameplates shall be NEMA ES-1, 3-ply, 1/16-inch thick, beveled and satin finished and shall be attached using rivets.

A. Nameplates. The nameplates shall be laminated black plastic with 1/4-inch high (unless otherwise specified) white letters. Nameplates on receptacles and local switchplates shall have 3/16-inch high letters. Nameplate inscriptions shall include the identifications for the equipment and loads and shall identify the controls on control equipment as shown on the drawings. Nameplate inscriptions on receptacles and local switchplates shall include the panelboard number and circuit that the device is connected to, i.e., "PA1-1".

B. Lockout/Tagout Nameplates shall be provided for all pumps and other mechanical equipment where multiple devices including but not limited to switches, circuit breakers, by-pass contactors, variable frequency drives, solid state starters, etc., may cause the equipment to be energized. Said nameplates shall be installed over the main circuit breaker or disconnect switch which will solely remove power from the equipment and all appurtenant controls and circuitry contained in the panel negating the possibility of power being applied by another source.

The nameplate shall be laminated red plastic with 3/8-inch high (unless otherwise specified) white letters. The inscription shall read “LOCKOUT/TAGOUT LOCATION FOR” with a description identifying the equipment (i.e. “FAN No. 1”).

PART 3 - EXECUTION

3.1 GENERAL
Provide the wiring installations and equipment installations, including connections and interconnections as indicated, specified and required.

Assure proper fits for all equipment and materials in the spaces shown on the drawings.
A. **Excavations and Backfills.** Earthwork shall be performed for equipment foundations, supports and underground conduits as indicated and as specified in Division 2.

B. **Concrete.** Concrete shall be provided for electrical equipment foundations, support foundations and conduit encasements as indicated and as specified in Division 3. All concrete encasements shall contain red dye unless otherwise noted.

C. **Painting.** Painting shall be provided for installations having unfinished surfaces as specified in Division 9. Field damaged factory finishes on equipment shall be touched-up with paint that is equal in quality and color to the original factory finish.

### 3.2 RACEWAYS

Provide all the conduit installations, including the outlet bodies, boxes, gaskets, covers, fittings and supports to complete the raceway systems as shown on drawings and as required. Install ground conductors in all non-metallic conduits.

A. **Underground Installations.** Provide the required rigid steel conduits and plastic conduits with watertight connections and completely encased with concrete. Provide at least 3 inches of concrete between the conduits and the outside of the encasement, and 2 inches of concrete between the conduits unless otherwise indicated. Install spacers and adapters to support and terminate non-metallic conduits. Connect the adapters to rigid steel conduit risers that terminate at above-grade equipment wrapped with 33 mil tape. The steel conduit riser shall be completely concrete encased to finish grade. The top of the concrete encasement shall be a minimum of 24 inches below finish grade. Trench backfilling shall be done according to Division 2 of these specifications. Restore the finish grade surface to match existing. Repave the trench to match existing pavement if trench passes through a paved area. Concrete shall contain red dye.

B. **Conduits in Concrete.** Conduits shall be installed in concrete encasements (red dyed), slabs, foundations, floors, and walls as shown on the drawings. The conduits shall be properly positioned in the concrete forms to provide the required clearance space with reinforcing steel. Conduit stub up's shall be galvanized rigid steel conduit wrapped with 33 mil tape. Refer to "L." in this Section Labeled stub up's.
C. **Exposed Installations.** The installations of conduit shall be completed with wrench-tight connections. In hazardous areas, only aluminum conduits shall be installed. In corrosive areas, and in hazardous corrosive areas, aluminum conduits shall be installed as shown on the drawings. Maintain a minimum clearance of 12 inches for conduits that shall be installed near hot pipes or surfaces (150°F or higher). Exposed conduits shall be installed parallel with buildings and structures.

D. **Concealed Installations.** Installations in walls and above furred ceilings shall be completed with galvanized steel electrical metallic tubing with tight couplings and tight double locknuts and bushing connections.

E. **Flexible Conduits.** Flexible conduits shall be liquidtight with fittings for short tight connections (30 inches maximum) to equipment, except in Class 1, Division 1 areas. A separate ground conductor shall be installed in flexible conduit that does not have the internal copper bonding conductor included by the manufacturer.

F. **Flexible Couplings.** The couplings shall be explosion-proof with fittings for short, flexible, tight connections to equipment in Class 1, Division 1 hazardous areas.

G. **Threads.** All metal conduit threads shall be coated with a corrosion resisting lubricant, and the connections shall be made watertight. The lubricant shall maintain the grounding continuity.

H. **Locknuts and Bushings.** Locknuts and bushings shall be installed on the threads of metal conduits that enter through close-fit openings in enclosures.

I. **Sealing Bushings.** The bushings shall be installed on the ends of exterior conduits that terminate at indoor equipment. The bushing shall provide a watertight seal inside the conduit.

J. **Seal Fittings.** Seal fittings shall be connected to rigid metal conduits in hazardous areas to prevent gases and flames to pass from one area to another through the conduit system. Also, sealing fittings shall be installed to completely water-seal inside conduits and the areas around steel conduits that pass through concrete floors and outside walls.

K. **Penetrations.** Penetrations through concrete for sleeves and conduits shall be approved by the Owner. Submit the sizes, locations, and methods for all penetrations.
L. **Stub-ups.** All steel conduit stub-ups shall have a coupling installed flush with the floor.

M. **Tool Marks.** Conduits and fittings that have tool marks shall be smoothed and finished with paint that matches the original finish.

N. **Conduit Through Roof.** Provide a watertight seal around the conduit on the roof. Coordinate the work with the roofing contractor.

O. **Furnished Equipment.** Provide conduit installations as shown on the drawings, and specified in other sections of the specifications for furnished equipment.

P. **Alterations.** Alterations to existing installations shall be completed as indicated and specified.

3.3 **BOXES AND FITTINGS**
Outlet bodies, boxes, gaskets, covers, fittings and supports shall be installed as indicated, specified and required.

A. **Cast Metal.** Cast metal outlet bodies, boxes, gasketed covers and fittings shall be connected to exposed aluminum conduits.

B. **Sheet Steel.** Sheet steel boxes shall be provided with close-fit holes for steel conduit connections. Weatherproof boxes shall be provided with interchangeable conduit hubs for steel conduit connections as indicated.

C. **Interchangeable Hubs.** The hubs shall be installed in steel enclosures for rigid metal conduit connections as required. Cut a close fitting hole in the sheet steel enclosure and place the interchangeable hub in the opening. Connect the hub on the conduit and make a tight connection to the enclosure.

3.4 **CONDUCTORS AND CABLES**
Install all the conductors and cables for the wiring as indicated, specified and required.

A. **Conductors.** Conductors shall be completely installed and connected. Apply wire lubricant to ease the pulling of conductors in conduits. Recommended pulling tensions shall not be exceeded. Splice and terminal connections shall be made tight with spring and compression connectors.
The connectors shall be crimped with a tool that provides uniform and tight connections. Connectors shall be sized as outlined in paragraph on "Wire Connectors" in this section. Include all the required wiring interconnections.

**B. Insulate.** All connections shall be insulated as required with tight wraps of plastic tape. Apply insulation putty to fill irregularities and voids in splices. High and medium voltage cable splices shall be completed as instructed by the cable manufacturer.

**C. Furnished Equipment.** Provide wiring installations as shown on the drawings, and specified in other sections of the specifications for furnished equipment.

**D. Wire Marking.** All wires shall be marked with wire markers at each end and at each intermediate j-box, pull box, or enclosure except for short "jumper" wires. Wire markers shall indicate the designation/destination of the wiring in the conduit. Example being-LPCB1 - REC1 to indicate lighting panel circuitbreaker #1 to receptacle #1; MCCCB4 - MTR4 indicating Motor Control Center Breaker #4 to Motor #4 etc. Conduit numbers shall be imprinted on brass tags with the numbers as indicated on the “conduit and wire schedule”.

3.5 **PANELBOARDS**

Install and completely connect all the factory assembled panelboards as shown on the drawings.

**A. Elevation.** The elevation to the top of the panelboard shall be six feet above the floor unless otherwise indicated.

**B. Clearance Space.** Provide at least ½ inch clearance between the back of the cabinet and masonry or concrete wall.

**C. Anchor Bolts.** Securely attach the panelboard to the wall with anchor bolts.

**D. Locking Devices.** Attach locking devices on the handles of branch circuit breakers for the "ON" position as shown on the drawings.

**E. Circuit Directory Card.** Completely type the card to identify each connected and spare circuit.
F. **Tight Connections.** Provide tight connections for feeder and branch circuit wiring.

### 3.6 MOTORS AND CONTROLS
Install all the wiring and control equipment as indicated, specified and required.

- **A. Motors.** Motors shall be provided (and coordinated) with the driven mechanical equipment.
- **B. Wiring.** The wiring installations shall be complete. Include all the required wiring interconnections between the motor magnetic starters. Provide oversized motor frame conduit connection boxes as required. Be certain that all wiring connections provide the proper motor rotation.
- **C. Relays.** Provide the control and time delay relays as shown on the drawings specified elsewhere and as required. Adjust the time delay relays so motors shall start up in proper sequence.

### 3.7 OVERCURRENT PROTECTION
Install all the overcurrent protective equipment as indicated, specified and required.

- **A. Metal Enclosures.** The enclosures for individual equipment shall be constructed to satisfy the condition in the location where they shall be installed.
- **B. Overload Relays.** Overload relays shall be provided in the control equipment for three-phase and single-phase circuits as required. Determine the motor nameplate full load running current for each motor. Then provide and install the proper overload relay heater elements corresponding to the nameplate full load running current per the starter manufacturer's recommendations and code. Replace the relays that shall not satisfactorily protect the connected motors.
- **C. Trip Settings.** Circuit breakers shall assure the required circuit protection with the indicated trip settings.

### 3.8 WIRING DEVICES
Install the required local switches, convenience outlets and clock outlets complete, including the supports and wiring.
3.9 DISCONNECT SWITCHES
Provide the complete installations for fused disconnect switches and non-fused disconnect switches where shown on the drawings and as required.

A. **Mounting Height.** Switches shall be installed 5 feet from grade or floor to the top of the enclosure unless otherwise indicated.

B. **Connections.** The steel enclosures shall be connected complete with metal conduits terminating into interchangeable hubs attached to the enclosures. Wire connectors shall be provided for connecting the copper conductors.

3.10 SUPPORTS
Install the required structural channels, brackets, stanchions, U-bolts, clamps, anchors, hangers, fittings, and other hardware to securely attach and support all the equipment and conduits.

A. **Painting.** Brackets, stanchions and other unfinished steel supports shall be painted as specified in Division 9.

3.11 NAMEPLATES
Plastic nameplates shall be positioned and lined-up to provide a neat appearance. They shall be attached to the cleaned metal surfaces of enclosures with machine screws or escutcheon pins. Nameplates shall be attached to receptacle and local switchplates with an adhesive or equal for circuit identification and placed above the device.

A. **Nameplate Location.** Nameplates shall be installed on toggle switches, convenience receptacles, motor control centers, panelboards, and individually enclosed circuit breakers, disconnect switches, magnetic starters, manual starters, relays and control stations unless otherwise indicated.

3.12 CHECKING, ADJUSTING AND TESTING
Provide the required labor and equipment, and all checking, adjusting and testing operations on the electrical installations.

A. **Check.** All wire terminals shall be checked to assure tight connections.

B. **Adjust.** Adjust repeat cycle timers, interval timers and time delay relays and other devices so the controls shall operate in the indicated sequence.
C. **Wiring Tests.** The tests shall be performed to detect wrong connections, short circuits, continuity and grounds. Insulation tests shall be made with a hand crank or battery operated test instrument on all cables, conductors and motors. Power feeders branch conductors and motors shall be tested phase-to-phase, and phase-to-ground. A copy of the test results for feeders and motors shall be submitted to the District when completed (after any deficiencies have been noted and corrected). Correct any installation and electrical defects in the wiring systems.

D. **Equipment Tests.** Perform equipment tests as indicated and directed by the manufacturer. Refer to Section 16010, Article 1.04E for Manufacturers' Certified Reports on motor control centers.

E. **Test Data.** Test data for equipment, shielded cables and supply voltage shall be submitted to the District.

F. **Supply Voltage.** Test the supply voltage while the normal plant loads are operating. If the voltage is not within normal limits (plus or minus one percent), notify the District.

G. **Operation Tests.** Perform operation tests and observe that all loads operate satisfactorily. Refer to Section 16010, Article 3.07 for Demonstration and Final Operation Test Plans and Results.

**END OF SECTION**
**SPECIFICATIONS - DETAILED PROVISIONS**
Section 16150 - Induction Motors

**CONTENTS**

<table>
<thead>
<tr>
<th>PART 1 - GENERAL</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.01 DESCRIPTION</td>
<td>1</td>
</tr>
<tr>
<td>1.02 RELATED SECTIONS</td>
<td>1</td>
</tr>
<tr>
<td>1.03 REFERENCE STANDARDS AND CODES</td>
<td>2</td>
</tr>
<tr>
<td>1.04 SUBMITTALS</td>
<td>3</td>
</tr>
<tr>
<td>1.05 QUALITY ASSURANCE</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PART 2 - PRODUCTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.01 GENERAL REQUIREMENTS</td>
<td>7</td>
</tr>
<tr>
<td>2.02 ELECTRICAL REQUIREMENTS</td>
<td>10</td>
</tr>
<tr>
<td>2.03 MECHANICAL REQUIREMENTS</td>
<td>12</td>
</tr>
<tr>
<td>2.04 ACCESSORIES AND OPTIONS</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PART 3 - EXECUTION</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.01 FACTORY TESTS</td>
<td>18</td>
</tr>
<tr>
<td>3.02 DELIVERY, STORAGE, AND HANDLING</td>
<td>19</td>
</tr>
<tr>
<td>3.03 INSTALLATION</td>
<td>19</td>
</tr>
<tr>
<td>3.04 FIELD CHECKS AND TESTS</td>
<td>20</td>
</tr>
</tbody>
</table>
PART 1 - GENERAL

1.01 DESCRIPTION

A. This section specifies the electrical requirements for squirrel-cage induction motors. Motors shall be supplied by the manufacturer of the driven equipment as specified in this section, and specifically outlined in the equipment sections of these Specifications. The requirements of the individual driven equipment sections are equally applicable to the work specified herein. Where conflict exists, the individual equipment sections shall take precedence.

B. Contractor shall furnish and install electric motors, accessories, and appurtenances as specified herein and in conformance with the individual specifications of driven equipment, to provide a complete and operable installation, all in accordance with the requirements of the Contract Documents.

C. The Contractor and equipment manufacturer shall be responsible for providing motors and controls sized in accordance with the requirements specified herein and in the individual equipment sections. Under no circumstances shall the nameplate rating of the motor be exceeded under the maximum design capacity of the equipment supplied. In addition, the motor service factor shall not be used for motor sizing.

1.02 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying electric motor driven equipment.
2. Section 16010 - General Electrical Requirements
3. Section 16050 - Basic Electrical Materials and Methods
4. Section 16151 - Vertical Hollowshaft Electric Motors
5. Section 16160 - Variable Frequency Drives
Induction Motors
Section 16150 – 2

6. Section 16480 - Motor Control Centers, Switchboards, and Panelboards
7. Section 17005 - General Instrumentation and Control Components

1.03 REFERENCE STANDARDS AND CODES

All equipment and materials, including installation of same, shall meet or exceed the applicable requirements of the following standards and codes (latest edition):

A. American Bearing Manufacturer's Association (ABMA)
   1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings
   2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings

B. Institute of Electrical and Electronics Engineers (IEEE)
   1. IEEE 43 – Recommended Practice for Testing Insulation Resistance of Rotating Machinery
   2. IEEE 85 – Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery
   3. IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators
   5. IEEE 303 – Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations and Class II, Division 2 and Zone 22 Locations
   7. IEEE 1349 – Guide for the Application of Motors in Hazardous (Classified) Locations

C. National Electrical Manufacturers Association (NEMA)
   1. MG 1 - Motors and Generators
2. MG 2 – Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

3. MG 13 – Frame Assignment for Alternating-Current Integral-Horsepower Induction Motors

D. National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code (NEC)

E. Underwriters Laboratories (UL)

1. UL 674 - Electric Motors and Generators for Use in Hazardous (Classified) Locations

1.04 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete information, drawings, and data for motor driven equipment as specified in the individual specification sections for same. Motor submittal information shall be provided as part of the submittals for the driven equipment. As a minimum, motor submittal information, drawings, and data shall include the following:

1. Machine name and specification section number of driven machine.

2. Motor manufacturer, motor type or model.


4. Motor data summary sheet, listing: nominal horsepower; NEMA design; frame size; enclosure type; winding insulation class and treatment; rated ambient temperature; service factor; voltage, phase, and frequency rating; full load current at rated horsepower for application voltage; starting code letter, or locked rotor kVA, or current; special winding configuration such as part-winding, star-delta (include winding diagram); rated full load speed; power factor at full load; noise certification and data sheets (where required); and bearing types and catalog numbers.
5. Motor performance characteristics:
   a. Guaranteed minimum efficiency at rated load at rated voltage.
   b. Guaranteed minimum power factor at rated load at rated voltage.
   c. Expected efficiency at 1/2, 3/4, and full load at rated voltage.
   d. Expected power factor at 1/2, 3/4, and full load at rated voltage.
   e. Full load current at 110 percent voltage.
   f. Starting current at rated voltage (motor locked rotor design code).

6. Motor outline, cross-section, and assembly drawings, with dimensions and motor net weight. Motor wiring diagrams, including wiring for all accessories and components.

7. Motor output shaft diameter, length, keying, drilling, etc. Motor coupling for connection to driven equipment (if applicable).

8. Bearing types and catalog numbers.

9. Special characteristics and features of motor(s) to be supplied.

10. Time in seconds motor can be subjected to locked rotor current at rated voltage without damage to motor with: (1) motor initially at the rated ambient temperature, and (2) motor initially at the rated temperature rise.

11. Thermal protection system (where required) including recommended alarm and trip settings for winding RTDs (if applicable).


13. Motor noise data sheets and certification (where required).

14. Vertical motor data (where applicable):
   a. Thrust bearing life.
   b. Type of thrust bearing lubrication.
   c. Type of guide bearing lubrication.
15. Inverter duty motor data (where applicable):
   a. Manufacturer's inverter duty motor specifications, including motor winding voltage rating.
   b. Maximum distance (in feet) motor may be located from variable frequency drive.
   c. Torque output rating: variable or constant.
   d. Operating speed range, continuous duty.
   e. Motor manufacturer's certification statement that the proposed motor is suitable to drive the selected equipment over the specified speed range with the selected motor.
   f. Motor noise data sheets and certification.

16. Factory test reports, including all factory test results.

B. Operation and Maintenance (O&M) Manuals

Contractor shall prepare a detailed O&M Manual for each type and size of motor required by the individual equipment sections for the driven equipment. Motor O&M Manuals shall be provided as a part of the O&M Manuals for the driven equipment. Equipment O&M Manuals shall be provided in accordance with the requirements of the District's General Conditions and Section 01430.

Motor O&M Manual information and data shall include, but not be limited to, the following:

1. Motor Performance Data and Drawings
   a. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, and illustrations.
   b. As-built motor outline, cross-section, and assembly drawings.
   c. As-built motor wiring diagrams, including wiring for all accessories and components.
2. Motor Installation Requirements
   a. Complete, detailed installation instructions for all motors, accessories, and components.
   b. Alignment and adjustment instructions.

3. Motor Service and Maintenance Data
   a. Maintenance data shall include all information and instructions required by District's personnel to keep motors properly lubricated and adjusted.
   b. Unloading, handling, and long term storage requirements.
   c. Explanation with illustrations as necessary for each maintenance task.
   d. Recommended schedule of maintenance tasks.
   e. Troubleshooting instructions.
   f. List of maintenance tools and equipment.
   g. Parts list with part illustrations.
   h. Name, address and phone number of manufacturer and manufacturer's local service representative.

4. Manufacturer's Warranty

5. Provide a signed written certification report with the Final Operation and Maintenance Manuals, certifying that each motor has been properly installed, lubricated, and adjusted, and is suitable for satisfactory continuous operation under varying operating conditions, and meets all requirements specified in the Contract Documents.

1.05 QUALITY ASSURANCE

A. All motors shall be UL listed and labeled.

B. Induction motors shall be manufactured by U.S. Motors, Baldor, General Electric, or equal.
C. Motors shall be provided with an extended warranty by the manufacturer against material and workmanship defects. The extended warranty shall be the manufacturer’s standard policy, and shall be in addition to the Contractor’s Contract warranty requirements.

1. Premium efficient motors shall be warranted for 36 months.

2. Inverter duty motor shall be warranted for 36 months.

3. Severe duty motors shall be warranted for 60 months.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

All electric motors shall comply with NEMA MG 1. Motors shall be suitable for the starting method indicated on the Drawings. All motors shall be sized to carry continuously all loads which may be imposed by the driven equipment through their full range of operation.

A. Minimum Service Conditions (Unless Specified Otherwise)

Motors shall be capable of operating continuously and satisfactorily in ambient temperatures from minus 10°C (+14°F) to plus 50°C (+122°F) and at a maximum elevation of 3,300 feet.

B. Minimum Requirements

1. Motors driving identical equipment shall be identical.

2. Motor nameplate horsepower:

   a. Motors shall be sized so that the brake horsepower (BHP) requirement of the driven equipment does not exceed 90 percent of the motor full load nameplate horsepower, unless specified otherwise.

   b. The motor horsepower indicated on the Drawings or specified in the driven equipment specification section are based on information and estimates from the manufacturer(s) of the driven equipment. The nameplate horsepower of the supplied motor shall not be less than the motor horsepower indicated on the Drawings or specified in the driven equipment specification section.
c. If the minimum specified motor horsepower is not adequate to satisfy the sizing requirements herein or any other requirements of the Contract Documents, motors with the necessary horsepower shall be provided at no additional cost to the District. In addition, any changes to equipment and material related to an increase in motor horsepower shall be made by the Contractor at no additional cost to the District. These related changes shall include, but not be limited to, the following: circuit breakers, motor starters, motor overload devices, motor power feed conductors, and conduit sizes.

3. Motors shall be rated for continuous operation at the specified service factor and specified minimum service conditions.

4. All motors shall be NEMA Design B unless specified otherwise in the driven equipment specification section, or required by the application.

5. Motors shall be rated for full voltage across-the-line starting.

6. Starting current at full voltage shall not exceed 650 percent of the motor full load current for all integral horsepower motors.

7. The motor shall be capable of accelerating the driven machine from zero to top speed with motor power supply at 90 percent of rated voltage without overheating.

8. Motors shall be designed for high power factor. Minimum motor power factor at full load shall be 80 percent.

9. Maximum locked-rotor kVA/hp code letter shall be Code G for motors 15 hp and larger, unless specified otherwise.

10. Two-speed motors shall be two-winding motors. Two-speed, one-winding motors are not acceptable.

11. All motors shall have a safe stall (locked-rotor) time equal to or greater than the maximum accelerating time under the worst voltage conditions specified.

12. Motors shall be designed for operation in either direction of rotation without a physical change to the motor.

13. Motor fans shall be suitable for bi-directional rotation, and shall be accurately balanced before assembly on the motor.
C. **Special Service Conditions**

1. Motors driven by Variable Frequency Drive (VFD) systems shall comply with the following:

   a. Inverter duty rated and labeled.

   b. Meeting the requirements of NEMA MG 1, Part 31 including winding insulation.

   c. Satisfactory for operation with standard power feed conductors (no requirements for special cables).

   d. Capable of operating continuously at 10% of full speed.

   e. Rotors shall be stiff shaft design, statically and dynamically balanced. First lateral critical speed shall be at least 20% above the maximum running speed of the driven equipment.

   f. Compatible with the VFD system to be supplied including peak output voltage and switching frequencies.

   g. Motor bearings shall be protected from shaft current produced by common mode voltages and other electromagnetic interaction of the motor and VFD.

   h. 30 hp and larger motors shall be provided with a shaft grounding device (ring) on the drive end.

   i. 100 hp and larger motors shall be provided with insulated bearings and a shaft grounding device.

   j. Sound pressure levels shall be limited to a maximum of 10 dB greater for motors used with PWM drives than for motor operation on sine wave power at a distance of 3 feet from any motor surface.

   k. Rated for a service factor of 1.0.
Induction Motors
Section 16150 – 10

2. Motors located in NEC hazardous Class I, Division 1 or Class I, Division 2 areas shall be properly rated for the hazardous location classification and ignition temperatures. As a minimum, motors located in Class I, Division 1 areas shall be rated explosion-proof, and shall be UL listed and labeled. Motors shall be in compliance with the requirements of UL 674. In addition, motor winding thermostats, motor starting, and motor controls shall be in accordance with the motor manufacturer’s recommendations, and shall satisfy the requirements of the NEC and UL.

3. Motors located in wet or corrosive areas shall be rated for severe duty. As a minimum, severe duty motors shall comply with the following:
   a. Fan material shall be strong and durable, and shall be abrasion and corrosion resistant.
   b. Enclosures shall be totally enclosed fan cooled (TEFC) or totally enclosed non-ventilated (TENV). Motor case construction shall be corrosion resistant cast iron, including one-piece frame, end shrouds, conduit box, and fan shroud.
   c. External surfaces shall have a high bond heavy build double epoxy enamel finish. The finish shall provide maximum corrosion protection and withstand the effects of outdoor weathering including sunlight.
   d. All hardware shall be constructed of stainless steel.
   e. Permanent bearing isolators shall be installed on the shaft extension and fan ends.
   f. Motors shall be designed and constructed to IEEE Standard 841.

2.02 ELECTRICAL REQUIREMENTS

Unless indicated otherwise on the Drawings, or specified otherwise in the individual equipment sections of the driven equipment, motor electrical requirements shall be as follows:

A. Voltage and Frequency

1. Motors 1/2 hp through 500 hp:
   Motors shall be rated for 460 V, 3-phase, and 60 Hz power.

2. Motors smaller than 1/2 hp:
Induction Motors
Section 16150 – 11

Motors shall be rated for 115/230 V, 1-phase, 60 Hz power, and shall be of the capacitor-start, induction-run type.

3. Motors shall operate successfully under running conditions at rated load with variation in the voltage or the frequency not exceeding the following conditions:
   a. +/-10% rated voltage at rated constant volts/hertz ratio, except for specific torque boost situations.
   b. +/-5% rated frequency at rated constant volts/hertz ratio.
   c. Motors shall operate successfully under running conditions at rated load and volts/hertz ratio when the voltage unbalance at the motor terminals does not exceed 1%.

B. Operating Characteristics

With rated volts/hertz ratio applied under specified service conditions, motor performance shall be as follows for critical operating characteristics:

1. Torque

   Motors shall meet or exceed the minimum locked rotor (starting) and breakdown torques specified in NEMA MG 1-12 for Design B for the rating specified when operating on sine wave power. Torque and slip characteristics shall be as recommended by the manufacturer of the driven equipment and as specified.

2. Current

   Locked rotor currents shall not exceed NEMA Design B values.

3. Efficiency

   Unless specified otherwise, all motors shall be premium efficiency in accordance with NEMA MG 1. Motor efficiency will be determined according to NEMA MG 1-12, IEEE Test Procedure 112 Method B, using accuracy improvement by segregated loss determination including stray load loss measurements.

4. Temperature Rise

   Temperature rise above the specified maximum ambient temperature, for each of the various parts of the motor, shall not exceed the values indicated in NEMA MG 1-12.
5. **Time Rating**

All motors shall be rated for continuous duty.

C. **Service Factor**

All motors shall be rated for a 1.15 service factor on sine wave power, unless specified otherwise. Service factor shall not be used for motor sizing.

D. **Insulation**

1. Motors shall be designed for a Class B temperature rise, and shall be provided with Class F insulation systems per NEMA MG 1. Insulation system shall be resistant to attack from moisture, acids, alkalis, and mechanical or thermal shock. Motor insulation and related components shall be constructed of non-wicking, non-hydroscopic materials. As a minimum, motors shall be furnished with one dip and bake in 100% solids, polyester or epoxy resin.

2. Motors constructed in NEMA frames 284 and larger, shall be provided with winding insulations that are vacuum pressure impregnated (VPI) with 100% solids, polyester or epoxy resin per approved manufacturer’s standards. As a minimum, motors shall be furnished with one VPI cycle of 100% solid resins. Motors installed outdoors shall be furnished with two VPI cycles of 100% solid resins to provide moisture-resistant windings.

3. Where required elsewhere in the Specifications or where indicated on the Drawings, a completely encapsulated insulation system shall be provided. Stator windings and end-turns in squirrel-cage induction motors shall be completely filled with an insulating resin which shall also form a protective coating. Winding insulations shall be vacuum pressure impregnated with 100% solids, polyester or epoxy resin per approved manufacturer’s standards. Encapsulated windings shall be tested in accordance with NEMA MG 1-20.35.7.

2.03 **MECHANICAL REQUIREMENTS**

A. **Frame Sizes**

Motor frame sizes shall be NEMA frame size designations for sizes 143 through 447. Motor frame sizes larger than NEMA frame designations shall be per approved motor manufacturers. NEMA frames shall be in accordance with NEMA MG 1.
B. **Enclosures**

1. Enclosures for induction motors shall be approved for the installation conditions, and as specified.

2. Unless specified otherwise, motor housings, motor frames, end shields, inner bearing caps, and fan covers shall be constructed of cast iron or heavy gauge fabricated steel.

3. The enclosure types shall be the following, unless specified otherwise in the individual equipment sections of the driven equipment.
   
   a. Motors installed indoors shall be Open Drip-Proof (ODP).
   
   b. Motors installed outdoors shall be ODP Weather Protected Type I, or Totally Enclosed Fan Cooled (TEFC).
   
   c. Vertical motors installed indoors and outdoors shall be ODP Weather Protected Type I.
   
   d. Motors to be installed in hazardous (classified) areas shall be provided as specified herein, and shall conform to the requirements of NEC Article 500.

4. Motors shall have drain openings suitable located for the type of enclosure and assembly being provided.

5. TEFC motors shall be furnished with tapped drain holes with stainless steel drain plugs for frames smaller than 284 and automatic breather and drain devices for frames 284 and larger. TEFC horizontal motors shall be furnished with drain holes at each end support bracket.

6. Openings on weather protected enclosures shall be covered with corrosion resistant metal guard screens have a mesh size no larger than 1/2 inch square.
C. Windings and Winding Protection

1. Windings shall be copper magnet wire rated at 200ºC and moisture resistant. Magnet wire insulation material shall be of the type designed to resist transient spikes, high frequencies, and short time rise pulses produced by inverters. Windings shall be firmly held in the stator slots to prevent coil shifts. Sharp edges and burs shall be removed from the stator core slots prior to inserting the winding. All coils shall be phase insulated and laced down such that the windings will not move during repetitive starting. All stator connections shall be securely made.

2. Motors 50 hp and larger shall be provided with three resistance temperature detectors (RTDs) or PTC thermistors in the windings. Any overload condition shall cause all phases to open. Motor temperature detectors shall be furnished with controllers for installation in Motor Control Centers or Motor Control Panels.

D. Bearings

Provide bearings that are designed for the specified conditions under continuous operation, with proportions, mountings, and adjustments consistent with best modern practices for all applied radial and thrust loads at specified speeds. Bearings shall be designed to withstand any inertial forces associated with starting and stopping of the motor. Bearings shall be anti-friction type and the bearing chamber shall be coated with a rust inhibiting grease or oil. When possible, provide end brackets with lube fill and relief plugs, which allow re-greasing while the motor is in service.

1. Bearings shall be designed to provide the following minimum L-10 bearing life:

   a. Direct connected 100,000 hours.

   b. Belt connected 50,000 hours.

   Bearings and lubrication shall be suitable for the specified ambient temperature and temperature rise.

2. Ball Bearings

   Ball bearings shall be double shielded, grease or oil lubricated. Provide lubrication from readily accessible inlet and outlet plugs or fittings. Provide bearing protection with internal shaft slingers or inner bearing caps.
3. Roller Bearings

Provide roller bearings for V-belt drive applications.

4. Oil Lubricated Bearing Housing

Furnish with adequate reservoir depth to provide space for settling of foreign matter. Provide drain plug accessible from motor exterior, and a visual oil level indicator.

5. Ball Bearing Couplings on Horizontal Motors

Construct to absorb total movement and thermal expansion of motor driven equipment shafts.

6. Sleeve Bearings

Sleeve bearings shall be furnished with proper oil rings. The use of wicks or packings are not acceptable.

7. Couplings for Sleeve Bearing Motors

Provide type to prevent motor rotating thrust surface from contacting sleeve bearing thrust collar.

8. Lubrication Fittings

Except on motors equipped with factory-sealed bearings, provide lubrication fittings with easily accessible grease/oil supply, flush, drain, relief, and extension tubes (where necessary).

E. Motor Shaft

Motor shaft shall be 1045 Hot Rolled Steel.

F. Fan Cooled

Motors specified as fan cooled shall be equipped with ventilating fans constructed of non-corroding and non-sparking materials.
2.04 ACCESSORIES AND OPTIONS

A. Grounding

Lugs shall be provided in all motor terminal boxes for grounding.

B. Terminal Boxes

1. Motors shall be equipped with terminal boxes for all conduit and wire connections, as specified and as required.

2. Gaskets shall be provided between each terminal box and motor frame, and terminal box and cover plate. Terminal boxes shall be attached to the motor frames with high strength zinc plated and chromated steel bolts and cap screws.

3. Terminal boxes for motor main power leads shall be over-sized (meeting or exceeding volumes provided in IEEE 841), diagonally split, and rotatable in 90º increments. Terminal boxes shall be provided with threaded conduit entrances.

4. A separate terminal box shall be provided for motor space heater power leads and motor winding temperature sensor wiring. Space heater leads and motor winding temperature sensor wiring shall be terminated on terminal blocks.

5. The internal temperature of motor terminal boxes shall allow use of 75ºC rated conductors.

C. Space Heaters

Space heaters shall be designed to maintain the winding temperature at 5°C above the ambient temperature when the motor is not in use. Unless specified otherwise, space heaters shall be 115 V, 1-phase, 60 Hz, and shall be thermostatically controlled.

Unless specified otherwise, space heaters shall be provided on all motors 30 hp and larger to be installed outdoors, and on all motors 50 hp and larger to be installed indoors.

Space heaters shall be unaffected by the accumulation of moisture and shall have terminals adequately protected against moisture under severe weather conditions. Space heaters shall be mounted on noncombustible material and shall be capable of operating continuously without thermal damage to the motor or themselves. Space heaters shall have a maximum sheath temperature of 200ºC.

Power leads for motor space heaters shall be brought out into a terminal box separate from the motor main power leads terminal box.
Where motors are provided with space heaters, a warning nameplate shall be provided on the motor space heater terminal box. The warning nameplate shall have red background with white letters and shall read: "CAUTION - CONTAINS AN EXTERNAL VOLTAGE SOURCE."

D. **Lifting Devices**

All motors weighing 150 pounds or more shall have suitable lifting devices for installation and removal.

E. **Finish**

Unless specified otherwise, motor castings, enclosures, terminal boxes, etc. shall be factory coated with a red-oxide zinc-chromate primer, and finished with a corrosion resistant epoxy coating. Motor field finish coatings shall be in accordance with Specification Section 09900, the Protective Coating Schedule on the Drawings, and manufacturer's written instructions.

F. **Nameplates**

Provide stainless steel nameplates of ample size with clear stamped or engraved numerals and letters. Motor nameplate data shall conform to NEMA MG 1 requirements, and shall include the following information, as a minimum:

1. Motor manufacturer, serial number, model number, type, frame size, enclosure type, rated horsepower, rated full load rpm, rated voltage, rated frequency, number of phases, rated full load amperes, NEMA design code, locked rotor code letter, torque, service factor, power factor, full load nominal efficiency, insulation class, maximum ambient temperature, time rating, altitude, thermal protection, space heater wattage and voltage, bearings, mounting, and other essential data.

2. Nameplate data shall be completely in English.

3. Nameplates shall be secured to the motor frame with corrosion resisting stainless steel pins in accessible locations.

G. **Hardware**

Unless specified otherwise, external screws and bolts shall be Grade 5, hex head and plated to resist corrosion.
H. **Dynamic Balance and Vibration**

1. All motors shall be dynamically balanced. Methods of measuring dynamic balance shall be in accordance with NEMA MG 1-7.

2. Motors shall have a maximum peak-to-peak amplitude of vibration in accordance with NEMA MG 1-7.8.

**PART 3 - EXECUTION**

3.01 **FACTORY TESTS**

A. **All Motors Smaller than 100 hp**

Motors shall be given a standard commercial test.

B. **All Motors 100 hp and Larger**

Motors shall be given complete tests including:

1. No load running current.

2. Locked rotor current.

3. Full load heat run.

4. High potential test.

5. Winding resistance.


7. Locked and idle saturation curves.

8. Service factor heat run.


11. Locked rotor torque.

12. Efficiency at full, 3/4, and 1/2 load.
13. Power factor at full, 3/4, and 1/2 load.

14. Balance to 0.001 inches total amplitude.

15. Noise test.

16. All tests (except locked rotor current) shall be made at full voltage and rated frequency.

3.02 DELIVERY, STORAGE, AND HANDLING

A. Contractor shall carefully inspect all motors at the time of delivery. Contractor shall notify the District in writing of any damage to the motor or motor components and accessories. Contractor shall repair or replace damaged motors to the satisfaction of the District, all at no additional cost to the District.

B. Storage and handling of motors shall be in accordance with the manufacturer’s written recommendations. Motors shall not be stored outdoors, and shall be protected from exposure to dirt, fumes, water, corrosive liquids and gases, and physical damage.

C. Contractor shall make provisions to protect motors from moisture by temporary connection of motor space heaters or installation of temporary heating equipment. Motors shall be protected against condensation until permanent motor power is provided.

D. Motor shafts shall be periodically rotated according to the manufacturer’s instructions.

3.03 INSTALLATION

A. Provide all the equipment installations and wiring installations, including connections as indicated on the Drawings, specified herein, and required.

B. Assure proper fits for all equipment and materials in the spaces shown on the Drawings.

C. Coordinate locations of all conduit stub-ups with actual locations of motor terminal boxes for power and motor auxiliary device connections.

D. General Requirements

1. Motors shall be installed in accordance with requirements of the individual driven equipment specifications, and in accordance with the manufacturer's recommendations.
2. Provide the required wiring for motor power, including installation of motor connections in accordance with the motor manufacturer’s requirements.

3. Provide the required wiring for all control equipment that shall be furnished and installed by other sections of the Specifications.

4. Provide the required wiring for heaters in the motor frames and the required controls to de-energize the heaters when the motors operate.

E. Install equipment local control stations on steel stanchions and building structures near their respective motors as shown on the Drawings.

F. Provide power, control, alarm, and grounding installations for all motors as indicated on the Drawings and required.

G. Connections of devices sensitive to electromagnetic interferences such as RTDs, thermistors, thermal protection switches, vibration sensors and other applicable instrumentation wiring shall be provided in accordance with the manufacturer’s written instructions. Shielded conductors shall be provided and routed in dedicated conduits, all in separate conduits runs end to end.

H. Align the motor shaft with driven equipment according to manufacturer’s written instructions.

I. Field damaged factory finish on equipment shall be touched-up with paint that is equal in quality and color to the original factory finish and in accordance with Specification Section 09900.

3.04 FIELD CHECKS AND TESTS

A. Field Checks

1. Check power and accessory connections for all motors.

2. Confirm correct rotation for all motors.

3. Confirm that the motor and coupled load are properly aligned, rotate freely, and are not binding.

4. Check all motors for correct clearances and proper installation of all safety guards and screens.

5. Check all motors for correct lubrication and correct any identified deficiencies in accordance with the manufacturer’s written instructions.
B. **Field Tests**

1. Contractor shall megger (1000 volts, DC) each motor winding before energizing the motor. If the insulation resistance is found to be low, Contractor shall notify the District and shall not energize the motor. Insulation resistance shall be measured after one (1) minute of megger test run, and all readings shall be recorded.

2. Operating tests shall be performed on the motor driven equipment to observe that motors start, run, and stop satisfactorily. Contractor shall submit field data to the District. The data shall indicate the full load current for each motor, and current rating for the overload relay in each motor starter and controller.

**END OF SECTION 16150**
SPECIFICATIONS - DETAILED PROVISIONS
Section 16160 - Variable Frequency Drives

CONTENTS

PART 1 - GENERAL ........................................................................................................................................... 1
1.01 SCOPE ...................................................................................................................................................... 1
1.02 SPECIFIC PROJECT VFD REQUIREMENTS ............................................................................................ 1
1.03 RELATED SECTIONS ............................................................................................................................... 1
1.04 REFERENCE STANDARDS, SPECIFICATIONS, AND CODES ............................................................. 2
1.05 SUBMITTALS ........................................................................................................................................... 3
1.06 QUALITY ASSURANCE ............................................................................................................................ 7
1.07 COORDINATION ....................................................................................................................................... 7
1.08 HARMONIC DISTORTION STUDY AND DISTORTION LIMITS ............................................................ 8

PART 2 - PRODUCTS ........................................................................................................................................... 10
2.01 DESCRIPTION ......................................................................................................................................... 10
2.02 RATINGS .................................................................................................................................................. 10
2.03 CONSTRUCTION ..................................................................................................................................... 11
2.04 OPERATOR INTERFACE .......................................................................................................................... 14
2.05 PROTECTIVE FEATURES ....................................................................................................................... 15
2.06 CONTROL INPUTS AND OUTPUTS ......................................................................................................... 16
2.07 CONTROL FUNCTIONS AND ADJUSTMENTS ....................................................................................... 17
2.08 SERIAL COMMUNICATIONS .................................................................................................................... 18
2.09 WIRING AND TERMINATIONS ............................................................................................................... 19
2.10 ENCLOSURES, HEATING, AND COOLING ............................................................................................. 20
2.11 HARMONIC DISTORTION SUPPRESSION .............................................................................................. 21
2.12 MOTOR PROTECTION OUTPUT FILTERS ................................................................................................. 26
2.13 EMI/RFI FILTERS .................................................................................................................................... 26
2.14 NAMEPLATES .......................................................................................................................................... 26
2.15 SPARE PARTS ......................................................................................................................................... 27

PART 3 - EXECUTION ........................................................................................................................................... 27
3.01 INSTALLATION .......................................................................................................................................... 27
3.02 TESTING AND STARTUP .......................................................................................................................... 28
3.03 INSTRUCTION .......................................................................................................................................... 29
PART 1 - GENERAL

1.01 SCOPE

A. This section specifies the requirements for the design, integration, fabrication, assembly, wiring, testing, delivery, and installation of low voltage (600 volt) variable frequency drive (VFD) units to control the speed of electric motor drivers for the driven equipment specified.

B. Contractor shall furnish and install VFDs as specified herein and shown on the Drawings, including all accessories and controls necessary for a complete and operable system.

C. All equipment specified herein shall be furnished as a complete assembly.

1.02 SPECIFIC PROJECT VFD REQUIREMENTS

Specific project requirements may be provided in Section 16160.1 attached to this Specification Section. Where provided, this section provides specific project details regarding VFDs and shall take precedence over requirements herein, in case of conflict.

1.03 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment and/or systems requiring electrical power and control.

2. Division 16 – Electrical

3. Division 17 – Instrumentation and Controls
1.04 REFERENCE STANDARDS, SPECIFICATIONS, AND CODES

A. Equipment and materials shall meet or exceed the applicable requirements of the following standards, specifications, and codes (latest edition):

Institute of Electrical and Electronics Engineers (IEEE)

IEEE 519  Recommended Practice and Requirements for Harmonic Control in Electric Power Systems

IEEE C62.41.1  Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2  Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

National Electrical Manufacturers Association (NEMA)

NEMA 250  Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA AB 1  Molded Case Circuit Breakers and Molded Case Switches

NEMA ICS 1  Standard for Industrial Control and Systems: General Requirements

NEMA ICS 4  Terminal Blocks

NEMA ICS 5  Industrial Control Systems, Control Circuit and Pilot Devices

NEMA ICS 6  Enclosures

NEMA ICS 7  Adjustable Speed Drives

National Fire Protection Association (NFPA)

NFPA 70  National Electrical Code
Underwriters Laboratories (UL)

UL 50 Standard for Enclosures for Electrical Equipment, Non-environmental Considerations

UL 50E Standard for Enclosures for Electrical Equipment, Environmental Considerations

UL 489 Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

UL 508A Standard for Industrial Control Equipment

UL 508C Standard for Power Conversion Equipment

UL 1283 Standard for Electromagnetic Interference Filters

UL 61800-5-1 Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy

B. Equipment shall bear the appropriate labels and markings in accordance with above standards, specifications and codes. Equipment shall be designed, manufactured, and tested in certified International Organization for Standardization (ISO) 9001 facilities.

1.05 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall submit complete information, drawings, and technical data for all equipment and components, including, but not limited to, the following:

1. Complete Bills of Materials for all equipment and components comprising the VFD system.
2. Manufacturer’s product literature and specifications for all VFD system equipment and components including, but not limited to, the following: variable frequency drives, input filters and line reactors, output filters, isolation transformers, phase shifting transformers, circuit breakers and fuse information (including time current characteristics), bypass contactors, enclosures, control power transformers, pilot devices, relays, timers, fans, and thermostats. Product literature and specifications shall be marked to clearly identify all applicable information and crossing out all inapplicable information. Sufficient data and detail shall be provided to demonstrate compliance with these specifications.

3. Summary for each type of VFD, listing design capabilities and operating parameters, including all user selectable features and setpoints.

4. VFD efficiency and VFD unit overall operating efficiency (including power for harmonic mitigation equipment, and power for equipment cooling) at full rated load and 100 percent speed.

5. Motor manufacturer’s guarantee that motor insulation and cooling is suitable for continuous operation over specified frequency range and VFD output pulse maximum peak voltage, pulse rise time, and pulse rate.

6. Drawings showing enclosure exterior elevation, interior elevation, and plan views with dimensional information, including, but not limited to: enclosure height and depth, section widths and shipping splits (if applicable), conduit stub-up/connection locations, and anchorage/mounting holes. Exterior elevation view shall show location of all door mounted components, including disconnect handle, operator interface, lights, switches, push buttons, and corresponding nameplates. Interior elevation view shall show general arrangement and identification of all major internal components.

7. Terminal size ranges for all cable connections (line and load sides).

8. Complete single line diagrams indicating all components comprising the VFD system, including, but not limited to: circuit breakers, motor circuit protectors, fuses, contactors, VFDs, control power transformers, control devices, space heaters, and fans.

9. Control ladder diagrams and interconnection diagrams (point to point wiring diagrams), including terminal blocks and identification numbers. Interconnection diagrams shall show wiring between VFD and all external field devices, and between VFD and all electrical panels, including (but not limited to) distribution panels, MCCs, PLCs, and RTUs.
10. Where the proposed enclosure is not the VFD manufacturer’s standard enclosure (e.g. NEMA 1 enclosure with a NEMA 3R wrapper, or a Hoffman type enclosure), design calculations shall be provided for the enclosure cooling system addressing all heat producing VFD unit components operating at full rated capacity and with the maximum specified ambient temperature. Where building cooling systems are shown on the Drawings, calculations shall be performed with building cooling system off.

11. Harmonic distortion study per Part 1.08 herein, demonstrating compliance with specified voltage and current distortion requirements.

12. Results for VFD unit(s) from Short Circuit/Coordination and Arc Flash Hazard Studies per Specification Section 16040.

13. Design calculations and details for equipment seismic design and restraint. Calculations and anchorage details shall be prepared and stamped by a Registered Professional Civil or Structural Engineer in the State of California. Equipment seismic design and restraint calculations shall be provided for all VFD units. Calculations shall include anchor bolt type, size, locations, and embedment depth. Anchor bolt embedment depth for free standing floor mounted VFD units shall be based on the thickness of the structure floor slab only, and shall not include any portion of the raised concrete housekeeping pad beneath the equipment structures. Calculations shall be performed in accordance with the California Building Code (latest edition) for Occupancy Category IV, Essential Facilities.

14. Manufacturer’s installation instructions, including:
   a. Receiving, handling, and storage instructions
   b. Installation procedures including mounting, conduit and wiring connections, and terminal torque requirements
   c. Grounding requirements
   d. Arc flash protection marking
   e. Operation of operator handles and unit interlocks
   f. Checklist before energizing
   g. Procedure for energizing equipment.

15. Manufacturer's warranty guaranteeing the operation of the VFD unit against failure due to defects for two (2) years from date of project acceptance. During this period, parts and labor shall be supplied at no cost to the District.
B. **Operation and Maintenance Manuals**

Operation and maintenance manuals shall be provided in accordance with the requirements of the General Conditions, and Specification Section 01430. Manuals shall be completely indexed and include step-by-step procedures for the operation and maintenance of the VFD as installed. As a minimum, operation and maintenance manuals shall include:

1. Design capabilities, operating parameters, and recommended ranges.
2. Specification packets on all components in the unit.
3. System schematic diagrams, block diagrams, interconnection diagrams, ladder diagrams, complete wiring diagrams, and enclosure drawings.
4. Safety provisions and precautions, including protective equipment and clothing.
5. Pre-energizing and energizing procedures.
6. Maintenance procedures, including: preventive measures, inspection and cleaning, servicing, and testing.
7. Troubleshooting.
8. Complete replacement parts list, and list of recommended spare parts.
9. Manufacturer warranties.
10. Contact Information, including name, address, and telephone number of manufacturer and manufacturer’s local service representative.
11. Complete listing of VFD control settings and setpoints for all controller inputs.

Contractor shall provide approved operations and maintenance manuals to District at least 30 days prior to VFD startup and testing.

Final operation and maintenance manuals shall include as-built drawings of all VFD schematic diagrams, block diagrams, interconnection diagrams, ladder diagrams, and enclosure drawings. As-built drawings shall include any field modifications. Final operation and maintenance manuals shall include the complete listing of VFD control settings and setpoints for all controller inputs (factory set and field set) as established at the completion of field startup and testing.
1.06 QUALITY ASSURANCE

A. Contractor shall provide a complete, reliable, fully tested, adjustable speed drive system suitable for manned or unmanned operation. VFD units shall be as manufactured by Toshiba, ABB, Allen Bradley, or Schneider Electric (no substitutes).

Third party distributor or packager modifications to a standard product will only be permitted with written approval from the VFD manufacturer, and statement confirming that the installed VFD equipment will be fully covered by manufacturer's warranty. In addition, VFD manufacturer (factory) shall review and approve all shop drawings prepared by third party distributors prior to submittal of said shop drawings to the District.

B. The District believes that the manufacturers listed herein are capable of producing equipment and/or products that will satisfy the requirements of these specifications. The listing of specific manufacturers herein does not imply acceptance of their products that do not meet the specified ratings, features, functions, and space restrictions. Manufacturers listed herein are not relieved from meeting these specifications in their entirety; and, if necessary, they shall provide non-standard, custom equipment and/or products. Contractor shall be responsible for confirming that the proposed equipment and/or products will meet these specifications.

C. Model numbers supplied herein are provided for information purposes only, to assist Contractor in selecting equipment that conforms to the Specification and Drawing requirements. In case of any conflict between model numbers provided and the descriptive requirements specified herein, the descriptive requirements shall govern.

1.07 COORDINATION

A. Each VFD unit shall be coordinated with the requirements of the driven equipment. Contractor shall be responsible for matching the motor and the VFD. Load requirements, torque, horsepower, and speed range of VFDs shall be coordinated with and meet or exceed that of the driven equipment.

B. In addition, Contractor shall be responsible for coordinating the collection of data and manufacturer’s design efforts necessary to comply with all requirements specified herein, including harmonic distortion limits. Contractor shall submit written confirmation to the District that all specified requirements have been satisfied and the proposed VFD has been approved by the driven equipment manufacturer.
Variable Frequency Drives
Section 16160 – 8

C. Contractor shall coordinate the working space allowed with the equipment to be provided, and any discrepancies shall be brought to the District's attention prior to the bid opening. Contractor shall be responsible for making the VFD manufacturer and supplier aware of project space requirements and ensuring that the proposed equipment will fit within the allowed space.

D. Where indicated on the Drawings, emergency standby power generation equipment shall be provided to operate electrical facilities in the event that normal utility power is not available. The VFD system shall be suitable to operate on a limited power generation source. Contractor shall coordinate the design and fabrication of the VFD system equipment and components with emergency power generation equipment, and ensure compatibility and performance in accordance with this Specification.

1.08 HARMONIC DISTORTION STUDY AND DISTORTION LIMITS

A. Harmonic Distortion Study

1. VFD manufacturer shall prepare a comprehensive pre-equipment selection harmonic distortion study of the system. The study shall conform to the requirements of IEEE 519, except as modified herein. The study shall include harmonics from existing equipment as well as the harmonics from equipment provided under this Section. In addition, the study shall include the electrical utility service connection, main service switchboard, distribution switchboards, motor control centers (MCCs), and all interconnecting power cables and busing. The harmonic distortion study shall demonstrate compliance with the harmonic distortion limits specified herein. The harmonic distortion study shall be submitted to the District as part of the shop drawing submittals.

2. VFDs will be provided with electrical power from a Southern California Edison Company (SCE) transformer and service. The SCE service will provide power to the service switchboard, distribution switchboards (if any), MCCs, and VFDs. Unless specified otherwise, the service switchboard shall be the point of common coupling (PCC) for calculating and measuring voltage and current distortion. Unless specified otherwise, the value of the utility short circuit current at the PCC shall be obtained from SCE by the Contractor for the project location and equipment. Contractor shall be responsible for all necessary coordination with SCE to obtain the short circuit current value, and pay all associated costs for same.
3. The harmonic distortion study shall be based on a computer aided system circuit simulation of the total actual system performed through the 50th harmonic, with information and data obtained from the utility (SCE), Construction Drawings, and equipment manufacturers. Unless indicated otherwise in the Specific Project VFD Requirements, the harmonic analyses shall be performed without any linear loads. The harmonic distortion study shall clearly describe all assumptions, computer input information, voltage and current distortion results, and comparison of results to specified limits.

4. If the harmonic distortion study indicates the need for harmonic suppression equipment, including: line reactors, passive filters, isolation transformers, 12-pulse VFDs, or 18-pulse VFDs, these shall be provided at no additional cost to the District. Harmonic suppression utilizing active front end VFDs will not be acceptable. Shop drawings shall indicate the location of the harmonic suppression equipment. Harmonic suppression equipment and its location shall be subject to acceptance by the District, prior to commencing fabrication of the VFDs and associated harmonic suppression equipment.

B. Harmonic Distortion Limits

The harmonic distortion values resulting from the operation of all or any combination of VFDs operating at full load and without any linear loads shall be limited to the following:

1. Maximum allowable Total Harmonic Voltage Distortion, THD Voltage shall be 8%.

2. Maximum allowable individual frequency harmonic voltage distortion shall be 5%.

3. Maximum allowable individual frequency harmonic current distortion; Total Harmonic Current Distortion, THD Current; and Total Demand Distortion, TDD shall be within the limits of IEEE 519.

Compliance with the specified limits shall be verified by onsite field measurements of the harmonic distortion at the PCC, performed with and without VFDs operating. Field measurements shall be obtained by an independent third party testing firm acceptable to the District, after satisfactory full-load operation of the equipment.
PART 2 - PRODUCTS

2.01 DESCRIPTION

A. The VFD shall be solid state with a pulse width modulated (PWM) AC to AC converter utilizing the latest isolated gate bipolar transistor (IGBT) technology. The VFD shall employ a sensorless vector inner loop torque control strategy that mathematically determines motor torque and flux. The VFD shall also provide an optional motor control operational mode for scalar of V/Hz operation.

B. The VFD shall employ a full wave rectifier to prevent input line notching and operate at a fundamental (displacement) input power factor of 0.98 at all speeds and nominal load.

C. Unless specified otherwise, each VFD unit shall include, but not be limited to, the following major components: solid state VFD (6, 12, or 18-pulse), input line power molded case circuit breaker or motor circuit protector, input current-limiting fuses, line reactor, passive filter (if necessary), motor protection output filter (if necessary), EMI/RFI filter (if necessary), enclosure with door mounted operator interface and pilot devices, control power transformer, integrated controls, enclosure cooling fans, and enclosure space heater.

2.02 RATINGS

A. VFD units shall be sized based on the maximum motor horsepower and required starting and operating torque of the selected equipment to be driven, or the minimum output as shown on the Drawings or specified herein, whichever is greater.

B. VFD units shall be rated to operate from 3-phase power at 480 VAC ±10%.

C. VFD units shall be rated to operate continuously at full load under any combination of the following environmental conditions:

1. Ambient temperature of 0 to 40°C; and where specified, up to 50°C with application of a derating factor. VFD units that can operate at 40°C intermittently (during a 24 hour period) are not acceptable and shall be sized (i.e. oversized) to operate continuously at the specified maximum ambient temperature.

2. Altitudes ranging from 0 to 3300 feet above sea level without derating.

3. Relative humidity of 95% or less (non-condensing).

D. VFD output frequency shall be adjustable between 0 Hz and 300 Hz (minimum).
E. VFDs shall be rated to operate from input power ranging from 48 Hz to 63 Hz.

F. Output voltage and current ratings shall match the adjustable frequency operating requirements of standard NEMA Design B motors.

G. Unless specified otherwise, VFDs shall have an overload current capacity for a duration of one (1) minute of at least 110% of rated motor current for variable torque units and at least 150% of rated motor current for constant torque units.

H. VFD efficiency shall be 98% or better at the full rated capability of the VFD at full speed and load. VFD unit overall efficiency, including all harmonic mitigation equipment, output reactor, sine wave filter, dV/dt filters, cooling fans, control power transformers, etc. shall be 95% or better of the full rated capability of the VFD at full speed and load.

I. VFDs shall be protected from atmospheric contamination by chemical and solid substances per IEC 60721-3-3. Chemical substances shall be classified 3C2 and solid substances shall be classified 3S2.

2.03 CONSTRUCTION

A. All VFD microprocessor and control circuitry shall be isolated by rigid non-conductive barriers providing finger-safe protection from all AC and DC power circuitry.

B. All power semiconductors shall be accessible from the front of the unit without the removal of the heat sinks upon which the devices are mounted. Each power semiconductor shall be capable of being visually inspected, electrically checked, and mechanically replaced from its heat sink assembly without removal of the entire heat sink or heat sink covers.

C. Each VFD unit shall be provided with an input molded case circuit breaker or motor circuit protector with a short circuit interrupting capacity of 65,000 RMS symmetrical amps (minimum), which shall disconnect all line power to the VFD, bypass contactors (if applicable), harmonic distortion suppression equipment, and control power transformer. The input power disconnect shall be provided with a door mounted operator that is padlockable in the Off position and mechanically interlocked with the VFD unit enclosure door.

D. Each VFD unit shall be provided with input line power fuses. Fuses shall be current limiting type with a short circuit interrupting rating of 200,000 amps, and shall be provided with blown fuse indicators.
E. Each VFD unit shall be provided with a 480V/120V control power transformer equipped with primary and secondary fuses. Unless indicated otherwise on the Drawings, the control power transformer shall be sized all control power loads, and enclosure cooling and heating loads.

F. Each VFD unit shall be equipped to function as specified herein and as indicated on the Drawings.

G. Door Mounted Components and Pilot Devices

Unless indicated otherwise on the Drawings, each VFD unit shall be provided with the following door mounted components and pilot devices.

1. Padlockable handle for VFD unit circuit breaker.

2. Power on indicator lamp (light).

3. VFD on-line indicator lamp.

4. Bypass on-line indicator lamp (if bypass contactors are specified).

5. VFD malfunction indicator lamp.

6. VFD fault reset push button.

7. Motor thermal and motor overload reset push buttons.

8. Operator Interface (Digital Display/Keypad Unit). Unit shall control, monitor and display VFD functions, operating conditions and faults. Operating conditions shall include, but not be limited to: output frequency, output voltage, motor current, running speed (rpm), input and output power.

9. VFD Manual, VFD Auto, Off, Bypass Manual (if bypass contactors are specified) selector switch as specified. Selector switch shall be provided with auxiliary contacts for position signal to remote control panel.

10. Elapsed time meter (eight (8) digit, minimum).

11. Motor high temperature indicator lamp.


13. Speed pot for VFD speed control in Hand mode.
Variable Frequency Drives  
Section 16160 – 13

14. Other functions and devices shown on the Drawings, or otherwise specified.

VFD shall shutdown on motor "high temperature" and "overload" conditions. External dry contacts shall be provided for each motor alarm condition and common VFD fault condition.

VFD unit pilot devices shall be in accordance with Specification Section 16480.

H. VFD Bypass

Where indicated on the Drawings or specified in the Specific Project VFD Requirements, VFD units shall be provided with bypass contactors to permit the motor to run at full speed in the event of a VFD shutdown. Unless specified otherwise, the VFD bypass shall be provided with the following components and features:

1. The bypass circuitry shall be located in a separate section of the VFD unit enclosure and shall isolate the VFD on both the line side and load side. For motors less than 100 hp, VFD units shall be provided with mechanically and electrically interlocked full-voltage bypass contactors sized for the motor full load amperage. For motors 100 hp and greater, VFD units shall be provided with solid-state reduced voltage starting (soft starter) for bypass motor starting; and the soft start shall be electrically interlocked with the VFD isolation contactors. Controls shall be provided for automatic bypass of the VFD to constant speed operation in event of VFD failure, except for condition of motor high temperature, motor overload, or motor moisture. When selector switch is in VFD Auto position, upon VFD failure the equipment shall stop and automatically restart in constant speed mode via bypass contactors with start/stop functioning as if operating on VFD. Time delay for restart in bypass mode shall be provided. Manual reset to return to VFD mode shall be required. The VFD shall be isolated on the line-side and load-side during bypass operation. The bypass motor starter shall be equipped with current overload protection and a minimum of one (1) NO and one (1) NC auxiliary contactors.

2. Full voltage contactors and soft starters shall be provided in accordance with Section 16480.

3. Indicating lights for operation in VFD mode and Bypass mode shall be provided. Selector switch shall be provided with Bypass Manual position to allow operation in bypass mode without VFD failure.

4. Dry contacts shall be provided for operation in bypass mode for connection to RTU and/or Plant SCADA system.
2.04 OPERATOR INTERFACE

A. The VFD shall be equipped with a door (front) mounted operator interface control panel consisting of a four (4) line (minimum) back-lit alphanumeric LCD display. The LCD display shall be configurable to show a bar graph or meter. The operator interface shall be provided with an integral keypad with keys for Run/Stop, Local/Remote, Increase/Decrease, Reset, Menu navigation and Parameter select/edit.

B. The operator interface control panel shall be removable, capable of remote mounting, and allow for uploading and downloading of parameter settings.

C. The display of the operator interface control panel shall have the following features:

1. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table.

2. During normal operation, one (1) line of the control panel shall display the speed reference, and status of run/stop, forward/reverse, and local/remote. The remaining three (3) lines of the display shall be programmable to display the values of any three (3) operating parameters. The parameter selection shall include at least the following values:
   a. Speed/torque in percent (%), RPM or user-scaled units.
   b. Output frequency, voltage, current and torque.
   c. Power and kilowatt hours.
   d. Heatsink temperature and DC bus voltage.
   e. Status of discrete inputs and outputs.
   f. Values of analog input and output signals.
   g. Values of PID controller reference, feedback and error signals.

D. The control panel shall be used for local control, for setting all parameters, and for stepping through the displays and menus.

E. A copy function to upload and store parameter settings from a VFD and download stored parameter settings to the same VFD or to another VFD shall be provided.
2.05 PROTECTIVE FEATURES

The VFD unit shall be provided with capabilities and features to protect the VFD components and the driven motor from damage. Protective features with user adjustable setpoints shall be accessed through the operator interface for enabling and disabling. As a minimum, each VFD unit shall be provided with the following protective features:

A. A message shall be displayed on the operator interface for each programmed warning and fault protection function. The VFD shall be capable of displaying up to five (5) active faults and store the previous five (5) non-active faults and provide a time stamp of when the faults occurred. The VFD shall provide a help feature to further explain the displayed fault.

B. The VFD shall be provided with internal metal-oxide varistors (MOVs) for phase-to-phase and phase-to-ground line voltage transient protection.

C. Output short circuit and ground fault protection rated for 100,000 amps (without relying on line fuses) shall be provided per UL508A.

D. Motor phase loss protection shall be provided.

E. The VFD shall provide electronic motor overload protection qualified per UL508C.

F. Protection shall be provided for AC line or DC bus overvoltage at 130% of maximum rated voltage or undervoltage at 65% of minimum rated voltage.

G. The VFD shall be provided with protection against input phase loss.

H. Stall protection shall be programmable to provide a warning or stop the VFD after the motor has operated above a programmed torque level for a programmed time limit.

I. Underload protection shall be programmable to provide a warning or stop the VFD after the motor has operated below a selected underload curve for a programmed time limit.

J. Over-temperature protection shall provide a warning if the power module temperature is less than 5°C below the over-temperature trip level.

K. Desaturation circuit to drive the inverter section transistor base current to zero in the event of a controller fault.

L. Input terminals shall be provided for connecting a motor winding thermistor (PTC type) to the VFD’s protective monitoring circuitry. An input shall also be programmable to monitor an external motor high temperature relay or switch contact.
2.06 CONTROL INPUTS AND OUTPUTS

A. Discrete Inputs

1. Minimum of six (6) discrete inputs shall be provided.

2. The inputs shall be independently programmable with function selections (run/stop, hand-off-auto, etc.).

3. Inputs shall be designed for use with either the VFD’s internal 24 VDC supply or a customer supplied external 24 VDC supply.

B. Discrete Outputs

1. Minimum of two (2) form C relay contact outputs shall be provided.

2. All outputs shall be independently programmable to activate with at least 30 function selections including:
   a. Operating conditions such as drive ready, drive running, reversed, and at set speed.
   b. General warning and fault conditions.
   c. Adjustable supervision limit indications based on programmed values of operating speed, speed reference, current, torque, and PID feedback.
   d. Relay contacts shall be rated to switch 2 A at 24 VDC or 115/230 VAC.

C. Analog Inputs

1. Minimum of two (2) analog inputs shall be provided and shall be selectable for either a current or a voltage input.

2. Inputs shall be independently programmable to provide signals including speed/frequency reference, torque reference or set point, PID set point and PID feedback/actual.

3. A differential input isolation amplifier shall be provided for each input.

4. Analog input signal processing functions shall include scaling adjustments, adjustable filtering and signal inversion.
5. If the input reference is lost, the VFD shall give the user the option of the following:

   a. Stopping and displaying a fault.

   b. Running at a programmable preset speed.

   c. Holding the VFD speed based on the last good reference received.

   d. Cause a warning to be issued, as selected by the user.

   The VFD shall be programmable to signal the lost input reference condition via an operator interface warning, relay output, and/or over the serial communications bus.

D. Analog Outputs

1. Minimum of two (2) 4-20 mA analog outputs shall be provided.

2. Outputs shall be independently programmable to provide signals proportional to output function selections including output speed, frequency, voltage, current, and power.

2.07 CONTROL FUNCTIONS AND ADJUSTMENTS

A. Output frequency shall be adjustable between 0 Hz and 300 Hz (minimum). Operation above motor nameplate speed shall require programming changes to prevent inadvertent high-speed operation.

B. Stop mode selections shall include coast to stop and ramp to stop.

C. The VFD shall be capable of controlling deceleration of a load without generating an overvoltage fault caused by excessive regenerated energy. Overvoltage control on deceleration shall extend the ramp time beyond the programmed value to keep the amount of regenerated energy below the point that causes overvoltage trip.

D. The VFD shall be capable of controlling a rotating motor regardless of the motor direction. From the time the start signal is given to the VFD to the time the VFD has control of the motor shall not exceed two (2) seconds. Once the VFD has control of the motor it shall then accelerate or decelerate the motor to the active reference speed without tripping or faulting or causing component damage to the VFD. The VFD shall also be capable of flux braking at start to stop a reverse spinning motor prior to ramp.
E. The VFD shall have the ability to automatically restart after a protective trip caused by overcurrent, overvoltage, undervoltage, or loss of input signal. The number of restart attempts, trial time, and time between reset attempts shall be programmable.

F. Control functions shall include two (2) sets of acceleration and deceleration ramp time adjustments with linear and an s-curve ramp time selection.

G. Speed control functions shall include:
   1. Adjustable minimum and maximum speed limits.
   2. Selection of up to 15 preset speed settings for external speed control.
   3. Three sets of critical speed lockout adjustments.
   4. A built-in PID controller to control a process variable such as pressure, flow or fluid level.

H. Functions shall include motor flux optimization for optimizing energy efficiency and limit the audible noise produced by the motor by providing the optimum magnetic flux for any given speed/load operating point.

I. The VFD shall be capable of sensing a loss of load (e.g. broken belt or broken coupling) and signal the loss of load condition. The VFD shall be programmable to signal this condition via an operator interface warning, relay output, and/or over the serial communications bus. Relay output shall include programmable time delays that shall allow for VFD acceleration from zero speed without signaling a false underload condition.

J. A minimum of two (2) programmable critical frequency lockout ranges shall be provided to prevent the VFD from operating the load continuously at an unstable or critical equipment speed.

2.08 SERIAL COMMUNICATIONS

A. The VFD shall be capable of communicating with other VFDs or controllers via a serial communications link. A variety of communications interface modules for the typical overriding control systems shall be available.

B. Interface modules shall be available for a number of communication protocols including, but not limited to: Modbus, Ethernet IP, ModBus TCP, and DeviceNet.

C. Interface modules shall mount directly to the VFD control board or be connected via fiber optic cables to minimize interference and provide maximum throughput.
D. VFD I/O shall be accessible through the serial communications adapter. Serial communication capabilities shall include, but not be limited to:

1. Run-Stop control.
3. Speed adjustment.
4. PID (proportional/integral/derivative) control adjustments.
5. Current limit control.
6. Acceleration and deceleration time adjustments.

E. The VFD shall have the capability of allowing the overriding controller to monitor feedback such as process variable feedback, output speed/frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), relay outputs, and diagnostic warning and fault information.

F. A connection shall also be provided for a personal computer interface. Personal computer software shall be provided for VFD setup, diagnostic analysis, monitoring and control. The software shall provide real time graphical displays of VFD performance.

2.09 WIRING AND TERMINATIONS

A. As a minimum, interconnecting wiring and wiring to terminals for external connection shall be stranded copper with thermoplastic insulation that is moisture-resistant and flame-retardant, and rated at 600 V and 90°C.

B. Where fine stranded conductors, Class C and higher (such as DLO cable) are utilized for internal wiring, all terminations in mechanical lugs shall be provided with copper flex-cable compression adapters to properly confine the fine strands and prevent overheating of the connection and wire pullout from lugs. The flex-cable compression adapters shall fit mechanical set-screw mechanical lug type connectors and shall be sized for the full current carrying capacity of the cable. The adapters shall be provided a flared barrel-opening to allow easy cable insertion. The adapter shall be constructed of wrought copper with pin of Class B stranded copper conductor, rated for 600 V and 105°C cable, and shall be UL listed. Pin length shall be sufficient to allow full engagement into the mechanical lug. Flex-cable copper compression adapters shall be Shoo-pin PT-FX Series, as manufactured by Greaves Corporation, or equal.

C. Wiring shall be neatly installed in wireways wherever possible, or bundled with wire tie-down straps and securely attached to mounting surfaces.
D. Terminals on door mounted components shall be provided with finger-safe protective barriers; or alternatively, a single clear plastic protective barrier shall be provided covering all terminals.

E. Terminal blocks shall be interlocking, track-mounted type, with a marking strip, covers, and pressure connectors. A terminal shall be provided for each conductor of external circuits, plus one ground for each shielded cable. Each control loop shall be individually fused and located for ease of maintenance.

F. Terminals shall be labeled to match with the identification shown on the shop drawings.

2.10 ENCLOSURES, HEATING, AND COOLING

A. VFD units shall be housed in wall mounted or floor mounted enclosures as shown on the Drawings and specified herein. Enclosures shall be of sufficient size to afford access to all parts and components, and constructed with all line, load, and control terminations fully front accessible. All control components and wiring shall be separated by rigid non-conductive barriers from all 3-phase AC and DC power components and wiring.

B. Where shown on Drawings or specified herein that the VFD shall be installed in a MCC line-up, the enclosure shall match MCC construction including height and depth.

C. Unless otherwise specified, the sheet metal surfaces of all enclosures shall be phosphetized and coated with a rust resisting primer. Over the primer a corrosion resistant baked enamel finish shall be applied on interior and exterior metal surfaces. Exterior color shall be medium light gray (unless otherwise specified) and interior color shall be white. All enclosure hardware shall have a corrosion resistant finish.

D. Unless otherwise specified, outdoor electrical equipment shall be housed in weatherproof, gasketed, NEMA Type 1 (dead front with front accessibility) enclosures with NEMA 3R wrappers, and indoor electrical equipment shall be housed in NEMA Type 12 (dead front with front accessibility) enclosures or gasketed NEMA Type 1 enclosures. Enclosures shall be provided with top and bottom entry/exit locations for conduit and power/control conductors.

E. Outdoor enclosures shall be provided with padlockable door handles and sufficient internal lighting to perform maintenance work. Lighting shall be controlled by an internal light switch. Unless otherwise specified, lighting shall be powered by the VFD control power transformer.
F. Enclosures shall be provided with 120 V, 60 Hz space heaters for condensation protection. Space heaters shall be strip or tubular type and shall be controlled by line voltage thermostats. Unless otherwise specified, heating systems shall be powered by the VFD control power transformer.

G. Where specified environmental conditions necessitate enclosures to be ventilated and/or provided with forced air cooling, all enclosures be gasketed and be equipped with gasketed air filters to prevent entry of dust. All cooling fans shall be constructed to enable regular maintenance or removal without dismantling of the VFD unit. Air filters shall be washable aluminum mesh type and shall be removable (without the use of tools) for cleaning. Refer to environmental conditions as specified herein and requirement to submit cooling calculations.

H. Where indicated on the Drawings or where specified environmental conditions necessitate VFDs to be provided with mechanical cooling, outdoor enclosures shall be gasketed NEMA Type 1 with walk-in gasketed NEMA Type 3R wrappers. The walk-in space between the NEMA Type 1 doors and NEMA Type 3R doors shall be air-conditioned with a pad mounted commercial air conditioner located adjacent to the enclosure. Supply and return ducting between the air conditioner and enclosure shall be insulated and weatherproofed. The air conditioner location shall be subject to the District’s review and approval.

2.11 HARMONIC DISTORTION SUPPRESSION

The electrical system shall be provided with the necessary equipment to protect the VFDs and power system(s) on the line side of the VFDs from harmonic distortion, as specified in Part 1.08 herein. Prior to equipment selection, a harmonic distortion study shall be performed to determine the characteristics and ratings of individual line reactors, passive filters, isolation transformers, 12-pulse VFDs, 18-pulse VFDs, or other suppression equipment necessary to achieve the specified distortion limits. Unless indicated otherwise in the Specific Project VFD Requirements, active filters or active front end VFDs will not be allowed for suppression of harmonic distortion.

A. Line Reactors

1. Unless otherwise specified, each VFD shall be provided with a line reactor. The line reactor shall be factory mounted and wired within the VFD unit enclosure.
2. Line reactors shall be provided on the incoming power lines to the VFDs to:
   a. Minimize the effects of "line notching" due to the switching of power semiconductor devices for controlled rectifier type drives.
   b. Prevent overvoltage trips and/or damage to the drive itself due to transients (i.e. utility power capacitor switching, etc.) on the VFD incoming power lines.
   c. Reduce input harmonic currents thereby improving the total power factor of the drive system.

3. The line reactor shall provide a minimum of 3% line impedance and be designed for harmonic filtering service and for slowing the rate of rapid current changes.

4. Line reactors shall be in accordance with the requirements specified herein, and shall be as manufactured by Trans-Coil, Inc., MTE Corp., or equal.

B. Passive Filters

1. Passive filters, if selected for harmonic distortion suppression, shall be provided for each VFD unit. Passive filters shall be factory mounted and wired within the VFD unit enclosure.

2. Passive filters shall contain tuned circuits designed to remove harmonics generated within the power distribution system while improving the system power factor. Passive filters shall consist of inductive and capacitive elements configured and tuned to resonate just below the harmonic frequency for which they are designed to filter.

3. Passive filters shall be provided with 3-phase contactors, which shall disengage the filter capacitor cells when the VFD is not running and engage the filter capacitor cells when the VFD is running. As a minimum, provide an adjustable (0 to 30 second) time-delay relay, which shall energize via a run contact from the VFD and cause the capacitor cell contactors to engage at the end of the time delay. Manufacturer shall modify the control diagrams shown on the Drawings as required to perform the above function.

4. Passive filters shall be in accordance with the requirements specified herein, and shall be as manufactured by Trans-Coil, Inc., MTE Corp., or equal.
C. **Components for Line Reactors and Passive Filters**

Line reactor and passive filter components shall comply with the following minimum requirements:

1. **Inductors**
   a. Both series line reactors and tuning reactors (inductors) shall be designed for harmonic filtering service and for slowing the rate of rapid current changes. The inductors shall be UL component-recognized and shall be built to comply with UL 508. Construction shall be of copper wire-wound on magnetic steel cores. Inductors shall be three-phase. Series line reactors shall be sized appropriately for the total connected load. Design maximum temperature rise for inductors shall be 115°C on bobbin wound and 155°C on form wound devices at rated current.

   b. The core shall be constructed of laminated, magnetic steel (grade M36 or better). Brackets shall be ASTM structural steel or structural aluminum. Coils shall be wedged in place and the core shall be locked in place using vertical ties or rods.

   c. Windings shall consist of copper wire or of copper foil. Terminations shall be copper alloy ring lugs, UL-recognized terminal blocks, or solid copper bus. Sheet insulation shall be DuPont Nomex 410, or 3M Cequin of the thickness as required for UL insulation systems.

   d. Completed inductors shall be impregnated, using 100% solid epoxy resin. All insulation varnish systems shall be rated Class H (180°C) or Class R (220°C), 600 V. Inductors shall be Hi-Pot tested (2,500 V, 60 Hz, 1 minute) line-to-line and line-to-ground.

   e. Inductors shall be air-gapped to avoid control point saturation. Inductance shall be measured under full load and shall be within -2% to +8% for the tuning reactor and +/- 20% for the series line reactor, of the design value.
2. Capacitor Cells

   a. Capacitor cells shall have a voltage rating capable of handling continuously the nominal system voltage plus 10% of the over voltage tolerance. Capacitor cells shall also be capable of operating under the worst case voltage gain due to the leading nature of the capacitive current. Dielectric material shall be low-loss (less than 0.25 watts per kVAR).

   b. Capacitor cells shall be standard (non-custom), high-endurance type, and shall be contained in hermetically sealed metal cans. Capacitor cells shall be rated to operate at an ambient temperature of 65°C.

   c. Capacitor cells shall be provided with a UL mandated, pressure-sensitive interrupter which, in case of a hazardous internal pressure increase, shall disconnect all three phases simultaneously. Capacitor cells shall be recognized or listed under UL810.

   d. Individual capacitor cells, or groups of cells, shall be provided with a 3-phase, discharge resistor network. The resistors shall be sized to reduce residual voltage to less than 50V within one minute of de-energization (per NEC Article 460-6).

   e. The RMS current in each capacitor cell at full load shall not exceed 150% of the current at no load to limit the stress on the capacitors.

3. Contactors

   a. Contactors shall be provided in the capacitor cell circuit. Contactors, shall be used in conjunction with the VFDs run relay, and shall remove the capacitors from the circuit when the motor is not operating; thereby, eliminating the opportunity for “leading” power factor condition.

   b. Contactors shall be designed for 3-phase capacitor cell switching applications, and shall be rated for 600 volts and be UL listed.
4. Protection
   a. Internal wiring, including wiring for the tuning reactors, shall be protected by three fuses, one for each phase. Fuses shall be current limiting type and rated for a minimum interrupting current of 200,000 symmetrical amperes at 600 VAC, 60 Hz.
   b. Fuses shall be Class T and shall be UL listed. Fuses shall be sized for a minimum of 150% of nominal capacitor cell rating. Fuses internal to capacitor cells shall not be acceptable as the primary means of protection.
   c. Protective barriers shall be furnished as necessary to provide finger-safe protection between 3-phase power components and control power circuitry.

5. Connections
   a. Unless otherwise specified, compression type, pure copper or copper alloy terminal lugs shall be provided for electrical connections of harmonic filters to 3-phase line power. An internal grounding lug shall also be provided. Lugs shall be UL listed.
   b. Distribution blocks, when necessary, shall be rated for copper wire and shall be UL listed or recognized.

6. Wire
   a. Unless specified otherwise, interconnecting wiring for inductors and capacitor cells shall be constructed of copper with thermoplastic insulation that is rated at 600 V and for a minimum of 90°C. All control wiring shall be copper wire that is rated at 600 V and 90°C.
   b. Signal wire shall be multi-conductor jacketed wire that is rated at 300 V and 80°C.
7. Enclosures

a. Unless specified otherwise, harmonic filters and reactors shall be incorporated in the VFD unit’s enclosure. Wherever possible, harmonic filters and reactors shall be mounted in a separate section of the enclosure from the VFD assembly.

b. The filters and reactors shall be provided with integral mounting brackets for horizontal or vertical mounting.

2.12 MOTOR PROTECTION OUTPUT FILTERS

A. Where the conductor length between the VFD and motor exceeds 100 feet, or where specified on the Drawings or in the Specific Project VFD requirements, a motor protection output filter shall be provided within the VFD enclosure. The motor protection output filter shall be a low pass filter which protects the motor and power cables from voltage spiking. The output filter shall be sized for the motor load and shall be located immediately adjacent to the output terminals of the VFD.

B. Motor output filter components shall be in accordance with Part 2.11, C herein.

C. The motor protection output filter shall be Model V1k as manufactured by Trans-Coil, Inc., Model dV Sentry as manufactured by MTE Corp., or equal.

2.13 EMI/RFI FILTERS

A. An electromagnetic interference and radio frequency interference (EMI/RFI) filter shall be provided on the incoming power lines of the VFD if required as a result of system startup and testing to prevent conducted radio frequency noise generated by the VFD from interfering with other sensitive electronic equipment (such as lighting systems, telecommunications equipment, instrumentation, etc.).

B. The EMI/RFI filter shall be capable of handling a 400% current overload at startup and a 150% current overload for at least 1 minute (minimum once per hour) when operating.

C. The EMI/RFI filter shall be designed and fabricated to meet the requirements of UL 1283. EMI/RFI filters shall be as manufactured by Schaffner, or equal.

2.14 NAMEPLATES

Nameplates shall be provided bearing the VFD unit description as indicated on the Drawings. In addition, nameplates shall be provided for all door mounted components and devices. Nameplates shall be in accordance with Specification Section 16480, Part 2.05.
2.15 SPARE PARTS

As a minimum, Contractor shall furnish the following spare parts:

A. Two (2) spare lamp lenses of each color.
B. Five (5) pilot lamps of each type.
C. Three (3) control fuses of each type and size.
D. Three (3) power fuses of each type and size.
E. Two (2) air filters of each size.
F. One (1) fan for each VFD unit.

Spare parts shall be undamaged and packaged and labeled in original containers and supplied to the District at time of final acceptance of the work.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Contractor shall install all equipment in accordance with the manufacturer's written instructions, NEC requirements, requirements and standards specified herein, and as shown on the Drawings. Each VFD unit shall be installed with clearance in front of the enclosure to satisfy all NEC requirements.

B. All equipment furnished under this Section shall be installed and adjusted under the supervision of a factory-trained service engineer, other than a sales representative.

C. Install arc flash hazard label in accordance with the Arc Flash Studies performed per Specification Section 16040, as accepted by the District.

D. Conduit stub-ups for power conductors and interconnected or remote cables shall be located and terminated in accordance with the VFD manufacturer's written recommendations which shall be subject to the District's review and approval.
E. Contractor shall anchor VFD enclosures to walls or floors in accordance with the calculations and details prepared by the manufacturer's engineer. Floor mounted enclosures shall be mounted on concrete bases, extending 3 inches above the surrounding ground or floor. Anchor bolt embedment depth shall be based on the thickness of the structure slab only, and shall not include any portion of the raised concrete housekeeping pad beneath the equipment.

F. Contractor shall require the VFD manufacturer to examine the Contract Documents as to the location and operating environment that the VFD unit will be subjected to, and advise the District prior to bidding of any potential problems, which could prevent the VFD from functioning as specified and as intended.

G. Perform all pre-energizing checks as recommended by the VFD manufacturer. Under no circumstances are any portions of the VFD unit to be energized without written authorization from the manufacturer's representative, as specified below.

3.02 TESTING AND STARTUP

A. Upon completion of manufacturing, each VFD unit shall be factory inspected and load tested. In addition, all VFD unit control logic shall be factory tested by simulating external control signals. Written certification that the factory inspections, load tests, and control logic testing have been successfully performed shall be submitted to the District prior to VFD unit shipment. All costs associated with said factory tests shall be included in the Contractor's bid.

B. Manufacturer or supplier of the equipment furnished under this Section shall furnish the services of competent factory-trained personnel to provide technical assistance during installation and startup of the VFD equipment.

C. Prior to the commencement of field testing, manufacturer’s service engineer shall perform the following:

1. Set and/or adjust all operating parameters according to the manufacturer's written instructions and District's preference for VFD features, which may be enabled or disabled through the operator interface.

2. Provide District with a complete listing of all VFD operating parameters (control settings and setpoints for all controller inputs).

3. Provide District with written certification stating that the VFD equipment, including controls, have been properly installed and adjusted, and are ready for operation.
D. **Field Testing**

1. VFD field testing shall be conducted concurrently with field testing of the driven equipment. All field testing shall be witnessed by the District.

2. Field testing shall demonstrate satisfactory operation of all interlocks, alarms, and normal operational sequences. The VFD manufacturer shall utilize suitable field test equipment to locate and correct all malfunctions. Repeated failure of any component will cause the test to be terminated and restarted when equipment has been repaired or replaced. VFD performance shall be documented by obtaining concurrent readings showing input and output: voltage, amperage, power factor, and power over the full speed range of driven equipment.

3. Harmonic distortion field tests shall be conducted at the PCC (service switchboard bus, unless otherwise specified) to determine the voltage distortion and current distortion, and compliance with specified limits. Measurements shall be made utilizing a Dranetz HDPQ Xplorer 400 analyzer (or equal) capable of recording current and voltage distortions. Measurements shall include phase-to-phase, phase-to-neutral, and neutral-to-ground. Measurements shall be obtained over the full range of VFD operation, and shall include individual voltage and current harmonic values up to the 50th harmonic as well as total harmonic distortion (THD) and total demand distortion (TDD). Graphs of the test results shall be submitted for speed values of 60%, 80%, and 100%. Also, testing shall be performed with no VFD units operating, then one unit, then two units, then three units, etc. operating simultaneously (no concurrent linear loads).

4. A written report covering the service engineer's inspection findings, field test readings, field test results, comparison of field test results to specified values/limits, and final listing of all VFD operating parameters (control settings and setpoints for all controller inputs) shall be submitted to the District. The report shall also include a comparison of readings from the VFD and Contractor/manufacturer furnished meters/analyzers, and an evaluation of field measured VFD efficiencies versus manufacturer's guaranteed VFD efficiencies.

**3.03 INSTRUCTION**

After the VFD equipment has been installed, tested, and adjusted, and placed in satisfactory operating condition, the equipment manufacturer shall provide classroom instruction to the District's personnel in the use and maintenance of the equipment. Comprehensive instruction shall be provided on the VFD controller and operator interface, including menu navigation, changing control parameters, and modifying setpoints. Equipment manufacturer shall provide and discuss the complete listing of VFD control settings and setpoints for all controller inputs (factory set and field set) as established at the completion of field startup and testing.
Four (4) hours of instruction shall be provided, unless otherwise specified. Contractor shall give the District formal written notice of the proposed instruction period at least two weeks prior to commencement of the instruction period. Scheduled training shall be at a time acceptable to the District and the manufacturer. During this instruction period, the manufacturer shall answer any questions from District personnel. The manufacturer's obligation shall be considered ended when he and the District agree that no further instruction is needed.

END OF SECTION 16160
## SPECIFICATIONS - DETAILED PROVISIONS

Section 16950 - Custom Control Panels

### CONTENTS

**PART 1 - GENERAL**
- 1.01 DESCRIPTION ............................................................................................................. 1
- 1.02 RELATED WORK SPECIFIED ELSEWHERE ................................................................. 1
- 1.03 SUBMITTALS .................................................................................................................. 1
- 1.04 DESIGN AND GENERAL REQUIREMENTS .................................................................. 6
- 1.05 QUALITY ASSURANCE ................................................................................................... 8
- 1.06 DELIVERY, STORAGE, AND HANDLING ...................................................................... 9

**PART 2 - PRODUCTS**
- 2.01 MANUFACTURERS ........................................................................................................ 10
- 2.02 MANUFACTURED ENCLOSURES .................................................................................. 10
- 2.03 ENCLOSURE LIGHTS AND RECEPTACLES ................................................................. 16
- 2.04 ENCLOSURE HEATING AND VENTILATION ................................................................. 16
- 2.05 CONTROL DEVICES AND COMPONENTS ................................................................. 18
- 2.06 MARKERS AND NAMEPLATES .................................................................................... 23
- 2.07 WIRING METHODS ...................................................................................................... 25
- 2.08 SPARE PARTS ................................................................................................................ 26

**PART 3 - EXECUTION**
- 3.01 FACTORY TESTS .......................................................................................................... 27
- 3.02 SITE TESTS ................................................................................................................... 28
- 3.03 CONTROL PANEL MOUNTING .................................................................................... 29
- 3.04 MANUFACTURER’S SERVICES ....................................................................................... 30
PART 1 - GENERAL

1.01 DESCRIPTION

Contractor shall furnish and install custom control panels as specified herein, shown on the Drawings, and where specified in other Specification Sections.

A. Custom control panels include, but are not limited to, Unit Control Panels (UCPs), Local Control Panels (LCPs), and Programmable Logic Controllers (PLCs). Custom control panels include control panels designed and supplied by equipment manufacturers as part of packaged equipment and equipment systems.

B. The Instrumentation and Control Subcontractor (per Section 17005) shall design or review design of custom control panels and coordinate the interface between custom control panels, MCCs, other control panels, instrumentation, and District's SCADA system (including remote telemetry units, RTUs).

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Subcontractors to review all sections to ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment and/or systems requiring electrical power and/or control.

2. Division 16 – Electrical

3. Division 17 – Instrumentation and Controls

1.03 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.
A. **Shop Drawings**

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11” x 17” for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Detailed Bill of Materials for all control panel hardware, and associated materials and components, listing: manufacturer’s name, quantity, description, size, and catalog/part number.

2. Complete documentation for all control panel equipment and associated components, including: manufacturer's product literature, specifications, performance capabilities, features and accessories, dimensions and weights, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer’s literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

3. Control panel fabrication drawings (plan view, and interior and exterior elevation views) with all equipment and components clearly shown, dimensioned, and labeled. Drawings shall show the equipment and component assembly, clearances, and locations for conduits/conductors and anchor bolts. Devices shall be identified with the same marking as used on the schematic diagrams. The drawings shall include a detailed layout of all door mounted pilot devices and instruments.

4. Enclosure construction, NEMA Type, and type and gauge of materials.

5. Detailed descriptions of control panel equipment, equipment installation requirements, and heat dissipations.

6. System configuration with power circuit single line diagrams, grounding circuits, circuit breakers, and fuses.

7. Control schematics, ladder diagrams, and interconnection drawings (see Part 1.03.B herein) for additional requirements.

8. Nameplate data including the nameplate material, heights of letter and inscriptions.

9. Spare parts list as specified in this Section.
10. Manufacturer's installation instructions including receiving, handling, and storage requirements.

B. **Control Diagrams**

1. Schematic diagrams shall show the equipment serial number, the purchaser's drawing number, purchase order number, or similar identification which will indicate the particular equipment to which the diagrams apply.

2. Diagrams shall show all equipment and components in the electrical system including internal wiring of subassemblies. Diagrams shall clearly identify internal and external devices, and all remote contacts and signals. Show all interconnections between power sources and device elements of a particular system or equipment, and all interlocks with other equipment/systems in a manner that fully indicates the circuit function and operation. Show all panel terminal block identification numbers and all wire numbers. Show all intermediate terminations between field elements and panels. Diagrams of subassemblies may be furnished on separate sheets.

3. Identify each device by a unique number or number-letter combination.

4. Conductor Identification: Identify each conductor by a unique number, letter, or number-letter combination. Consecutive numbering is preferred. Each conductor shall have the same identification at all terminals and tie points. All conductors connected to the same terminal or tie point shall have the same identification. Where multi conductor cable is used, a color code may be used to supplement the above identification. Where color coded multi conductor cable is used for wiring identical components, such as limit switches, the color code used shall be consistent and charted on related diagrams.

5. Provide a schematic diagram for each electrical system. The schematic diagram shall be drawn between vertical lines which represent the source of control power. Show control devices between these lines. Show actuating coils of control devices on the right-hand side. Show contacts between the coils and the left vertical line.

   a. Where the internal wiring diagrams of subassemblies are furnished on separate sheets, they shall be shown as a rectangle in the schematic diagram with all external points identified and cross-referenced to the separate sheets of the control circuit. Show coils and contacts internal to the subassemblies in the rectangle connected to their terminal points.

   b. For clarity, show control device symbols in the order in which the controls are positioned on the diagram.
Custom Control Panels
Section 16950 – 4

c. Use a cross-referencing system in conjunction with each relay coil so that associated contacts may be readily located on the diagram. Where a relay contact appears on a sheet separate from the one on which the coil is shown, describe the purpose of the contact on the same sheet.

d. Show all spare contacts.

e. Show limit, pressure, level, flow, temperature, and similar switch symbols on the schematic diagram with all utilities turned off (electric power, air, gas, oil, water, lubrication, etc.) and with the equipment at its normal starting position.

f. Show contacts of multiple contact devices (e.g., selector switches and pushbuttons) on the line of the schematic diagram where they are connected in a circuit. Indicate a mechanical connection between the multiple contacts by a dotted line or arrow.

g. Additional charts or diagrams may be used to indicate the position of multiple contact devices such as limit, pressure, level, and selector switches.

h. Show the purpose or function of all switches adjacent to the symbols.

i. Show the purpose or function of controls such as relays, starters, contactors, solenoids, subassemblies, and timers on the diagram adjacent to their respective symbols. Show the number of positions of the solenoid valve adjacent to the valve solenoid symbol.

C. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all custom control panels specified herein and shown on the Drawings. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Specification Section 01430, and as specified herein.

The O&M Manual shall include, but not be limited to, the following:

1. Equipment Performance Data and Drawings

   a. Detailed Bill of Materials for all control panel equipment and components, listing: manufacturer's name, quantity, description, size, range, and model/part number.
b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, and illustrations.

c. Manufacturer’s data and drawings showing dimensions, physical configurations, installation and mounting details, and wiring schematics.

d. Control ladder diagrams and wiring schematics. Loop diagrams for each monitoring and/or control loop.

2. Installation and Operation Requirements

a. Complete, detailed installation and operation instructions for all control panel equipment and components.

3. Service and Maintenance Data

a. Service and maintenance data shall include all information and instructions required by District’s personnel to keep the control panel and all associated components functioning properly under the full range of operating conditions.

b. Explanation with illustrations as necessary for each service and maintenance task.

c. Recommended schedule of service and maintenance tasks.

d. Troubleshooting instructions.

e. List of maintenance tools and equipment.

f. Recommended spare parts list.

g. Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

D. Final O&M Manual

Upon successful completion of startup and initial operation, Contractor shall submit a Final O&M Manual in accordance with the requirements of the District’s General Conditions, Specification Section 01430, and as specified herein. In addition to the O&M Manual requirements specified above, the Final O&M Manual shall be supplemented with the as-built drawings (including all field changes) for all control panel wiring and loop diagrams.
1.04 DESIGN AND GENERAL REQUIREMENTS

A. Power for Control Panels and Interconnected Devices

1. All control panels shall be supplied with 480 VAC, 3-phase, 240 VAC Single Phase or 120 VAC Single Phase 60 Hz. power, as shown on the Drawings. All control panels shall be designed to minimize sources of control power (foreign power) from other panels.

2. Each control panel shall have a flange mounted disconnecting circuit breaker operable from the control panel front and interlocked with the enclosure door, to be used to isolate the control panel from the power supply.

3. The panel shall have a nameplate identifying the circuit breaker feeding the panel. Warning labels shall be provided identifying sources of foreign power to be disconnected prior to accessing the control panel.

4. The control voltage within the control panel controls shall be 120 VAC. Where the electrical power supply to the control panel is 240 VAC single phase or 480 VAC 3-phase, as shown on the Drawings, the control panel shall be provided with control power transformers, overcurrent protection, and power supplies to convert supply voltage to utilization voltage.

5. The control panel shall be the source of power for all 120 VAC devices interconnected with the control panel including, but not limited to solenoid valves, instruments, and transmitters both mounted in the control panel and remotely connected to the control panel.

B. Enclosure General Requirements

Unless indicated otherwise on the Drawings, or in the individual packaged equipment specification sections, control panels shall comply with the following requirements:

1. Control panels enclosures shall meet, or exceed, area classifications requirements per NEC.

2. Control panel enclosures shall have the following NEMA ratings:
   a. Enclosures installed indoors shall be rated NEMA 12.
   b. Enclosures installed outdoors shall be rated NEMA 4X.
   c. Enclosures installed indoors in wet or corrosive areas shall be rated NEMA 4X.
d. Enclosures installed indoors in hazardous areas shall be rated NEMA 7.

e. Enclosures installed outdoors in hazardous areas shall be rated NEMA 4 and NEMA 7.

3. Control panels shall be either freestanding, pedestal-mounted, wall-mounted, or equipment skid-mounted, as specified in the individual packaged equipment specification sections or indicated on the Drawings.

4. Internal control components shall be mounted on an internal back-panel.

5. Each source of foreign control voltage shall be isolated by providing fuses on a separate terminal block, clearly labeled for incoming foreign control voltage.

6. Discrete outputs from the control panel shall be provided by electrically isolated contacts rated for 5 A (minimum) at 120 VAC. Output isolation shall be provided through interposing relays or PLC relay output cards (if applicable).

7. Analog inputs and outputs shall be an isolated 4-20 mA 2-wire signal with power supply, power supply pilot light, and fuses.

8. Programmable Logic Controllers (PLCs) may be supplied in lieu of hardwired relay logic with the District's approval or if specified in the specification section for the specific equipment. The PLC shall be in accordance with Section 17010, Programmable Logic Controller.

9. All control panel mounted indicating lights, switches, and operator interface devices shall be mounted at least 3 feet above the finished floor elevation, but no more than 6 feet above the finished floor elevation.

10. Terminals shall be mounted vertical and locations of terminals and wireways shall be coordinated to account for conduit entrances.

11. Control panels that contain circuit breakers, combination full-voltage motor starters, soft starters, variable frequency drives, or other motor controls shall comply with the requirements Section 16480, Motor Control Centers, Switchboards, and Panelboards, and Section 16160, Variable Frequency Drives.
1.05 QUALITY ASSURANCE

A. References

This section contains references and information from the following documents which are made a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless specified otherwise, references to documents shall mean the documents in effect at the time of Bid (or on the effective date of the Agreement if there were no bids).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA 70</td>
<td>National Electrical Code (NEC)</td>
</tr>
<tr>
<td>NFPA 70E</td>
<td>Standard for Electrical Safety in the Workplace</td>
</tr>
<tr>
<td>NFPA 79</td>
<td>Electrical Standard for Industrial Machinery</td>
</tr>
<tr>
<td>NEMA 250</td>
<td>Enclosures for Electrical Equipment (1000 Volts Maximum)</td>
</tr>
<tr>
<td>NEMA ICS 6</td>
<td>Industrial Control and Systems: Enclosures</td>
</tr>
<tr>
<td>UL 508A</td>
<td>Industrial Control Panels</td>
</tr>
<tr>
<td>UL 698A</td>
<td>Industrial Control Panels Relating to Hazardous (Classified) Locations</td>
</tr>
</tbody>
</table>

Assembly:

1. The assembled panels and individual components shall be Underwriters Laboratory (UL) listed and labeled.

2. Equipment and components shall be UL listed for the proposed purpose.

3. The control panels shall have factory applied UL 508A labels.

4. The intrinsic safety barriers required within a control panel shall be provided per UL 698A with factory applied labels as required by UL.

C. Factory Testing

Prior to shipment, the manufacturer shall test the functional operation of the control panels as specified in Part 3.01 herein.
D. **Environmental Sustainability**

1. All indoor and outdoor panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents.

2. Unless specified otherwise, heating, cooling and dehumidifying devices shall be provided in order to maintain all instrumentation components to within a range equal to 20 percent above the minimum and 20 percent below the maximum of the rated environmental operating ranges. All required power wiring and temperature controls shall be provided for these devices.

3. Enclosures suitable for the designated environment shall be furnished.

4. All control panels and instrumentation enclosures in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

### 1.06 DELIVERY, STORAGE, AND HANDLING

A. **Delivery**

All control panels shall be crated for shipment using heavy framework and skids:

1. Each panel shall further be cushioned satisfactorily to protect the finish of the instruments and panel during shipment.

2. All instruments, which are shipped with the panel, shall further have suitable shipping stops and cushioning material installed in a manner to protect instrument parts, which could be damaged due to mechanical shock during shipment.

3. Large panel units and/or panel units weighing over 100 lbs. shall be provided with removable lifting lugs to facilitate handling.

B. **Storage and Handling**

Control panels shall be stored and handled in accordance with the manufacturer's instructions and requirements and in a manner to protect the panel from the elements. Panels shall be handled in a manner to protect the components and enclosures.
PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Control panel enclosures shall be standard manufactured enclosures, whenever possible, and shall be as manufactured by Hoffman Engineering, Rittal, Stalin, or equal.

B. Dimensions

1. The Instrumentation and Control Subcontractor (ICS) and/or manufacturer of the packaged equipment system shall be responsible to design and size all panel enclosures based upon:

   a. Available space in area, as indicated on the Drawings.

   b. Equipment and device requirements for components located within the control panel enclosure.

2. The size of the control panel enclosures as indicated on the Drawings is based on preliminary, non-certified, information and as such these sizes are to be used as a general guideline.

3. A narrow or wide panel enclosure shall be provided if necessary to accommodate the available space. A larger enclosure shall be provided if necessary to accommodate the equipment, devices, and appurtenances located within the panel.

2.02 MANUFACTURED ENCLOSURES

A. Type NEMA 1 and NEMA 12 Enclosures for Indoor Installation

1. Unless specified otherwise, enclosures rated NEMA 12 shall be provided for all indoor panels located in dry, non-corrosive areas. Where panels are located in dry, non-corrosive areas and are required to be ventilated for cooling (fan or non-fan cooled), enclosures shall be rated NEMA 1 gasketed.

2. NEMA 1 gasketed enclosures shall be designed to house electrical controls, terminals, and instruments and shall provide protection from dust and dirt.

3. NEMA 12 enclosures shall be designed to house electrical controls, terminals, and instruments, and shall provide protection from dust, dirt, and oil.
4. Enclosure minimum construction requirements shall be as follows:

a. Seams continuously welded and ground smooth.

b. Door and body stiffeners as needed to make a rigid enclosure.

c. Heavy gauge continuous hinge.

d. Rolled lip around 3 sides of the door and all sides of the enclosure opening to prevent migration of liquids and contaminants into enclosure.

e. Oil-resistant gasket attached to door with oil-resistant adhesive. Gasket to seal against roll lip on the enclosure opening.

f. Interior back panel held in place by collar studs welded to enclosure. Back panel shall be full size, constructed of 10 gauge steel with stiffeners as required. Provide split back panel where specified or indicated on the Drawings.

g. Door window where specified or indicated on the Drawings:

i) Safety plate glass.

ii) Held in place by rubber locking seal.

iii) Sized to allow full view of alphanumeric display, operator interface, PLC Human-Machine Interface (HMI), etc.

h. Door panel cutouts for instruments, devices, and windows shall be cut, punched, or drilled and smoothly finished with rounded edges. Reinforce around cutouts with steel angles or flat bars for large panel cutouts such as for HMIs and for pilot device groupings where the removed metal exceeds 50 percent of the available metal in an area bound by a 3-inch envelope around said pilot devices.

i. Finish for NEMA 1 and NEMA 12 Enclosures

i) All steel parts shall be provided with UL listed acrylic/alkyd baked enamel paint finish or TGIC powder coat, except plated parts used for ground connections. All painted parts shall undergo a multi-stage treatment process, followed by the finishing paint coat.
ii) Pre-treatment shall include:
   a) Hot alkaline cleaner to remove grease and oil.
   b) Iron phosphate treatment to improve adhesion and corrosion resistance

iii) The paint shall be applied using an electro-deposition process to ensure a uniform paint coat with high adhesion.

iv) The standard paint finish shall be tested to UL 50 per ASTM B117 (5% ASTM Salt Spray) with no greater than 0.125 inch loss of paint from a scribed line.

v) Paint color for enclosures shall be #49 medium light gray or #61 dark gray per ANSI Standard Z55.1 (60-70 gloss) on all exterior surfaces, unless specified otherwise. All unit interior surfaces shall be painted white for better visibility inside the unit.

vi) Panels that are in the same room as motor control centers switchboards, etc. shall be of the same color as the motor control center or switchboards so that the control panel blends into the lineup.

j. Manufacturer's standard gauge steel.

k. Each door to have a three-point latching mechanism and padlocking handle with rollers on the ends of the latch rods.

l. Print pocket inside door which shall be furnished with final as-built wiring diagrams and all applicable manufacturer warranties.

m. Heating and cooling per Part 1.05.D and Part 2.04 herein.

n. Heavy duty lifting eyes for all free standing panels.

o. Free standing, wall mount, or with floor stands or legs as indicated on the Drawings.

p. With flange mounted, disconnect for incoming power.

q. Hinges: steel piano-type running full length of doors.
r. Copper ground bus bar 1/4-inch x 1-inch with solderless connectors for all equipment grounds.

s. Bonding and grounding kit, including all cable and mounting hardware required to ground equipment to the door and body of the enclosure.

B. Type NEMA 4X Enclosures for Outdoor and Indoor (Wet or Corrosive Locations) Installation

1. Unless specified otherwise, enclosures rated NEMA 4X shall be provided for all outdoor panels and indoor panels located in wet, corrosive areas.

2. NEMA 4X enclosures shall be designed to house electrical controls, terminals, and instruments and shall provide protection from dust, dirt, oil, water, and corrosion.

3. In general, NEMA 4X enclosures shall be constructed of stainless steel. NEMA 4X enclosures constructed of non-metallic fiberglass reinforced polyester resin shall be provided only where specifically indicated on the Drawings or specified in individual specification sections for packaged equipment systems.

4. Minimum construction requirements for stainless steel enclosures shall be as follows:
   a. Type 316 stainless steel, 14-gauge minimum.
   b. Seams continuously welded and ground smooth.
   c. Door and body stiffeners as needed to make a rigid enclosure.
   d. Heavy gauge continuous hinge.
   e. Rolled lip around three sides of the door and all sides of the enclosure opening to prevent migration of liquids and contaminants into enclosure.
   f. Oil-resistant gasket attached to door with oil-resistant adhesive. Gasket to seal against roll lip on the enclosure opening.
   g. Interior back panel held in place by collar studs welded to enclosure. Back panel shall be full size, constructed of 10 gauge steel with stiffeners as required. Provide split back panel where specified or indicated on the Drawings.
h. Unless specified otherwise or indicated otherwise on the Drawings, panels shall be provided with interior swing-out door for:

i) Mounting switches, lights, devices, and HMI.

ii) A window shall be provided in the exterior door for view of interior lights, devices, and instruments if indicated on the Drawings.

i. Door panel cutouts (exterior and swing-out doors) for instruments, devices, and windows shall be cut, punched, or drilled and smoothly finished with rounded edges. Reinforce around cutouts with steel angles or flat bars for large panel cutouts such as for HMI and for pilot device groupings where the removed metal exceeds 50 percent of the available metal in an area bound by 3-inch envelope around said pilot devices.

j. Door window where specified or indicated on the Drawings:

i) Safety plate glass.

ii) Held in place by rubber locking seal.

iii) Sized to allow full view of alphanumeric display, operator interface, PLC Human-Machine Interface (HMI), etc.

k. Finish:

i) Stainless steel surfaces shall be unpainted and provided with a brushed finished.

ii) Interior steel parts shall be finished per Part 2.02.A.4.i herein. Finish paint color shall be white (60-70 gloss).

l. Each door to have a three-point latching mechanism and padlocking handle with rollers on the ends of the latch rods.

m. Print pocket inside door which shall be furnished with final as-built wiring diagrams and all applicable manufacturer warranties.

n. Heating and cooling per Part 1.05.D and Part 2.04 herein.

o. Heavy duty lifting eyes for all free standing panels.
p. Free standing, wall mount, or with floor stands or legs as indicated on the Drawings.

q. With flange mounted, disconnect for incoming power.

r. Hinges: steel piano-type running full length of doors.

s. Copper ground bus bar 1/4-inch x 1-inch with solderless connectors for all equipment grounds.

t. Bonding and grounding kit, including all cable and mounting hardware required to ground equipment to the door and body of the enclosure.

5. Minimum construction requirements for non-metallic enclosures shall be as follows:

a. Shall meet the applicable requirements herein for stainless steel enclosures plus the following additional requirements.

b. Non-metallic enclosures shall be molded fiberglass reinforced polyester resin with plate steel reinforcing on the sides, top, and bottom. The fiberglass reinforced polyester resin shall meet the following minimum standards:

   i) Minimum flexural strength of 29,000 psi per ASTM D790.
   
   ii) Maximum water absorption of 0.07% per ASTM D570.
   
   iii) Minimum tensile strength of 17,500 psi per ASTM D651.
   
   iv) Heat distortion at 400°F per ASTM D648.
   
   v) Minimum specific gravity of 1.35 per ASTM D792.
   
   vi) Minimum dielectric strength of 400 V/mil per ASTM D149.
   
   vii) Minimum arc resistance of 180 seconds per ASTM D495.
   
   viii) Flammability of 94V-O per ASTM D3801 and UL-94.

c. All seams shall be sealed.

d. Hinges shall be constructed of fiberglass with no exposed metal parts.
Custom Control Panels
Section 16950 – 16

e. No exposed metal parts, except for captive stainless steel door screws which shall be replaceable.

f. Provisions for mounting panels shall be an integral part of the enclosure whether by way of internal mounting channels welded to the interior or by way of spot-welded collar studs.

g. Panel exterior gelcoat shall be UV light resistant and shall be light gray in color.

h. Each panel shall be provided with a stainless steel door hasp suitable for padlocking.

i. Enclosure mounting panels shall be constructed of 1/4” thick (minimum) aluminum plate with rounded corners and no sharp edges. Aluminum shall be provided with a uniform brushed finish.

2.03 ENCLOSURE LIGHTS AND RECEPTACLES

A. Each control panel shall be provided with LED lighting fixtures of sufficient size and quantity to provide 50 foot-candles of illumination within the panel. The lighting fixtures shall be horizontal LED tube type fixtures and shall be mounted to the top of the enclosure. The light fixtures shall be wired to a UL-approved switch mounted inside the panel.

B. Each control panel shall be provided with a duplex, 120VAC, 15A, 3-wire grounded GFCI type convenience receptacle.

C. The light fixture(s) and receptacle shall be provided with power by a control transformer in the panel or by a separate 120 VAC circuit, if indicated on the Drawings.

2.04 ENCLOSURE HEATING AND VENTILATION

A. Control panel enclosures shall be provided with heating and ventilation designed by the manufacturer to meet the following requirements and Part 1.05.D herein.

1. Space heaters shall be provided to prevent condensation. Space heaters shall operate on 120 V, 60 Hz power. Adjustable line voltage thermostats shall be provided for controlling the space heaters.
2. Non-forced air and forced air ventilation cooling shall be provided as required to maintain the required temperature of the housed equipment. Forced air ventilation shall be provided with supply fans mounted at the bottom of each enclosure section. The bottom door fans shall force fresh air into the enclosure to create a positive internal air pressure; and thereby, forcing out dirt and contaminants, and moving warm air out through ventilation louvers mounted at the top of the doors. A line voltage thermostat shall control the fans based on the panel internal temperature. Door interlock switches shall be provided to turn the fans off when the door is opened.

3. Supply fans shall be provided with air intake openings equipped with fixed louvers and washable aluminum mesh filters.

Ventilation air shall be exhausted through fixed, louvered openings equipped with washable aluminum mesh filters.

Air supply and exhaust openings shall be sized by the control panel manufacturer for the air flow required to maintain the proper inside temperature. All air filters shall be provided with interior door mounted frames allowing easy removal for cleaning.

B. Where necessary or where specified elsewhere, control panels shall be provided with air conditioning to maintain the required temperature for the housed equipment. Control panel air conditioning units shall be provided in accordance with the following requirements:

1. The air conditioning system shall provide closed-loop cooling and shall be sized by the control panel manufacturer based on: heat generated from all panel equipment and auxiliary components operating at full rated capacity, and said equipment operating under maximum ambient temperature conditions.

2. Unless specified otherwise, air conditioning unit shall operate on 115 V or 230 V, single phase, 60 hertz power supplied by the control panel.

3. Air conditioning unit shall be provided with: 16-gauge (minimum) welded steel framework, an efficient and quiet rotary compressor, built-in condensate evaporator, HFC environment friendly refrigerant, and additional corrosion protection for all aluminum, copper, and ferrous metal surfaces.

4. Air conditioning units for indoor control panels shall be furnished with built-in digital temperature controllers. Air conditioning units for outdoor control panels shall be furnished with remote temperature controllers mounted inside the control panel enclosure in an accessible and visible location.
5. Unless indicated otherwise on the Drawings, the air conditioning unit shall be designed to mount on the side of the control panel enclosure while maintaining NEMA Type 12, 4, or 4X integrity, and shall be furnished with a gasket kit at the interface between the enclosure and air conditioner. Air conditioning units mounted to NEMA Type 4X stainless steel enclosures shall be constructed of stainless steel.

6. Air conditioning unit shall be constructed to allow easy access for maintenance, including easy pull-out air filters. A minimum of three (3) spare replacement air filters shall be provided with each air conditioning unit.

7. Air conditioner units shall be UL listed, and shall be as manufactured by Ice Qube, Inc., or equal.

C. Control power transformers with primary and secondary fuse protection shall be provided as required for proper operation of the enclosure heating and ventilating equipment, unless Drawings show otherwise. Supply voltage shall be 120 VAC and 60 Hz. Separate line voltage thermostats shall be provided for heating and cooling.

2.05 CONTROL DEVICES AND COMPONENTS

A. Control Transformers

If incoming power supply as shown on the Drawings is other than 120 VAC, each control panel shall be provided with a control transformer. Control transformers shall comply with the following requirements:

1. Each control transformer shall be rated 480/120 V or 240V/120V single phase, 2 wire, 60 Hz, and shall conform to the applicable requirements of NEMA ST 1. The transformer shall have adequate volt-ampere capacity for all connected control function loads indicated, plus an additional 20 percent capacity. Transformer capacity shall be increased as required for any additional non-control function loads, such as condensation heaters, ventilation fans, or air conditioning.

2. Each control transformer shall be feed from the load side of the panel or motor controller disconnect. Control transformers rated 480/120 V shall be provided with two primary fuses rated to interrupt 50,000 A (minimum) at 600 V. One transformer secondary lead shall be provided with a time delay, slow-blow fuse rated to interrupt 10,000 A at 250 V, and the other secondary lead shall be grounded. All fuses shall be provided with blown fuse indicators.
Where control circuit power is provided from a source other than a unit transformer (e.g. a lighting panel circuit breaker), the motor controller disconnect shall include an electrical interlock for disconnection of externally powered control circuits.

B. Control Relays

Control relays shall be general purpose, electrically operated, magnetically held, plug-in blade or pin style with DIN rail mountable socket and LED indicator. Control relays shall be UL listed with 10 A rated contacts (thermal continuous current at 120 VAC), and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles and pole arrangement shall be as indicated on the Drawings and as specified herein. Control relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.

C. Time Delay Relays

Time delay relays shall be general purpose, multi-range, multi-function plug-in blade or pin style with DIN rail mountable socket and LES indicators (timing and timed out). Time delay relays shall be provided with multiple programmable timing ranges (0.5 sec to 24 hours, minimum) and multiple operating modes. As a minimum, relay operating modes shall include: on-delay, off-delay, repeat cycle off start, repeat cycle on start, and signal on/off delay. Time delay relays shall be UL listed with 5 A rated contacts (thermal continuous current at 120 VAC) non-inductive load, and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles, pole arrangement, and maximum timing adjustment shall be as indicated on the Drawings and as specified herein. Time delay relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.

D. Elapsed Time Meters

Elapsed time meters shall be electromechanical, NEMA Type 4X rated, with rectangular or round case suitable for flush panel mounting. Each meter shall have 6-digit (minimum) registers with counter numbers at least 3 mm high, and shall be non-resetable. White counter numbers on black backgrounds shall provide hour indication with the last digit in contrasting colors to indicate tenths of an hour. Each meter shall operate on 120 VAC input power. Elapsed time meters shall be as manufactured by Eaton, Honeywell/Hobbs, or equal.

E. Pilot Devices

1. Pilot devices consisting of pushbuttons, selector switches, pilot lights, and incidental items shall be as manufactured by Allen-Bradley, Eaton/Cutler Hammer, or Schneider/Square D (no substitutes).
2. Pilot devices shall be suitable for mounting on MCCs, switchgear, control panels, and control stations. Pilot devices shall be 30.5 mm, NEMA Type 4/13 with cast metal bases, chrome-plated octagonal mounting nuts, and legend plates.

3. Contact blocks shall have AC contact ratings of NEMA A600, 10 A with silver contacts for corrosion resistance and clear side plates for contact inspection.

4. Pushbuttons and switch knobs shall be heavy duty plastic. Unless indicated otherwise on the Drawings, switch knobs shall be black and pushbuttons shall colors shall be as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Function</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Emergency Stop, Stop, Off</td>
<td>Emergency Stop button, Master Stop button, Stop of one or more motors</td>
</tr>
<tr>
<td>Yellow (Amber)</td>
<td>Return, Emergency Return, Intervention (suppress abnormal conditions)</td>
<td>Return of machine to safe position, override other functions previously selected</td>
</tr>
<tr>
<td>Green</td>
<td>Start-On</td>
<td>General or machine start. Start of cycle or partial sequence.</td>
</tr>
<tr>
<td>Black</td>
<td>No specific function assigned</td>
<td>Permitted to be used for any function except for those listed above.</td>
</tr>
</tbody>
</table>

5. Pilot light devices shall be push-to-test type and shall be provided with LEDs and transformers suitable for operation on 120 VAC power. Pilot light lenses shall be shatter resistant plastic. Unless indicated otherwise on the Drawings, pilot light lens colors shall be as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Function</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Fail or Alarm (abnormal condition requiring immediate attention)</td>
<td>Indication that a protective device has stopped the machine, e.g. overload</td>
</tr>
<tr>
<td>Yellow (Amber)</td>
<td>Warning (marginal condition, change or impending change of conditions)</td>
<td>Some value (e.g. pressure) is approaching its permissible limits. Overload permitted for a limited time. Ground fault indication.</td>
</tr>
</tbody>
</table>
### Custom Control Panels

#### Section 16950 – 21

<table>
<thead>
<tr>
<th>Color</th>
<th>Function</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Normal Condition, Confirmation</td>
<td>Normal pressure. Control power on.</td>
</tr>
</tbody>
</table>

**F. Mounting of Instruments**

1. Provide cutouts, and door mount all instrument items indicated on the Drawings or specified to be panel mounted, including any instruments specified to be furnished by other vendors but installed in panel (if applicable).

2. Mount, behind panel doors, other instrument accessory items as required and/or specified.

3. The rear of panel mounted equipment shall be installed with due regard to commissioning adjustments, servicing requirements and cover removal.

4. Spare space shall be kept clear of wiring, etc. to give maximum space for future additions.

**G. Door Mounted Device Shield**

Provide a clear acrylic glass (Plexiglass) shield to cover back of door mounted devices (lights, switches, OIT, etc.). Plexiglass shield shall be 1/8" thick and shall be mounted to the panel door (outer door and/or inner swing-out door) with 1/4" diameter stainless steel bolts and spacers between back of panel door and Plexiglass shield. Bolts and spacers shall be provided at shield corners and along shield edges as necessary to provide a rigid shield.

**H. Terminals and Power Supplies**

All terminals and power supplies shall be as manufactured by Phoenix Contact (no substitutes).

1. Provide terminal blocks for all incoming and outgoing control wires. Unless indicated otherwise on the Drawings, mount terminal blocks vertically. Wire and mount terminal blocks so that internal and external wiring do not cross over the terminals. No more than two conductors shall be terminated at each terminal connection.
2. Field wiring shall terminate on the "field side" of the terminal blocks. Do not connect internal panel wiring to the "field side" of the terminal blocks. Do not connect field wiring to the "panel side" of the terminal block.

3. Unless specified otherwise, all field wiring shall be connected to fused terminal blocks, including input and output terminals to and from PLCs. PLC loop powered analog signals shall be connected to two-level, non-fused terminal blocks.

4. Terminal blocks shall be modular, rail mounted, rated at 20 amperes, 600 volts capable of terminating wire sizes 12 through 24 AWG and constructed of polyamide thermoplastic. Terminal blocks shall be UL listed in accordance with UL 486A and 1059. All current carrying parts shall be made of copper or brass electroplated with tin/lead. Terminal connection shall be a screw clamp pressure plate connection, designed such that the clamping screw does not clamp the screw directly to the wire.

5. Provide symmetrical steel assembly rails, end brackets, jumper bars, and other accessories as required for a complete terminal block assembly.

6. Terminal blocks shall be consecutively numbered from top to bottom with preprinted marking tags. Tags shall be white polyamide and hot printed with black symbols so that the print is permanent.

7. Specific model terminal blocks shall be as follows:
   a. Phoenix Contact Terminal Block, Single-Level, Non-Fused, Model UK5N
   b. Phoenix Contact Terminal Block, Two-Level, Non-Fused, Model UKKB5
   c. Phoenix Contact Terminal Block, Fused, Model UKK5-HESILED
   d. Phoenix Contact End Cover, Model D-UKKB3/5
   e. Phoenix Contact Clamp, Model E/UK1.

   Alternate model terminal blocks or terminal blocks from other manufacturers are not acceptable.

I. Power Supplies

Unless specified otherwise, power supply shall be Phoenix Contact Power Supply AC-DC 24V @ 2A 85-264V In, Enclosed DIN Rail Mount Mini Series, Model 2938730. Alternate model power supplies from other manufacturers are not acceptable.
2.06 MARKERS AND NAMEPLATES

A. Markers

Each signal, control, alarm, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number, which shall be shown on all manufacturer shop drawings. These numbers shall be marked on all conductors at every terminal. Conductor markers shall be pre-printed white identification tags with clear heat shrinkable tubing. Heat shrinking of the identification tags and clear tubing shall be in accordance with manufacturer's specifications.

1. Conductor identification tags shall be in accordance with the following requirements:

   a. The conductor identification tags shall consist of heat shrinkable flame retarded identification sleeves that fit tightly over the conductor or cable to be marked. Identification sleeves shall be made of a seamless cross-linked polyolefin with a 3 to 1 shrink ratio.

   b. The conductor identification tag system shall be UL recognized to Standard 224, MIL-M-81531. Identification tags shall be smear resistant prior to shrinking and achieve a permanent mark when shrunk, without the need for permatizing equipment. Identification marks shall be legible after 20 eraser rubs and 30 solvent brush strokes.

   c. Identification sleeves shall be seamless. Sleeves shall be resistant to common industrial fluids including Freon TF, Isopropyl Alcohol and Ethylene Glycol. Identification sleeves shall have a temperature range of -30°C to 105°C and a dielectric strength of 500 V/mil minute. The identification sleeves shall be suitable for indoor or outdoor use. The conductor identification tag system shall be as manufactured by Raychem/Kroy Cable Marking, or Brady-Permasleeve White Polyolefin (B-342), or equal. Heat shrinkable thermoplastic tags are not acceptable.

2. The conductor identification sleeves shall be provided with heat shrink clear tubing in accordance with the following:

   a. To provide a long-term permanent marker in high ambient temperatures, a translucent (clear) shrink tube shall be placed over each wire marker (extending past both edges of adhesive wire marker) and heat shrunk.
b. The clear tube shall be suitable for high temperature performance, abrasion resistance and cut-through resistance and resistant to chemicals and solvents. The clear tubing shall meet the high temperature performance that meets or exceeds military industrial standards: MIL-1-23053, Test C, with UL VW-1 ratings. Operating temperature range shall be -55°C to 175°C. Product shall be Kynar as manufactured by Raychem, or equal.

B. Nameplates

1. Plainly and permanently identify control and power devices using the same identification as shown on the schematic diagrams. Show identification for devices inside the enclosure on a nameplate adjacent to, not on, the device.

   a. Exception No. 1: Where the size or location of the devices make individual identification impractical, such as on electronic assemblies, use group identification.

   b. Exception No. 2: Where panel layouts do not permit the mounting of identification nameplates adjacent to components, such as relays, place the permanent relay identification on the relay where it is plainly visible, and provide a second identification on the top of the panel wireway cover directly below the relay. Identify the wireway covers to show their proper location.

2. Identification nameplates for devices mounted inside and outside the control enclosure shall be one of the following:

   a. Laminated phenolic for engraving stock; a minimum of 0.062 inch thick with black background and white lettering. Fasten nameplates with stainless steel drive screws, or the equivalent. Use permanent adhesives for attaching nameplates to wireway covers.

   b. Stainless steel; a minimum of 0.031 inch thick for engraving stock or 0.012 inch thick for embossing stock. Fasten nameplates with stainless steel drive screws, or the equivalent.
2.07 WIRING METHODS

A. Panel wiring shall be neatly contained in panel wireways, including incoming and outgoing field control wiring. Provide separate wireways for internal wiring and field wiring. Panelways shall be colored white for 240 VAC circuits and colored light gray for 120 VAC, restricted slot design, with matching snap on overs. Provide panelways with mounting holes and nylon "push" rivets for mounting. Panelways material shall be PVC or noryl. Panelways shall be as manufactured by Panduit, or equal.

B. Provide minimum 2 inches of clearance between panelway and wire terminations to allow for clear viewing of wire identification marking.

C. Wiring run to control devices on the front door shall be tied together at short intervals and secured to the inside front door with Panduit adhesive mounts. Mounts shall be Clincher adjustable releasable clamp type for wire bundles 0.69 inch in diameter or smaller, or AM2-C mounts with Uni-Ty releasable nylon cable ties for bundles larger than 0.69 inch in diameter. Mounts shall be attached to front panel with Eastman 910 adhesive, or equal.

D. Signal and Control Circuit Wiring

1. Wire type and sizing:
   a. Conductor shall be flexible stranded copper machine tool wire.
   b. These shall be UL listed Type MTW flexible or Type SIS and shall be rated 600 volts.
   c. Wires for instrument signal circuits and alarm input circuits shall be No. 14 AWG, minimum.
   d. Wires connecting to PLC wiring arms shall be multiconductor No. 16 AWG, minimum.
   e. All other wires, including shielded cables, shall be No. 16 AWG, minimum. Shielded cables shall be used for analog signals.
   f. Wire insulation colors shall be as follows:
      i) Control Wiring
         a) PLC Inputs (Status) DI = Blue
         b) PLC Outputs DO = Brown
         c) 12VDC Positive = Red
d) 12VDC Negative = Black  
e) 24VDC Positive = Yellow  
f) 24VDC Negative = Blue  
g) 120 VAC Positive = Red  
h) 120 VAC Negative = White  
i) 120VAC Switch Leg = Do not use Black, Red or Blue  
j) 480 VAC Switch Leg = Do not use Brown, Orange or Yellow

ii) Power Wiring

a) 480 VAC A-Phase = Brown, B-Phase = Orange,  
   C-Phase = Yellow  
b) 120/208/240 VAC A-Phase = Black, B-Phase = Red, C-Phase = Blue  
c) Phase tape with colors is acceptable  
d) Foreign Power = Yellow

Note: Match existing wiring when appropriate.

2.08 SPARE PARTS

A. All spare parts shall be of the same material and workmanship, shall meet the same requirements, and shall be interchangeable with the corresponding original parts furnished. Spare parts shall be properly packaged for shipment and storage, and shall be labeled with the manufacturer's part number(s).

B. As a minimum, Contractor shall furnish the following spare parts:

1. Five (5) fuses of each type and size for single-phase power (including control power).
2. Two (2) indicating light assemblies for each type of pilot light.
3. One (1) control relay of each type and rating.
4. One (1) time delay relay of each type and rating.

C. Where control panels operate on 3 phase power and/or are equipped with motor starting equipment and components, Contractor shall furnish the following additional spare parts:

1. Three (3) fuses of each type and size for three-phase power.
2. Two (2) complete sets of 3-pole stationary and moving contact assemblies for each size AC contactor.

3. Two (2) operating coils for each size AC contactor.

4. One (1) contactor auxiliary contact of each type.

5. Three (3) contactor overload relays of each type and rating, each relay with a complete set of contact blocks.

6. One (1) spare set of heater elements for each heater rating provided.

**PART 3 - EXECUTION**

3.01 FACTORY TESTS

Prior to shipment, each control panel shall be inspected and tested for correct operation by the manufacturer. Each circuit shall be tested for continuity, short circuits, and fault grounds. The functional operation of the control panel shall be tested, including operation of all input and output (I/O) points, control devices, and motor controls. Temporary connections shall be provided between control panels and other system components. Subsequent testing of the system shall include, but not be limited to, programming of the PLC and operator interfaces. PLC system shall be programmed as required.

A. Initial Testing

Initial testing of the control panel shall include configuration of the PLC and its communications equipment (where PLC is provided) energizing each digital I/O and simulating each analog I/O using a loop simulator and calibrator. Circuits not energized shall be tested for continuity. Energized circuits shall be tested through all components from the terminal blocks in the control panel to the control devices and hardware I/O memory locations in the PLC. Testing of the control system shall be considered completed after control system operation has been successfully simulated at least four (4) times.

An I/O checklist shall be provided for all points in the control panel. The checklist shall include, for each point, the tag name of the point, a description of the point, comments, date and time of the test, and a signature line for the person performing the test. Where a PLC is provided, each digital point set and reset shall be shown. Verification of all analog points shall be shown at 0%, 25%, 50%, and 100% of range. The checklist shall be submitted to District.
B. **District-Witnessed Factory Testing**

District shall have the option of witnessing the functional shop test. Contractor shall notify District at least three (3) weeks prior to the scheduled functional shop test.

After completion of initial testing, the subsequent testing shall be conducted for inspection by District. All control functions and all status and alarm monitoring and indication shall be demonstrated under simulated operating conditions. Simulating equipment shall be provided and wired into the control system for this testing. The system shall be revised, modified, and adjusted as required by District during the testing period. Testing shall continue for the time period required by District to observe and verify any revisions and shall continue to District’s satisfaction. Where panel is equipped with a PLC, the PLC and HMI programs shall be loaded and fully tested in the factory. All hardware, instruments, and software shall be provided as necessary to perform the testing.

### 3.02 SITE TESTS

A. **General**

Control panel shall be tested with all field wiring connected. All adjustable set points and time delays shall be set as required. Operation of control panel and field devices shall be checked to verify correct operation. All required adjustments shall be made as required for correct operation.

B. **Specific Field Verifications**

The following specific field verifications shall be performed:

1. Panel control circuits are grounded with one (1) terminal of each load device connected to the grounded conductor.

2. Panel signal and control wiring are separated and installed in separate wireways with barriers between the power wiring and the signal and control wiring.

3. Panel is connected to the facility grounding system as specified.

4. Panel tops of wall-mounted panels are mounted at the same elevation (unless noted otherwise).

5. Panel inner door contains a copy of the as-built elementary and wiring diagrams.

6. Panel inner door contains copies of all applicable equipment warranties.
7. Panel inner door contains a drawing holder.

8. Panel as-built shop drawings and applicable equipment warranties are enclosed in a transparent, protective jacket.

9. All panel functions are as specified.

3.03 CONTROL PANEL MOUNTING

A. General

Control panels shall be field mounted as indicated on the Drawings or on equipment supplied as shown on District-accepted shop drawings.

B. Mounting Requirements

Unless indicated otherwise on the Drawings or in the specification sections for the packaged equipment systems, control panels shall be mounted as follows:

1. Control panels supported directly by concrete or concrete masonry walls shall be spaced apart not less than 1-5/8" by strut channel between panel and wall. Strut channel shall be attached to the wall as shown on the Drawings. Panels shall be attached to strut channel with stainless steel strut threaded studs, washers, and nuts. Unless specified others, strut stud diameter shall be 1/16” less than the panel mounting holes.

2. Panels shall be mounted to structures or support systems that are free of vibration or shock.

3. Support systems shall not be attached to handrails, process piping, or mechanical equipment, unless indicated on the Drawings.

4. Unless indicated otherwise on the Drawings, materials used for support of control panels shall be constructed of Type 316 stainless steel. Support systems, including panels, shall be designed to prevent deformation greater than 1/8" under the enclosed equipment load and an external load of 200 pounds in any direction.

5. Panels shall be shimmed to precise alignment so doors operate without binding.

6. Floor-mounted cabinets shall be mounted on 3" minimum high concrete housekeeping pads or grouted bases as indicated on the Drawings.
7. Terminals and terminal blocks shall be sprayed with a silicone resin, similar to Dow Corning R-4-3117 conformal coating, after all terminations and testing have been completed.

3.04 MANUFACTURER'S SERVICES

Unless specified otherwise, equipment manufacturer's services shall be provided at the job site for the minimum number of 8-hour work days listed below, travel time excluded:

A. Two (2) work days to check the installation, calibrate the equipment, supervise start-up, and supervise testing of the system.

B. One (1) work day to instruct the District's personnel in the operation and maintenance of the equipment.

END OF SECTION
SPECIFICATIONS - DETAILED PROVISIONS
Section 17005 - General Instrumentation and Control Components

CONTENTS

PART 1 - GENERAL ....................................................................................................................... 1
1.01 DESCRIPTION ...................................................................................................................... 1
1.02 RELATED SECTIONS ......................................................................................................... 1
1.03 REFERENCE STANDARDS AND CODES ........................................................................... 1
1.04 INSTRUMENTATION AND CONTROL SUBCONTRACTOR .................................................. 2
1.05 PERFORMANCE SPECIFICATIONS AND DRAWINGS ....................................................... 4
1.06 INSTRUMENTATION AND CONTROL EQUIPMENT ............................................................. 4
1.07 SUBMITTALS ....................................................................................................................... 5
1.08 QUALITY ASSURANCE .................................................................................................... 10

PART 2 - PRODUCTS ................................................................................................................... 11
2.01 GENERAL ......................................................................................................................... 11
2.02 GENERAL REQUIREMENTS FOR COMPONENTS AND APPURTENANCES ...................... 12
2.03 FLOAT SWITCHES AND INTRINSICALLY SAFE RELAYS ..................................................... 13
2.04 PRESSURE GAUGES ........................................................................................................ 14
2.05 DIAPHRAGM SEALS .......................................................................................................... 14
2.06 PRESSURE SWITCHES ....................................................................................................... 15
2.07 DIFFERENTIAL PRESSURE SWITCHES ............................................................................... 15
2.08 PRESSURE TRANSMITTERS ............................................................................................. 16
2.09 DIFFERENTIAL PRESSURE TRANSMITTERS .................................................................. 16
2.10 ULTRASONIC LIQUID LEVEL MEASUREMENT SYSTEM ................................................... 17
2.11 SUBMERSIBLE LIQUID LEVEL MEASUREMENT SYSTEM .................................................. 19
2.12 CONDUCTANCE LIQUID LEVEL MEASUREMENT SYSTEM ............................................. 21
2.13 CONDUCTIVITY MEASUREMENT SYSTEM ..................................................................... 22
2.14 ANCILLARY MATERIALS AND COMPONENTS ................................................................ 25

PART 3 - EXECUTION .................................................................................................................. 26
3.01 GENERAL .......................................................................................................................... 26
3.02 INSTALLATION .................................................................................................................. 26
3.03 FIELD QUALITY CONTROL .............................................................................................. 28
3.04 FIELD TESTING ............................................................................................................... 30
3.05 INSTRUCTION .................................................................................................................... 31
PART 1 - GENERAL

1.01 DESCRIPTION

A. Contractor shall provide all equipment, materials, and labor, and required to place into service a fully configured, integrated, and operational instrumentation and control system as indicated on the Drawings and specified herein.

B. Design, fabricate, coordinate, install, calibrate, and test the instrumentation and control system to provide proper operation and to interface with related equipment and materials.

C. Furnish and install auxiliary and accessory devices necessary for system operation or performance and to interface with equipment specified herein and in other Sections of these Specifications.

1.02 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all Sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Division 11 – Equipment
2. Division 13 – Special Construction
3. Division 15 – Mechanical
4. Division 16 – Electrical
5. Division 17 – Instrumentation and Controls

1.03 REFERENCE STANDARDS AND CODES

A. International Society of Automation (ISA)

1. ISA S5.1 – Instrumentation Symbols and Identification.
2. ISA S5.3 – Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems.

3. ISA S5.4 – Instrument Loop Diagrams.

4. ISA S20 – Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.


B. National Electrical Manufacturers Association (NEMA)

C. National Fire Protection Agency (NFPA)

1. NFPA 70 - National Electrical Code (NEC).

2. NFPA 79 – Industrial Control Equipment.

Equipment and materials, including installation of same, shall meet or exceed the applicable requirements of the above standards and codes (latest edition).

1.04 INSTRUMENTATION AND CONTROL SUBCONTRACTOR

Contractor shall designate an Instrumentation and Control Subcontractor (ICS) to be responsible to furnish all services, equipment, and material specified herein.

A. Qualifications

1. As a minimum, the ICS shall have been regularly engaged in the design, selection, purchase, fabrication, installation, calibration, startup, and testing of instrumentation and control equipment on municipal water and wastewater projects.

2. ICS shall have been regularly engaged in performing coordination, design, and selection of equipment and controls to interface between instrumentation and control equipment, and to interface with system control panels, motor control centers, variable frequency drives, packaged systems, programmable logic controllers, etc. for municipal water and wastewater projects of similar or larger magnitude for at least 5 years.

3. Contractor shall submit ICS qualifications and project references (5 minimum) for District review and approval.
4. Personnel employed for system engineering, coordination, supervision, installation, startup, operational testing, and training shall be regularly employed and trained by the ICS.

B. Responsibilities

1. Design, select, fabricate, coordinate, calibrate, and test the instrumentation and control system to provide proper operation and to interface with related equipment and materials furnished by other suppliers under other Sections of these Specifications, with existing facilities (where required), and with District provided Remote Telemetry Unit (RTU) equipment and/or Supervisory Control and Data Acquisition (SCADA) system equipment.

2. Coordinate the design, selection, and fabrication of instrumentation and control systems furnished by others, and confirm that the proposed equipment will provide the required monitoring/control and shall properly interface with other equipment systems (new and existing).

3. Design and prepare control and interconnect diagrams (loop drawings) for all field devices, local control panels, main control panels, motor control centers, etc. showing wiring interconnections for all project equipment, instrumentation, and controls (including existing equipment, instrumentation, and controls).

4. Review and approve shop drawings prepared by the motor control center, variable frequency drive, and other electrical equipment suppliers. ICS shall date and sign said shop drawings prior to submittal to the District for review.

5. Coordinate work so that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling, alarming devices, and all appurtenances are selected, designed, and calibrated to provide the specified accuracy and performance, and are completely compatible and shall function as specified.
6. Provide auxiliary and accessory devices necessary for system operation or performance and to interface with equipment provided by other suppliers under other Sections of these Specifications, with existing facilities (where required), and District provided RTU equipment and/or SCADA system equipment. These devices include, but are not limited to, current isolators, signal conditioners, transducers, and interposing relays. These devices shall be provided whether they are shown on the Drawings or not, and shall be at no additional cost to the District.

7. Installation of instrumentation and control equipment and materials need not be performed by the ICS; however, the ICS shall provide onsite technical supervision of the installation.

8. Prior to installation of any conduit associated with instrumentation and controls, the ICS shall verify conduit size and conduit runs with the Electrical Subcontractor and equipment suppliers for specific equipment to be furnished, and notify the District of any conflicts or deviations.

9. Coordinate services of manufacturer's engineering representatives for instrumentation and control equipment during installation, startup, operation, and instruction of District personnel.

Contactor shall subcontract the work specified herein to a qualified ICS. All work performed is the responsibility of the Contractor even though references are made herein to work requirements and responsibilities of the ICS and Electrical Subcontractor.

1.05 PERFORMANCE SPECIFICATIONS AND DRAWINGS

Instrumentation and control systems shall be furnished and installed to provide equipment performance, operation control, and/or monitoring functions as specified on the Drawings, in specific equipment sections of these Specifications, or in the Special Conditions. Control schematic diagrams, where provided on the Drawings, show control wiring and control functions for specific equipment. ICS shall prepare, or coordinate preparation of all wiring and control diagrams, and computer programs. ICS shall furnish and install all instrumentation and control components required to provide said specified performance and operation.

1.06 INSTRUMENTATION AND CONTROL EQUIPMENT

Instrumentation and control equipment shall be as specified herein, per individual equipment sections of these Specifications, and as shown on the Drawings. Not all products specified herein are necessarily required for this project.
1.07 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11” x 17” for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Detailed Bill of Materials for all instrumentation and control equipment, and appurtenances, listing: manufacturer's name, quantity, description, size, range, and catalog/part number.

2. Summary data sheets for all instrumentation and control equipment in accordance with ISA-20.00.01 format. As a minimum, data sheets shall include the following information: Plant equipment name/number and ISA tag number shown on the Drawings (where provided); item name as specified herein, or separate Specification sections, or indicated on the Drawings; manufacturer’s complete model number, item location; input/output characteristics; range, size, and gradation in engineering units; materials of construction for wetted parts and enclosure; and enclosure NEMA classification.

3. Complete documentation for all instrumentation and control equipment, including: manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer’s literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

4. Engineering selection and design parameters and calculations for instrumentation and control components including range, material compatibility for process medium, temperature ratings for project ambient conditions, temperature error and proposed mitigation for same, and other pertinent selection and sizing criteria.

5. Manufacturer’s data and drawings showing dimensions, physical configurations, methods of connecting instruments and control equipment together, installation and mounting details, single instrument loop diagrams, and wiring schematics.
6. Product data sheets for instrument cables and controller/transmitter cables. Installation requirements for cables and conductors, including shielding, splicing, and grounding requirements.

7. Control program for programmable controllers (if applicable) with complete listing and description of all program functions, all input and output parameters, and factory settings.

8. Interface between instruments, controllers, motor starters, control panels, variable frequency drives, PLCs, etc., District furnished equipment (when supplied), and other equipment related to the instrumentation and control system.

9. Control ladder diagrams for all control, protection and monitoring circuits, including control panel wiring. Ladder diagrams shall show all switches, push buttons, relays, timers, etc. Show all interconnections between power sources and device elements of a particular system or equipment, and all interlocks with other equipment/systems in a manner that fully indicates the circuit function and operation.

10. Loop diagrams for each monitoring and/or control loop. The loop diagrams shall show all components of the loop: analog, digital, and discrete including all relays, switches, signal isolators, etc. which are being provided for proper operation. Loop diagrams shall be provided for all analog and control system components, including those components specified in other Sections of these Specifications and/or shown on the Drawings. Loop diagrams shall be prepared according to ISA-S5.4 format, and shall also include the following:

   a. All interconnecting wiring between equipment, panels, terminal junction boxes, and field mounted components. Show all panel terminal board identification numbers and all wire numbers. Show all intermediate terminations between field elements and panels.

   b. The location of all devices.

   c. The instrument description, including type, manufacturer, model number, range, set points, and operation (e.g. fail open, open on energization, normally closed, etc.) as applicable.

   d. The instrument loop power requirements back to the termination on the terminal block, fuse block (including fuse size), etc., as applicable.
e. All grounding points within cabinets and panels and identify the connection point of individual components.

f. Each diagram shall include a table summary with output capability of the transmitting instrument, input impedance of each receiving instrument, estimate of loop wiring impedance based on wire size and approximate length, total loop impedance, and reserve output capacity.

11. Interconnection diagrams for all field devices, local control panels, main control panels, motor control centers, etc. showing wiring interconnections for all project equipment, instrumentation, and controls (including existing equipment, instrumentation, and controls). Interconnection diagrams shall be provided for all equipment and appurtenances, including equipment specified in other Sections of these Specifications and/or shown on the Drawings. Interconnection diagrams shall be point-to-point type and shall show all conduit and wiring interconnections with electric panel and circuit numbers for all power sources.

12. Proposed nameplate descriptions for all instrumentation and control equipment.

B. Field Testing and Demonstration Plan

Contractor shall prepare and submit for approval a written plan for field testing and demonstrating that each instrumentation and control system meets the specified operational and performance requirements. Submit a written plan with step by step procedures to be used during pre-startup, startup, and final demonstration testing of system operation and performance.

C. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all instrumentation and control equipment specified herein and incorporated into the Work. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Section 01430, and as specified herein.
The O&M Manual shall include, but not be limited to, the following:

1. Equipment Performance Data and Drawings
   a. Detailed Bill of Materials for all instrumentation and control equipment, and appurtenances, listing: manufacturer's name, quantity, description, size, range, and model/part number.
   b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, and illustrations.
   c. Manufacturer’s data and drawings showing dimensions, physical configurations, installation and mounting details, single instrument loop diagrams, and wiring schematics.
   d. Control diagrams, loop diagrams, and interconnect diagrams for all field devices, local control panels, main control panels, motor control centers, etc. for all project equipment, instrumentation, and controls (including existing equipment, instrumentation, and controls).

2. Equipment Installation Requirements
   a. Complete, detailed installation instructions for all instrumentation and control equipment, and appurtenances.

3. Equipment Operation Data
   a. Complete and detailed instructions for adjusting all equipment settings, including: input power, output signal, range, span, sensitivity, etc.
   b. Complete and detailed user manuals and operating instructions, including operator interface menus, programming, and setup parameters for all controllers.
   c. Printed list of all final setup parameters for each controller, including factory settings and any field modifications to factory settings.
General Instrumentation & Control Components
Section 17005 – 9

4. Equipment Service and Maintenance Data
   
a. Maintenance data shall include all information and instructions required by District's personnel to keep equipment adjusted and calibrated so that it functions properly under the full range of operating conditions.

b. Explanation with illustrations as necessary for each maintenance task.

c. Recommended schedule of maintenance tasks.

d. Troubleshooting instructions.

e. List of maintenance tools and equipment.

f. Recommended spare parts list.

g. Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

5. Manufacturer Warranties

D. Final O&M Manual

Upon successful completion of startup and initial operation, Contractor shall submit a Final O&M Manual in accordance with the requirements of the District’s General Conditions, Specification Section 01430, and as specified herein.

1. As-built drawings (including all field changes) for all wiring and interconnection diagrams shall be incorporated into the Final O&M Manuals.

2. In addition, pre-startup and post-startup written certification reports as specified herein shall be included in the Final O&M Manual.
1.08 QUALITY ASSURANCE

A. Manufacturers

To facilitate the District’s future operation and maintenance, furnish equipment which is the product of one manufacturer to the maximum extent possible. Where this in not practical, all equipment of a given type shall be the product of one manufacturer.

All equipment shall be of the manufacturer’s latest design and shall produce or be activated by signals which are standards for the water and wastewater industry.

B. Model Numbers

Model numbers supplied herein are provided for information purposes only, to assist Contractor in selecting equipment that conforms to the Specification and Drawing requirements. In case of any conflict between model numbers provided and the descriptive requirements specified herein, the descriptive requirements shall govern.

C. Standard of Quality

Only equipment of the types and sizes specified which has been demonstrated to operate successfully shall be furnished. All material and equipment furnished shall be listed by and shall bear the label of Underwriters Laboratories (UL), Edison Testing Labs (ETL), or Factory Mutual (FM).

D. Instrumentation and Control Subcontractor's Certifications

Prior to startup and initial operation of all instrumentation and control equipment (including existing instrumentation and control equipment), the ICS shall submit a written report stating that equipment has been coordinated, calibrated, properly installed, and is ready for startup. After startup and when equipment is ready to be operated, the ICS shall submit a written report for the instrumentation and control equipment certifying that the equipment is ready to be operated, is safe to operate and has been checked, inspected, calibrated, and adjusted as necessary; has been operated under varying service conditions and operated satisfactorily; and is fully covered under the terms of the guarantee.
PART 2 - PRODUCTS

2.01 GENERAL

A. Where indicated on the Drawings, specified by the individual equipment sections in these Specifications, or by the Special Conditions, the instrumentation and control components shall be as specified herein.

B. Unless specified otherwise, all equipment shall be suitable for operation over an ambient temperature range of 15°F to 122°F, and at a maximum elevation of 3,300'. Cooling or heating equipment shall be provided if required by the instrumentation and control equipment. Where dissipation of heat cannot be adequately accomplished with natural convection (NEMA 4X enclosures) or forced air ventilation (NEMA 1 gasketed enclosures), additional cooling or heating shall be furnished.

C. Unless specified otherwise, electrical enclosures for indoor equipment shall be rated NEMA 1 gasketed, or better. Unless specified otherwise, electrical enclosures for outdoor equipment shall be rated NEMA 4X. Outdoor enclosures with sunlight exposure shall be provided with sun shields. In addition, instrumentation located in areas subject to wash down or exposure to chemicals shall be provided with NEMA 4X electrical enclosures.

D. All instrumentation in hazardous areas shall be intrinsically safe and shall be approved for use in the particular hazardous (classified) location in which it is to be installed.

E. All panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be of one manufacturer.

F. Analog measurements and control signals shall be as indicated herein, and shall vary in direct linear proportion to the measured variable, except as noted. Unless specified otherwise, analog output signals shall be 4 to 20 milliamperes (ma) DC.

G. Unless specified otherwise, power for the instrument and control equipment shall be 120VAC, single phase, 60 Hz.

H. Where DC power supplies are not furnished integral with any one instrument system loop, Contractor shall provide a separate solid-state power supply and fuses (primary and secondary).
2.02 GENERAL REQUIREMENTS FOR COMPONENTS AND APPURTENANCES

A. Materials and Components

Electrical materials and components shall be as specified in Section 16050, as indicated on the Drawings, and as specified herein.

B. Signal Isolators, Converters, and Power Supplies

Signal isolators shall be furnished and installed in each measurement and control loop, wherever required to ensure adjacent component impedance match, or where feedback paths may be generated. Signal converters shall be included where required to resolve any signal level incompatibilities. Signal power supplies shall be included, as required by the manufacturer's instrument load characteristics, to ensure sufficient power to each loop component.

C. Tags and Nameplates

1. Each field instrument shall be provided with a rectangular Type 316 stainless steel tag. The tag shall be engraved with the project instrument tag number. The instrument tag shall be attached directly to the instrument with stainless steel screws or with a stainless steel chain.

2. Each panel mounted instrument, controller, or control component shall be provided with a nameplate. The nameplate shall be engraved with the project description of the device. Nameplates shall conform to the requirements of Section 16050.

D. Wiring and Cables

1. Wire Type and Sizes

All power and control wiring shall be provided in accordance with Section 16050. Instrument supply power conductors shall be minimum #12 AWG. Control signal conductors shall be minimum #14 AWG. Wire insulation colors shall be in accordance with Section 16050.
2. Cables

Shielded cables shall be minimum #16 AWG and shall be in accordance with Section 16050. Instrument transducers or sensors requiring special cable shall be provided by the instrument manufacturer and shall be factory connected to the device. Cable between the transducer or sensor and corresponding controller shall be provided with the device. ICS shall verify the length of cable required for each specific installation location. Cable shall be installed in a single run with no splices.

3. Wire Termination

Conductors from field instruments or components shall terminate in control panels, MCC sections, etc. at terminal blocks.

4. Wire Marking

All conductors and cables shall be marked at termination points with a marking system as specified in Section 16050.

2.03 FLOAT SWITCHES AND INTRINSICALLY SAFE RELAYS

A. Float switches shall be designed for operation in water and raw sewage and shall be hermetically sealed in high impact corrosion resistant polypropylene or polyurethane. Cable shall be minimum 16 gauge multi-strand polyvinylchloride (PVC) jacketed cable (oil and water resistant) suitable for underwater use and heavy flexing service. Float switches shall be rated minimum 4 A at 120 VAC. Each float switch shall be utilized for one operation. A single float switch shall not be used as example for pump start and stop.

B. Float switches shall be as manufactured by Flygt Corporation, Warrick Controls, Anchor Scientific Inc., Consolidated Electric Co., or equal.

C. Unless specified otherwise, each float switch shall be provided with an intrinsically safe relay complete with reduced voltage transformer and contacts. Intrinsically safe relays shall be specified for use in NEC, Class I, Division 1 (hazardous) locations, and shall be Factory Mutual or UL listed for explosion proof service. Intrinsically safe relays shall be as manufactured by Warrick (no substitutes).
2.04 PRESSURE GAUGES

A. Unless otherwise shown or specified, pressure gauges shall be weatherproof and provided with 4-1/2" dials, 1/4" or 1/2" threaded connections, and black phenolic resin, black Pocan, or epoxy coated aluminum cases with safety glass windows. Gauge socket and internal component materials shall be compatible with the process medium. As a minimum, gauge sockets and internal components (including bourdon tubes and tips, bellows, or diaphragms) shall be constructed of Type 316L stainless steel. Gauges shall be suitable for dry or liquid filled operation. Gauge accuracy shall be ±0.5% of span per ASTM B40.1, Grade 2A. Gauge range shall be selected for 150% of the working pressure or vacuum of the monitored medium. Gauge dials shall be provided with white backgrounds and black markings. Gauge units shall be applicable to the medium and pressure and/or vacuum range.

B. Pressure gauges shall be as manufactured by Ashcroft, Wika, Marsh Instruments, or equal.

2.05 DIAPHRAGM SEALS

A. General

Where shown on the Drawings or specified elsewhere, diaphragm seals shall be provided between the process medium and the pressure or vacuum sensing element (e.g. gauge, transmitter, or switch). Diaphragm seals shall be provided with upper and lower housings and diaphragms that are welded or clamped between the housings. Upper and lower housings shall be connected with bolts (4 minimum). Diaphragm seals shall be provided with 1/2" threaded female NPT process connections, 1/4" or 1/2" threaded instrument connections, and lower housings with 1/4" flushing connections. Unless otherwise shown on the Drawings, one (1) diaphragm seal shall be provided for each instrument for direct mounting.

Manufacturer shall be responsible for selecting the diaphragm seal based on each specific instrument assembly, including the diaphragm size, diaphragm material, diaphragm spring constant, assembly fill fluid medium, assembly fill fluid volume, and connection piping size (if not direct mounted) to maintain a minimum accuracy of ± 1% of full instrument range based on an ambient temperature range of 20°F to 120°F and exposure to direct sunlight. In addition, manufacturer shall be responsible for selecting diaphragm, bottom housing, and
gasket materials to be compatible with the process medium. As a minimum, diaphragm, lower housing, upper housing, and bolts shall be constructed of Type 316L stainless steel.

Diaphragm seals shall be as manufactured by Ashcroft, Wika, or equal.

B. **Water Service (Potable and Non-Potable)**

Diaphragms seals for water service shall be of all Type 316L stainless steel construction, including diaphragm, lower housing, upper housing, and hardware.

C. **Chlorine Service (Solution)**

Diaphragms seals for chlorine service shall be of all Hastelloy C-276 construction, including diaphragm, lower housing, upper housing, and hardware.

### 2.06 PRESSURE SWITCHES

A. Pressure switches shall utilize bourdon tubes, diaphragms, or bellows as the sensing/actuating element. Unless otherwise specified, the sensing/actuating element material shall be Type 316 stainless steel. The set point shall be readily field adjustable over the range specified. Switches shall have deadband adjustable up to a maximum of 100% of switch range. Pressure range shall be as indicated on the Drawings. Switches shall be SPDT, rated for 5 A at 240 VAC. Unless specified otherwise, switch enclosures shall be rated NEMA 4X. Switch pressure connection shall be 1/4” FNPT.

B. Pressure switches shall be Model 836 as manufactured by Allen Bradley (no substitutes).

### 2.07 DIFFERENTIAL PRESSURE SWITCHES

A. Differential pressure switches shall utilize bourdon tubes, diaphragms, or bellows as the sensing/actuating element. Unless otherwise specified, the sensing/actuating element material shall be stainless steel. The set point shall be readily field adjustable over the range specified. Switches shall have deadband adjustable up to a minimum of 50% of switch range. Repeatability shall be ±1% of range. Switch pressure range shall be as indicated on the Drawings. Switches shall be SPDT, rated for 10 A (minimum) at 240 VAC. Unless specified otherwise, switch enclosures shall be rated NEMA 4X. Switch pressure connections shall be 1/4” FNPT.

B. Differential pressure switches shall be as manufactured by Winters, Ashcroft, or equal.


2.08 PRESSURE TRANSMITTERS

A. Pressure transmitters shall be electronic two wire devices with the following features: adjustable span, zero and damping adjustments, integral indicator scaled in engineering units, solid state circuitry and 4-20 mA output. Accuracy shall be ±0.25% of span. Overrange capacity, without affecting calibration, shall not be less than 150% of maximum range. Process wetted materials shall be compatible with the process fluid, unless specified for installation with a diaphragm seal. Unless specified otherwise, process wetted materials shall be Type 316 stainless steel. Body material shall be Type 316 stainless steel. Transmitter process connection shall be 1/2" NPT. Fill fluid, unless otherwise specified, shall be silicone oil. Transmitter housing shall be epoxy coated low copper aluminum alloy and rated NEMA 4X, unless specified otherwise.

B. Unless specified for direct mounting, pressure transmitters shall be provided with mounting brackets and installation kits. Bracket shall be suitable for surface mounting, pipe mounting, or block and bleed valve manifold mounting. Mounting bracket wetted materials shall be shall be compatible with the process fluid, unless specified for installation with a diaphragm seal. Unless specified otherwise, mounting bracket wetted materials shall be constructed of Type 316 stainless steel. Mounting brackets, installation kits, and accessories shall be provided by the pressure transmitter manufacturer.

C. Pressure transmitters shall be as manufactured by Foxboro (no substitutes).

2.09 DIFFERENTIAL PRESSURE TRANSMITTERS

A. Differential pressure transmitters shall be electronic two wire devices with the following features: adjustable span, zero and damping adjustments, integral indicator scaled in engineering units, solid state circuitry and 4-20 mA output. Accuracy shall be ±0.25% of span. Over-range capacity, without affecting calibration, shall not be less than 150% of maximum range. Span shall be field adjustable over at least a 4 to 1 range. Process wetted materials shall be Type 316 stainless steel. Body material shall be Type 316 stainless steel. Process connections shall be 1/2" NPT. Fill fluid, unless otherwise specified, shall be silicone oil. Transmitter housing shall be epoxy coated low copper aluminum alloy and rated NEMA 4X, unless specified otherwise. A three (3) valve manifold shall be provided with the transmitter, unless indicated otherwise on the Drawings. Manifold wetted materials shall be Type 316 stainless steel.
B. Differential pressure transmitters shall be provided with mounting brackets and installation kits. Bracket shall be suitable for surface mounting, pipe mounting, or block and bleed valve manifold mounting. Mounting bracket wetted materials shall be shall be compatible with the process fluid, unless specified for installation with a diaphragm seal. Unless specified otherwise, mounting bracket wetted materials shall be constructed of Type 316 stainless steel. Mounting brackets, installation kits, and accessories shall be provided by the differential pressure transmitter manufacturer.

C. Pressure transmitters shall be as manufactured by Foxboro (no substitutes).

2.10 ULTRASONIC LIQUID LEVEL MEASUREMENT SYSTEM

A. General

Ultrasonic liquid level measurement systems shall consist of a microprocessor based electronic controller, a non-contacting transducer, and cable from transducer to controller. The electronic controller shall be capable of receiving, processing, and transmitting ultrasonic signals. All operating parameters shall be entered via the controller keypad. For liquid level, the controller shall, upon demand, display current head, temperature, and distance from transducer to liquid level.

The ultrasonic liquid level measurement system shall be Miltronics Multi Ranger Plus as manufactured by Siemens (no substitutes).

B. Service

The transducer shall be capable of submergence without degradation. Transducer shall function over an ambient temperature range of -40°F to 200°F, and shall be rated by FM and CSA for Class I and II hazardous environments. Controller shall function over an ambient temperature range of 15°F to 122°F.

C. Performance

The transducer shall transmit and receive an acoustic signal to accurately measure liquid level over a range of 0' to 30', unless specified otherwise. Point of zero reference shall be operator adjustable. The output signal shall be proportional to level from 0 to 100% with a resolution of ±0.1%. The transducer shall be provided with integral temperature sensor for speed-of-sound compensation. Unless specified otherwise, the transducer shall be the Echomax XPS Series with a 6° beam angle.
D. **Level Measurement Features**

1. Controller shall be provided with output indicating meter with four character LCD display programmable in engineering units of: feet, inches, or percent of span.

2. Interconnecting Cable: Cable between transducer and controller shall be supplied with unit, and shall be suitable for a maximum system length of 1,000'. Contractor shall verify length of cable required for each specific installation. Cable shall be installed in a single run with no splices.

3. Discrete Outputs: Controller shall provide up to five discrete outputs, each adjustable over entire scale range.

4. Alarms: Alarms shall be programmable for level, rate of change of level, differential level, or loss of echo.

5. Alarm Messages: Loss of echo and cable circuit open or shorted.

E. **Controller Interface**

1. Controller Output: 4-20 mA DC output, current isolated, into a maximum of 600 ohms (return to ground).

2. Power Supply: Unit shall operate on 120-Volt, 60 Hz power, unless specified otherwise.

3. Discrete Outputs: Form "C" SPDT relays, 5 amps (continuous), non-inductive, 250 VAC.

4. Controller shall be provided with necessary output functions and communication interfaces to enable implementation of control and monitoring operations as specified in other equipment sections of these Specifications, and/or shown on the Drawings.

F. **Controller Enclosure**

1. Controller enclosure shall be rated NEMA 4.

2. Indoor controllers shall be wall mounted or panel mounted. Where controller is specified to be panel mounted, it shall be flush mounted in the panel door. ICS shall provide all brackets, supports, bezels, etc. necessary for flush panel mounting.
3. Outdoor controllers shall be provided with stainless steel, sheet metal sun shields (20 gauge, minimum). Sun shields shall be open at the front and bottom, and shall be of sufficient size to allow access to controller for operation and maintenance. Free edges shall be rolled. Sun shields shall be constructed without sharp edges and corners.

2.11 SUBMERSIBLE LIQUID LEVEL MEASUREMENT SYSTEM

A. General

The submersible liquid level measurement system shall continuously monitor the liquid level in a groundwater well, tank, or wet well. The measurement system shall be of the submersible level pressure type. As a minimum, the measurement system shall consist of a submersible pressure sensor, cable, and accessories, as specified herein. Unless indicated otherwise on the Drawings, the system power supply and display unit shall be the RTU or MCP identified to receive the analog level signal. The power supply shall be 24 VDC normal (9 to 28 VDC operation range).

The submersible liquid level measurement system shall be Model PTX 1830 as manufactured by Druck, Inc. (GE Sensing).

B. Sensor and Cable

1. The sensor shall be an all-titanium device that accurately measures depth or level in a well, tank, or body of fluid. A micro-machined silicon measuring element shall be sealed within a titanium pressure module assembly and shall be fully isolated from the pressure media. The pressure module assembly shall be contained in a slimline, welded titanium body and terminated with an injection molded cable assembly.

2. The molded cable shall be a two-conductor cable with aluminum-mylar shield, Kevlar strain cord, nylon vent tube, and polyurethane jacket. The integral cable vent tube shall reference the sensor to atmospheric pressure. The molded polyurethane cable along with the internal potting in the sensor transmitter shall be constructed to prevent the ingress of water into the cable and back of the sensor transmitter for indefinite immersion in a pressure of 1,000 psi.

3. The cable jacket material shall be impervious to water and chemicals normally found in groundwater, surface water, and wastewater.
4. Cable lengths shall be available in 1 ft. increments up to a maximum of 1,600 ft. ICS shall determine the required cable length for each specific installation location.

5. The sensor transmitter shall be a 4-20 mA, two-wire, loop powered device. The sensor accuracy shall be ±0.1% of full scale. Long term stability shall be ±0.1% of full scale per year. The sensor shall be suitable for operating temperatures ranging from -4 to 140°F, and sensor output shall be temperature compensated from 30 to 86°F.

6. The sensor operating pressure range shall be as indicated on the Drawings, or specified in the Special Conditions. The sensor shall be capable of being over-pressurized to 400% of the operating full scale pressure (to a maximum of 2,000 psig) with negligible effect on calibration.

7. The sensor shall be rated by FM for use in NEC Class I, Division 1, Groups A through D hazardous environments.

C. Accessories

Unless specified otherwise, each submersible liquid level measurement system shall be provided with the following accessories:

1. A sensor termination enclosure with the following components:
   a. DIN rail mounted terminal blocks for termination of sensor cable conductors and conductors from 4-20 ma shielded cable to signal termination point.
   b. Gore-Tex micro-filter designed to prevent the ingress of water into the enclosure.
   c. Desiccant module with sight gage for determining desiccant change intervals.
   d. PVC base and clear polycarbonate cover. Enclosure shall be rated NEMA 4X.
   e. 2-inch pipe mounting kit.

2. A cable clamp designed to hold cable by distributing the clamping force over an 8-inch long section of cable jacket.
General Instrumentation & Control Components
Section 17005 – 21

3. A sensor slimline sink weight.

4. A direct calibration adaptor.

5. Spare desiccant modules (5 total) in sealed containers.

D. Lightning Surge Arrestor

Where Drawings show installation of a submersible sensor in a surface water location, the sensor shall be provided with an integral lightning surge arrestor assembly certified to IEC Standard 61000-4-5 (Level 4). Contractor shall provide a separate ground rod assembly for the surge arrestor. The resistance of the ground rod assembly shall be less than 100 ohms. A minimum #12 AWG ground conductor shall be provided from the lightning arrestor to the ground rod and shall interconnect with the drain-wire on the sensor cable.

E. Intrinsically Safe Barriers

Where Drawings show installation of a submersible sensor in a wastewater location classified as hazardous by the NEC, the sensor shall be provided with the appropriate intrinsically safe barriers.

2.12 CONDUCTANCE LIQUID LEVEL MEASUREMENT SYSTEM

A. General

Each conductance liquid level measurement system shall consist of level sensors, connection fitting, and relays as shown on the Drawings and specified herein. Contractor shall furnish and install all material and appurtenances as necessary to provide a complete liquid level measurement system.

Conductance liquid level measurement system shall be as manufactured by Warrick Controls Inc., Gems Sensors Inc., or equal.

B. Level Sensors

Level sensors shall be conductance type, utilizing electrodes and the conductivity of the process fluid itself to measure level. The system shall be equipped with multiple level sensing electrodes and one ground electrode. The number and lengths of level sensing electrodes shall be as shown on the Drawings. Unless specified otherwise, the electrodes shall be constructed of Type 316 stainless steel and shall be provided with PVC heat shrink sheathings.
C. **Connection Fitting**

Each connection fitting shall be pressure-tight, and suitable for connection to the flanged top outlet of a pressure vessel. Connection fitting shall be provided with an integral epoxy coated aluminum terminal housing and Type 316 stainless steel electrode couplings. The number of electrode couplings shall accommodate the number of level-sensing electrodes shown on the Drawings and required grounding electrode. Connection fitting flange shall be rated for a pressure that is equal to or greater than the pressure vessel rating. As a minimum, the connection fitting flange shall be rated for a working pressure of 230 psig at 100°F. The connection fitting flange shall be constructed of Type 316 stainless steel or 1018 carbon steel. Contractor shall coordinate the size of the pressure vessel top outlet flange with the connection fitting flange provided by the level measurement system manufacturer.

D. **Relays**

Liquid level measurement system relays shall be solid-state, plug-in modules suitable for 11-pin octal sockets. Relays shall be general purpose, single level or differential service, with DPDT dry contacts rated for 5A (minimum) at 120 VAC. Relays shall be suitable for operation on 120 VAC primary voltage with 12 VAC secondary voltage.

### 2.13 CONDUCTIVITY MEASUREMENT SYSTEM

A. **General**

The conductivity measurement system shall continuously measure conductivity in aqueous solutions. The measurement system shall be sense, transmit and display/control liquid conductance, expressed in microSiemens/centimeter (mS/cm). Conductivity measurement system shall include: sensor, sensor mounting assembly, controller, junction box, interconnecting cables, cable plugs, and all appurtenances necessary to provide a complete and operable measurement system. Sensor material and mounting assembly material shall be compatible with measured liquid. The ICS shall confirm material compatibility with the measured liquid and shall confirm the pressure and temperature ratings of all components with the maximum operating conditions.

Conductivity measurement system shall be the Hach 3700-SC Electrodeless Conductivity System as manufactured by Hach Company (no substitutes).
B. **Conductivity Sensor**

Conductivity sensor shall be inductive electrodeless type. The conductivity sensor shall have a built-in Pt 1000 RTD temperature compensator. The sensor shall be water resistant. Sensor wetted materials shall be available in polypropylene, PVDF, PEEK, or PFA Teflon. Unless specified otherwise, sensor wetted materials shall be PFA Teflon. The sensor shall be rated for a maximum pressure of 200 psi and a maximum temperature of 200°C. The sensor shall be equipped with an integral 5 conductor cable. Unless specified otherwise, the cable shall be provided with a Teflon coated jacket rated for 200°C.

C. **Sensor Mounting Assembly**

Sensor shall be convertible style with 3/4-inch NPT end connection suitable for immersion mounting, union mounting, or insertion mounting, as indicated on the Drawings and as specified below:

1. Immersion mounting – sensor shall be directly fastened on the end of a CPVC pipe (1/2-inch diameter by 4-foot long) with 1/2 x 3/4-inch NPT coupling and plastic pipe-mount junction box with terminal strip.

2. Union mounting – sensor shall be fastened to a union adapter for mounting into a standard 2-inch NPT pipe tee. Unless specified otherwise, union and pipe tee shall be construction of Type 316 stainless steel and shall be rated for a maximum pressure of 200 psi and a maximum temperature of 60°C.

3. Insertion mounting – sensor shall be fastened into a 2-inch ball valve assembly for mounting into a standard 2-inch NPT pipe tee. Unless specified otherwise, ball valve assembly and pipe tee shall be construction of Type 316 stainless steel and shall be rated for a maximum pressure of 80 psi and a maximum temperature of 95°C.

Mounting assembly hardware shall be provided by the sensor manufacturer.

D. **Controller**

1. The conductivity controller shall be a programmable microprocessor based electronic device with full input/output signal isolation. The controller shall be correctly matched to the conductivity sensor. Unless specified otherwise, controller shall be configured to operate two (2) digital sensor inputs.

2. Controller display shall be graphic dot matrix LCD with LED backlighting.
3. The controller shall be provided with the following features: two (2) conductivity analog output signals (4-20 mA) capable of transmission into a maximum impedance of 500 ohms; four (4) user configurable SPDT relays (Form C) rated 5A to 230 VAC and 30 VDC resistive maximum; and 25W sensor/network card with Modbus RS232/RS485 network connection.

4. Conductivity measurement range shall be 0.5 to 10,000 mS/cm, 0 to 99.99 % concentration, and 0 to 9999 ppm total dissolved solids. Repeatability shall be ±2% of full span. Operating temperature range shall be -20 to 60°C.

5. Unless specified otherwise, power supply to controller shall be 120 VAC, 60 Hz.

6. Controller enclosure shall be rated NEMA 4X, and shall be suitable for panel or surface mounting as indicated on the Drawings.

7. Unless specified otherwise, controller shall be Hach SC200 Model LXV404.99.00552 as manufactured by Hach Company (no substitutes).

E. Accessories

Each conductivity measurement system shall be provided with all accessories and components necessary for a complete and operational system. As a minimum, each conductivity measurement system shall be provided with the following accessories:

1. Digital gateway designed to provide a digital interface between the conductivity sensor and controller. Unless specified otherwise, each digital gateway shall be provided with a mounting clip, NEMA 4X FRP junction box with back panel (sized for housing digital gateway), and cord fittings for sensor cable and digital extension cable.

2. Digital extension cable with end connectors for connection to digital gateway and controller. The ICS shall determine the required cable length for each specific installation location.

A digital termination box shall be provided when the distance between the digital gateway and controller exceeds 100 meters.
2.14 ANCILLARY MATERIALS AND COMPONENTS

A. **Pipe and Fittings**

Unless indicated otherwise on the Drawings, all pressure gauges, pressure switches, and pressure transmitters shall be connected to process piping with Class 150 threaded fittings, Schedule 40 pipe nipples, and isolation ball valve. Unless specified otherwise, all fittings, pipe nipples, and ball valves shall be constructed of Type 316 stainless steel.

B. **Block and Bleed Valve Manifolds**

Where indicated on the Drawings, pressure transmitters and differential pressure transmitters shall be provided with block and bleed valve manifolds capable of isolating process sensing lines, venting to atmosphere, and connection of test equipment for instrument calibration. Block and bleed valve manifolds shall be 3-valve or 5-valve, as indicated on the Drawings. All wetted materials shall be compatible with the process fluid. Unless specified otherwise, valves shall be constructed of Type 316 stainless steel. Block and bleed valve manifolds shall be as manufactured by Foxboro, Anderson Greenwood, or equal.

Unless indicated otherwise on the Drawings, block and bleed valve manifolds shall be provided with mounting kits for mounting the manifold and pressure transmitter assembly to a 2” diameter Schedule 40 hot dipped galvanized pipe stanchion.

C. **Protective Coatings**

All metallic enclosures, except stainless steel, shall be provided with a corrosion resistant factory coating, fusion bonded epoxy or equivalent coating system.

D. **Fasteners**

Unless indicated otherwise on the Drawings, equipment and appurtenances shall be securely mounted to walls and floors using Type 316 stainless steel wedge anchors or epoxy anchors for masonry and concrete structures, and Type 316 stainless steel machine bolts and lag screws for metal and wood structures (respectively).
PART 3 - EXECUTION

3.01 GENERAL

A. It is the general intent of these Specifications that installation of all instrumentation and control equipment; and supply and installation of all field wiring, conduit, and wiring external to the motor control centers, control panels and electrical equipment shall be performed by the Electrical Subcontractor. The ICS shall furnish all instrumentation and control equipment specified herein and supervise installation by the Electrical Subcontractor. In addition, the ICS shall coordinate design of controls within motor control center(s), control panels and electrical equipment, and ensure compatibility of design with equipment and equipment systems.

B. The ICS's attention is directed to the electrical and mechanical details of this project. Referral to these portions of the Contract Documents shall be required in order to understand the full intent and scope of work required.

3.02 INSTALLATION

A. General

1. All instrumentation and control equipment shall be installed in accordance with the manufacturer’s written instructions, NEC standards, requirements and standards specified herein, and as shown on the Drawings.

2. Wiring between process instruments and remote mounted signal converters/controllers shall conform to the manufacturer’s recommended cable type and procedures.

3. All instrumentation and control equipment shall be grounded per manufacturer's requirements. Contractor shall coordinate grounding between process instruments and remote mounted signal converters/controllers, and electrical ground system to ensure compliance with the manufacturer's recommended grounding procedures.

4. Minimum process connection size for pressure gauges, switches, and transmitters shall be 1/2" NPT. Provide threaded reducers and 1/4" diameter nipples to transition from 1/2" diameter process connection appurtenances to 1/4" device pressure connections.
5. Unless indicated otherwise on the Drawings, all pressure gauges, pressure switches, and pressure transmitters shall be connected to process piping with Class 150 threaded fittings, Schedule 40 pipe nipples, and isolation ball valve. Unless specified otherwise, all fittings, pipe nipples, and ball valves shall be constructed of Type 316 stainless steel.

B. **Pressure Gauges**

1. Pressure gauges shall be liquid filled (fill fluid as selected by manufacturer), except where diaphragm seals are specified.

2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and isolation ball valves shall be constructed of the same material as the diaphragm seal lower housing.

C. **Pressure Switches**

1. Pressure switches shall be provided with Type 316 stainless steel pulsation dampeners, except where diaphragm seals are specified.

2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and isolation ball valves shall be constructed of the same material as the diaphragm seal lower housing.

D. **Pressure Transmitters**

1. Direct connected pressure transmitters shall be provided with Type 316 stainless steel pulsation dampeners, except where diaphragm seals or block and bleed valve manifolds are specified.

2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and isolation ball valves shall be constructed of the same material as the diaphragm seal lower housing.

3. Bracket mounted pressure transmitters and bracket mounted pressure transmitters with block and bleed valve manifolds shall be mounted to 2” diameter Schedule 40 hot dipped galvanized pipe stanchions with stainless steel U-bolts. Each stanchion shall be provided with 3/8” thick steel base plate and four 3/8” diameter anchor bolts for floor mounting.
E. **Differential Pressure Transmitters**

1. Where indicated on the Drawings, differential pressure transmitters shall be provided with block and bleed valve manifolds. Block and bleed valve manifolds shall be in furnished accordance with the requirements specified herein.

2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and appurtenances shall be constructed of the same material as the diaphragm seal lower housing.

3. Unless indicated otherwise on the Drawings, differential pressure transmitter brackets or manifolds shall be mounted to 2” diameter Schedule 40 hot dipped galvanized pipe stanchions with stainless steel U-bolts. Each stanchion shall be provided with 3/8” thick steel base plate and four 3/8” diameter anchor bolts for floor mounting.

4. Connections from process piping to differential pressure transmitter brackets or block and bleed valve manifolds shall be Schedule 40 piping as specified herein, or Type 316 stainless steel tubing (0.035” wall thickness) with compression (Swagelok) fittings.

F. **Float Switches**

1. Unless indicated otherwise on the Drawings, float switches shall be provided with stainless steel clamps and appurtenances suitable for mounting switches to a vertical 3/4-inch pipe.

2. Vertical pipe shall be accessible by District personnel without entering the structure and shall be capable of being easily removed for float cleaning and adjustment.

3.03 **FIELD QUALITY CONTROL**

A. **Manufacturer's Engineering Representative**

The services of manufacturer's engineering representative especially trained and experienced in the installation of the equipment shall be provided to supervise the installation, be present when the instruments and equipment are first put into operation, and inspect, check, adjust as necessary, and calibrate the instruments. All costs for representative's services shall be included in the Contract Price.
B. **Calibration**

1. Unless specified otherwise, each field instrument shall be calibrated after installation, in conformance with the requirements specified herein and the instrument manufacturer's instructions. Those components having adjustable features shall be set for the specific conditions and applications of the project, and shall be within the specified limits of accuracy.

2. Each field instrument shall be calibrated at 0%, 25%, 50%, 75%, and 100% of span using test instruments to simulate inputs and read outputs that are rated to an accuracy of at least 5 times greater than the specified accuracy of the instrument being calibrated. Test instruments shall have accuracies traceable to the National Institute of Standards and Technology (NIST).

3. A calibration sheet shall be prepared for each instrument recording all calibration readings, including the readings as finally adjusted within the specified tolerances. Contractor shall submit a written report to the District on each instrument. The report shall include the field calibration sheet for each instrument, and associated manufacturer’s standard calibration sheet (if applicable).

4. Elements and equipment which cannot achieve proper calibration or accuracy, either individually or within a system, shall be replaced.

C. **Certify Proper Installation**

After all installation and connection work has been completed, the ICS and manufacturer’s representative shall check it all for correctness, verifying polarity of electric power and signal connections, making sure all process connections are free of leaks, and all other similar details. The ICS and manufacturer's representative shall certify in writing that for each loop or system checked out, that equipment is properly installed, setup, calibrated, and is ready for operation. Refer to Part 1.08C herein for ICS Certification.
3.04 FIELD TESTING

A. Operational Demonstration Testing

Contractor shall demonstrate that the performance of installed instrumentation and control equipment and materials complies with specified requirements. Equipment shall be operated through its full range for not less than 2 hours unless a longer period is specified elsewhere. Immediately correct defects and malfunctions with approved methods and materials in each case, and repeat the demonstration. Operational demonstration testing shall conform to the approved startup, initial operation and demonstration testing plan.

B. Field Operation Tests

Unless specified otherwise, test all instrumentation and control systems for not less than 24 hours, with no interruptions except for normal maintenance. Field operation tests shall conform to the approved test plan.

1. Testing Materials and Equipment

Contractor shall furnish all labor, equipment, and materials for required tests, including all test instruments, recorders, gauges, chemicals, power, etc.

2. Testing Methods

Contractor shall perform field tests on equipment as specified in the Special Conditions and/or Detailed Provisions for the specific equipment. Unless specified otherwise, operate systems continuously for a minimum of 24 hours. Cause equipment to cycle through the applicable range of operation at a steady rate of change. Induce simulated alarm and distressed operating conditions, and test controls and protective devices for correct operation in adjusting system functions or causing system shutdown.

3. Defects

Contractor shall immediately correct all defects and malfunctions disclosed by tests. Contractor shall use new parts and materials as required to perform corrective work, as approved by the District. The specified total test period shall be extended by the interruption time for corrective work.
4. **Test Records**

Contractor shall continuously record all function and operation parameters during the entire test period. Contractor shall submit complete, well organized, and clearly labeled test data to the District for review and approval.

### 3.05 INSTRUCTION

District's personnel shall be instructed in the functions and operation of each system and shall be shown the various adjustable and set point features which may require re-adjustment, resetting or checking, re-calibration, or maintenance by them from time to time. Instruction shall include interactions of the systems, operations, shutdowns, alarms, failure, and controls. This instruction shall be scheduled at a time arranged with the District at least two (2) weeks in advance. Instruction shall be classroom type for a minimum of four (4) hours, or as specified by the Special Conditions. Instruction shall be given by the ICS and other qualified persons who have been made familiar in advance with the systems in this Facility.

**END OF SECTION 17005**
SPECIFICATIONS - DETAILED PROVISIONS
Section 17010 - Programmable Logic Controller

CONTENTS

PART 1 - GENERAL ................................................................................................................... 1
  1.01 DESCRIPTION .............................................................................................................. 1
  1.02 RELATED SECTIONS ................................................................................................. 1
  1.03 REFERENCE STANDARDS AND CODES ................................................................. 2
  1.04 DEFINITIONS ............................................................................................................... 2
  1.05 SUBMITTALS ............................................................................................................... 3
  1.06 DESIGN REQUIREMENTS ......................................................................................... 8
  1.07 INSTALLED-SPARE REQUIREMENTS ................................................................... 13
  1.08 SPARE PARTS ......................................................................................................... 13
  1.09 MANUFACTURER SERVICES AND COORDINATION ........................................... 14
  1.10 QUALITY ASSURANCE ......................................................................................... 15

PART 2 - PRODUCTS AND MATERIALS ................................................................................. 15
  2.01 PLC CAPABILITIES AND PERFORMANCE .............................................................. 15
  2.02 PLC SOFTWARE REQUIREMENTS ....................................................................... 16
  2.03 PLC HARDWARE .................................................................................................... 19
  2.04 HUMAN-MACHINE INTERFACE (HMI) ................................................................. 25
  2.05 PLC ENCLOSURE AND APPURTEANCES ............................................................. 26
  2.06 INTERPOSING RELAY SUBASSEMBLIES ............................................................... 27
  2.07 WIRING .................................................................................................................. 28

PART 3 – EXECUTION ............................................................................................................. 28
  3.01 FABRICATION .......................................................................................................... 28
  3.02 INSTALLATION ......................................................................................................... 29
  3.03 FIELD QUALITY CONTROL .................................................................................. 30
  3.04 FIELD TESTING ....................................................................................................... 30
  3.05 TRAINING ................................................................................................................ 31
PART 1 - GENERAL

1.01 DESCRIPTION

A. This section specifies the requirements for a programmable logic controller (PLC) provided to monitor and control process conditions for an equipment system, including packaged equipment systems. The PLC shall be supplied by the Instrumentation and Control Subcontractor (ICS) or the manufacturer of the packaged equipment system. The requirements of the individual equipment system are equally applicable to the work specified herein. Where conflict exists, the individual equipment system sections shall take precedence.

B. The equipment system PLC shall interface with the Plant and/or District Supervisory Control and Data Acquisition (SCADA) system, and shall include all components required for a complete, fully functional and operable process monitoring and control system.

C. The PLC shall include all required enclosures, chassis, power supplies, central processing units, input/output (I/O) systems, communication systems, interfaces, instruments, devices, wiring, and terminations, as specified herein and as shown on the Drawings.

D. PLC components specified herein shall be provided, as well as any ancillary or incidental equipment or devices, whether identified or not, that are required to support the monitoring and control of the equipment system and permit full use of the process equipment’s capabilities.

1.02 RELATED SECTIONS

A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.

B. Related Specification Sections include, but are not limited to, the following:

1. Sections of the Specifications specifying equipment systems controlled by PLCs.
1.03 REFERENCE STANDARDS AND CODES

All materials and equipment specified herein, including installation of same, shall conform to or exceed the applicable requirements of the following standards and codes (latest edition) to the extent that the provisions thereof are not in conflict with other provisions of these Specifications.

A. International Society of Automation (ISA)
   1. ISA S5.1 – Instrumentation Symbols and Identification
   2. ISA S5.3 – Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems
   3. ISA S5.4 – Instrument Loop Diagrams

B. National Electrical Manufacturers Association (NEMA)
   1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
   2. NEMA ICS 6 – Industrial Control and Systems: Enclosures

C. National Fire Protection Agency (NFPA)
   1. NFPA 70 - National Electrical Code (NEC)
   2. NFPA 79 – Electrical Standard for Industrial Machinery

D. Underwriters Laboratories (UL)
   1. UL 508A – Standard for Industrial Control Panels
   2. UL 698A – Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations

1.04 DEFINITIONS

The following definitions are used throughout this Section:

A. AI: Analog Input
B. AO: Analog Output
C. CPU: Central Processing Unit
D. DI: Digital Input
E. DO: Digital Output
F. EEPROM: Electrically erasable programmable read-only memory
G. HMI: Human-Machine Interface
H. I/O: Input and/or Output
I. LAN: Local Area Network
J. Peer to Peer: Communication between two or more devices, typically PLCs, in which each device can control the data exchange.
K. PID: Control action, proportional plus integral plus derivative.
L. PLC: Programmable Logic Controller
M. RAM: Random Access Memory
N. Remote I/O: Any and all I/O that is located remotely from the processor.
O. SCADA: Supervisory Control and Data Acquisition
P. TCP/IP: Transmission Control Protocol and Internet Protocol
Q. UPS: Uninterruptible Power Supply

1.05 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.
A. **Shop Drawings**

Contractor shall prepare and submit complete and organized information, technical data, and drawings for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11” x 17” for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Detailed Bill of Materials for all PLC panel hardware, and associated materials and components, listing: manufacturer's name, quantity, description, size, and catalog/part number.

2. Complete documentation for all PLC panel hardware and associated components (i.e. PLC chassis backplane, CPU, power supply, I/O modules, communication modules, HMI, UPS, enclosure, relays, terminal blocks, etc.), including: manufacturer's product literature, specifications, performance capabilities, features and accessories, dimensions and weights, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer's literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.

3. PLC block diagram showing all PLC components, HMI, and all communication interfaces, including Ethernet and serial communications to all equipment, devices, and SCADA.

4. PLC control logic documentation in hard copy format, including a logic diagram and a control strategy in written, well organized sections using easy to understand narrative text explaining all input and output parameters, and all monitoring, control, and alarming functions. Provide a list of all addresses referenced in the logic diagram with a description of data associated with each address.

5. Complete PLC I/O lists with I/O description, tags, addresses, and field terminal numbers.

6. Where applicable, provide addressing for all communication network nodes using an Ethernet network connection. Coordinate Ethernet TCP/IP addressing with the District.

7. Hard copy documentation for HMI screens, including color prints of all proposed screen displays, written descriptions for each screen display parameter and input function.
8. PLC panel hardware arrangement drawings (plan view, and interior and exterior elevation views) with all hardware and components clearly shown, dimensioned, and labeled. Drawings shall show the equipment assembly, space requirements, clearances, and locations for conduits and anchor bolts.

9. Nameplate data including the nameplate material, heights of letter and inscriptions.

10. Control ladder diagrams for all hard wired control, protection, and monitoring circuits. Ladder diagrams shall show all switches, lights, pushbuttons, relays, etc., and shall be labeled with all associated wiring and termination numbers.

11. PLC panel wiring schematics. Wiring schematics shall show all interconnections between power sources, PLC, HMI, and all panel devices and components, and shall show all wiring numbers and termination numbers.

12. Loop diagrams for each monitoring and/or control loop. The loop diagrams shall show all components of the loop: analog and discrete I/O with reference to each PLC module I/O point, field instruments and components, and local switches, relays, signal isolators, etc., which are being provided for proper monitoring, control and operation. Loop diagrams shall be provided for all PLC I/O and all control system components, including those components specified in other Sections of these Specifications and/or shown on the Drawings. Loop diagrams shall be prepared according to ISA-S5.4 format, and shall also include the following:

   a. All interconnecting wiring between equipment, field instruments and devices, local control panels (if applicable), and PLC panel. Show all panel terminal block identification numbers and all wire numbers. Show all intermediate terminations between field elements and panels.

   b. The location of all equipment, instruments, and devices.

   c. The instrument/device description, including type, manufacturer, model number, range, set points, and operation (e.g. fail open, open on energization, normally closed, etc.) as applicable.

   d. The instrument/device loop power requirements back to the termination on the terminal block, fuse block (including fuse size), etc., as applicable.
e. All grounding points within panels and cabinets, and identify the connection point of individual components.

f. Each diagram with an instrument shall include a summary table with output capability of each transmitting instrument, input impedance of each receiving instrument, estimate of loop wiring impedance based on wire size and approximate length, total loop impedance, and reserve output capacity.

13. Spare parts list as specified in this Section.

14. Test procedures for factory testing and field testing required by Section 16950.

B. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all PLC equipment and components specified herein. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Specification Section 01430, and as specified herein.

The O&M Manual shall include, but not be limited to, the following:

1. PLC Performance Data and Drawings
   a. Detailed Bill of Materials for all PLC equipment and components, listing: manufacturer's name, quantity, description, size, range, and model/part number.
   b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, and illustrations.
   c. Manufacturer's data and drawings showing dimensions, physical configurations, installation and mounting details, and wiring schematics.
   d. Control ladder diagrams for all hard wired control, protection, and monitoring circuits. PLC panel wiring schematics. Loop diagrams for each monitoring and/or control loop.

2. PLC Installation and Operation Requirements
   a. Complete, detailed installation and operation instructions for all PLC equipment and components.
3. PLC Programming Software and Licenses
   
a. Complete and detailed user manuals for all PLC and HMI programming software packages.

b. Software licenses issued to the District for all programming software packages. Software licenses originally assigned to others and transferred to the District will not be acceptable. Unless specified otherwise, two (2) complete licenses shall be provided for programming software packages for use on general purpose laptop computers with Windows 10 (or latest) operating systems.

c. A hardcopy printout and CD of all PLC and HMI programming and configuration files.

4. PLC Service and Maintenance Data
   
a. Service and maintenance data shall include all information and instructions required by District's personnel to keep the PLC and all associated components functioning properly under the full range of operating conditions.

b. Explanation with illustrations as necessary for each service and maintenance task.

c. Recommended schedule of service and maintenance tasks.

d. Troubleshooting instructions.

e. List of maintenance tools and equipment.

f. Recommended spare parts list.

g. Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

5. Manufacturer Warranties
C. Final O&M Manual

Upon successful completion of startup and initial operation, Contractor shall submit a Final O&M Manual in accordance with the requirements of the District’s General Conditions, Specification Section 01430, and as specified herein. In addition to the O&M Manual requirements specified above, the Final O&M Manual shall be supplemented with the following:

1. As-built drawings (including all field changes) for all wiring and loop diagrams shall be incorporated into the Final O&M Manuals.

2. A hardcopy printout and CD of all final PLC and HMI programming and configuration files (including all field changes).

1.06 DESIGN REQUIREMENTS

A. Environmental

The PLC, including all associated components, shall be of industrial grade capable of operating continuously and satisfactorily in harsh environments. The PLC shall meet or exceed the following environmental requirements:

1. Operating temperature: 0 to 55°C (+32 to +131°F)

2. Storage temperature: -25 to 70°C (-13 to 158°F)

3. Relative humidity: 30 to 95% non-condensing

4. Altitude: 0 to 6,500 feet

5. Degree of protection: NEMA 4X

6. Shock resistance: 147m/s² for 11ms

7. Vibration resistance shall be in compliance with IEC 60068 and 61131.

The complete PLC shall be guaranteed to operate satisfactorily within the specified NEMA rated enclosure in ambient temperatures ranging from +32 to +110°F.
B. General Functions

As a minimum, the PLC system shall be designed to perform the following functions:

1. Provide fully automated control of equipment system operation, including monitoring process conditions, providing control feedback, optimizing process performance, and interfacing with other Plant PLCs and/or the District SCADA system, as shown on the Drawings and as specified in individual equipment system sections and herein.

2. Where specified, provide manual override of the automated controls via the HMI. Unless specified otherwise, critical system monitoring, alarm, and safety shutdown functions shall remain in effect.

3. Unless specified otherwise, hold all system alarms locally until manually reset from the PLC HMI or from the SCADA system.

4. Communicate with the SCADA system, which shall provide supervisory control of the equipment system operation via an Ethernet communication link.

5. Provide control capabilities to restart the equipment system, including associated equipment, as required after a Plant shutdown or power failure in coordination with and as commanded by the SCADA system.

C. General Performance Capabilities and Features

As a minimum, the PLC system shall be provided with the following performance capabilities and features:

1. The PLC shall be capable of handling analog inputs/outputs (4-20ma); and discrete inputs/outputs (contact closures, pulses; momentary or latch operation) in addition to power monitoring.

2. Input/output modules shall be furnished to accommodate all process monitoring and control specified in the equipment system specifications and shown on the Drawings plus any additional modules not shown, but essential to controlling and monitoring the system, providing a complete and final product.
3. All control programs shall reside in the PLC. All monitoring and control functions specified in the equipment system specifications and control loops/logic diagrams shown on the Drawings, and any additional controls necessary for operation of the system, shall be supplied and implemented by the equipment system manufacturer.

4. The PLC shall incorporate pre-programmed self-diagnostic software routines for maintenance.

5. The PLC shall incorporate a watchdog function to monitor: internal CPU failure, CPU memory failure, loss of communication between CPU and I/O modules, and CPU failure to execute logic program.

6. Unless specified otherwise, activation of alarms and stopping of equipment shall result from de-energization of control circuits, rather than energization of control circuits.

7. Unless specified otherwise, PLC failure mode shall be designed such that the loss of PLC supply power or output control signals to the equipment shall result in the equipment shutting down or operating in a predetermined safe mode.

8. PLC logic system failure shall not preclude proper operator intervention.

9. Unless specified otherwise, safety shutdown of equipment or equipment system shall require manual operator intervention via PLC HMI prior to reestablishing operation of the equipment or system.

10. Internal PLC system status and faults shall be monitored and displayed on the HMI. As a minimum, monitored items shall include:

   a. Power-up diagnostic (self-test) - passed/failed.
   b. Memory - OK/loss of memory.
   c. CPU - OK/fault
   d. Program run status – OK/fault
   e. Scan time - OK/overrun.
   f. Battery status – OK/low

   As a minimum, each monitored item shall be displayed on the HMI on a single PLC system status screen.
11. PLC and HMI programming and configuration shall incorporate the following general strategies and functions:

a. All calculations, analog value trip points, timers, etc. shall be accomplished in the PLC and not in the HMI.

b. All analog inputs to the PLC shall be configured in the HMI software for historical trending.

c. All set points for minimum and maximum values of analog outputs shall be operator adjustable via the HMI software.

d. All set points for minimum and maximum values of analog inputs for process monitoring/control shall be operator adjustable via the HMI software.

e. All open/close automatic valves and remote start/stop motors controlled by the PLC system shall have an adjustable maximum time value allowed to either open/close or start/stop. Failure to achieve the control function within this maximum time value shall result in a time out alarm for each piece of equipment. An alarm shall be generated from the PLC to the HMI for indication of the control function time out failure (e.g. Pump XXX Fail to Start, Valve XXX Fail to Open).

f. The status of all alarms shall be latched until manually acknowledged via the HMI.

g. HMI entries by the operator, such as set points and operation modes, shall be displayed on the process screens for information.

12. Prevent unauthorized access to PLC and HMI programs and configurations with password-based security in the PLC and HMI software.

13. The PLC system shall be designed with high noise immunity to prevent occurrence of false logic signals resulting from switching transients, relay and circuit breaker noise, or conducted and radiated radio frequency interference. Incorporate noise suppression and inductive load suppression design into PLC input, output, and logic modules.

14. At a minimum, the PLC system shall be capable of using Ethernet/IP, Modbus, and OPC as communication protocols to communicate with other PLCs on the network and Plant SCADA or District SCADA, as applicable.
15. All PLC components such as PLC power supply, I/O modules, CPU, communication modules, backplane, wiring harnesses, etc. shall be provided with conformal coatings for protection against moisture and chemical contaminants.

16. All PLC component connections shall be screw-in type. Plug-in type connections will not be acceptable. All terminal blocks shall be screw-in type and shall provide a location for identifying associated terminal numbers.

17. Independent line fuses or circuit breakers shall be provided, per the manufacturer’s recommendation, for each power supply, input module, output module, and other modules with separately derived power requirements.

18. All communication signals and 4-20 mA signals shall be properly conditioned for the PLC and protected from all sources of radiated energy or harmonics.

D. Appurtenances

1. The PLC processor, I/O modules, power supplies, and communication modules shall be provided as a complete system, as specified in the equipment system specification section and herein, and as shown on the Drawings. The PLC shall include all necessary components and hardware for a complete and fully functional system.

2. All special chassis or panel mounted power supplies, special interconnecting and programming cables, special grounding hardware, or isolation devices shall be furnished as required for proper operation of the equipment.

3. Signal converters, signal boosters, amplifiers, special power supplies, intrinsically safe relays and current repeaters, surge suppression devices, and isolation devices shall be furnished and installed as required for proper operation of the equipment.

E. Fabrication, Installation, and Testing

1. In addition to the design, fabrication, delivery, installation, and testing requirements specified herein, the PLC panel shall comply with all applicable requirements in Section 16950 - Custom Control Panels.

2. Equipment and components shall be Underwriters Laboratory (UL) listed for the purpose or UL recognized.
3. The assembled PLC panel and individual components shall be UL listed and labeled. The assembled panel shall have a factory applied UL 508A label.

4. Where applicable, intrinsic safety barriers within the PLC panel shall be provided per UL 698A with factory applied labels as required by UL.

5. The PLC system shall be factory tested prior to delivery per Specification Section 16950.

1.07 INSTALLED-SPARSE REQUIREMENTS

A. Each PLC shall be provided with the following spare capacities.

1. I/O points – 20 percent spare I/O capacity for each type of I/O signal required. All spare I/O shall be wired to the field terminal blocks.

2. PLC chassis and backplane – the greater of:
   a. 20 percent spare capacity, or
   b. 3 spare backplane slots.

   All spare backplane slots shall be equipped with slot filler modules.

3. PLC memory – 50 percent spare program volatile memory capacity after all required programming is in place and operating. Executive or “housekeeping” programs shall not be counted in memory size rating.

4. Field terminal blocks – 10 percent spare terminal blocks for each type of I/O signal required. These spare terminal blocks shall be in addition to the wired terminal blocks required for spare I/O capacity.

1.08 SPARE PARTS

A. Each PLC shall be provided with the following spare parts. Spare parts shall be packaged for long term storage and identified with labels describing contents.

1. I/O Modules: provide a spare of each type of module installed.

2. CPU: provide a spare for each type of CPU installed.

3. PLC Power Supplies: provide a spare for each type of power supply installed.
4. Memory Cards: provide a spare for each type of memory card installed.

5. Communication Module: provide a spare for each type of communication module installed.

B. Provide manufacturer’s recommended special tools for the PLC and associated components. Special tools shall include, but not be limited to: module installation/removal tools, terminal block installation/removal tools, reset tools, and drivers for special fasteners and screws.

1.09 MANUFACTURER SERVICES AND COORDINATION

A. The ICS or packaged equipment system manufacturer shall design, engineer, fabricate, program, factory test, and deliver to the project site a complete and fully functional PLC to provide process monitoring and control of the specified equipment system and to interface with the Plant and/or District SCADA system.

B. The manufacturer shall coordinate with the Contractor, Electrical Subcontractor, Instrumentation and Control Subcontractor, and District to ensure proper communication between PLC, Plant equipment, instrumentation and control devices, and SCADA system(s).

C. The ICS or packaged equipment manufacturer shall provide qualified and experienced engineering representatives to participate in project software development and coordination workshops with the District. As a minimum, the manufacturer’s representatives shall attend two (2) separate workshop sessions (one half day per session). The workshop sessions shall address the following:

1. PLC I/O list. Conventions for tag names and addressing.
2. PLC program monitoring and control strategy. PLC local/remote and auto/manual control modes.
3. PLC communication and control approach (PLC to PLC, and SCADA to PLC).
4. Network address assignments, where applicable.
5. Alarm acknowledgment and reset strategy.
6. Communication monitoring between PLCs and SCADA.
7. Software security approach.
8. Strategy for automatic restart following a power failure (Plant and equipment system).

9. HMI screens (standard objects, data display, and color conventions).

D. The manufacturer shall provide programming services incorporating direction received during the workshops with the District, including a complete monitoring and control logic program for operation of the equipment system. In addition, the manufacturer shall provide programming services for fully configured HMI screens.

E. After the equipment system has been installed, the manufacturer shall perform pre-startup, startup, commissioning, and field testing of the system.

F. Upon completion of system startup and testing, the manufacturer shall provide the District with a certificate of proper installation, and provide onsite training to District personnel.

1.10 QUALITY ASSURANCE

A. The District believes that the manufacturers listed herein are capable of producing equipment and/or products that will satisfy the requirements of these Specifications. The listing of specific manufacturers herein does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed herein are not relieved from meeting these Specifications in their entirety; and, if necessary, they shall provide non-standard, custom equipment and/or products. Contractor shall be responsible for confirming that the proposed equipment and/or products will meet these Specifications.

B. Products of one manufacturer and of the same series or family of models shall be used to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer support services.

PART 2 - PRODUCTS AND MATERIALS

2.01 PLC CAPABILITIES AND PERFORMANCE

A. General

1. The PLC shall collect data, perform process control functions, communicate with other PLCs, and distribute process information along the local area network.
2. The PLC shall be capable of providing proportional, integral, and derivative control in real time, with preemptive priority multitasking.

3. The PLC shall be able to have its program downloaded from a remote workstation over the local area network, and be locally programmed from a portable laptop computer.

4. The executive firmware of all intelligent modules shall be stored in flash memory and shall be able to be updated in the field using standard programming tools. Executive firmware files shall be readily available via the PLC manufacturer’s website.

5. The PLC shall be field expandable to allow for the expansion of the system by the simple addition of hardware and configuration of same.

6. A controller, or I/O module, shall be capable of being inserted under power, without upsetting the process being controlled by other controllers.

7. The PLC shall have the capability to preselect the failure status of each output point in the event of CPU failure.

2.02 PLC SOFTWARE REQUIREMENTS

A. Programming Software

As a minimum, the PLC programming software shall have the following capabilities:

1. Allow the use of all textural and graphic languages specified in IEC 61131-3, including:
   
a. Relay Ladder Diagram (LD)

b. Function Block Diagram (FBD)

c. Structured Text (ST)

d. Sequential Function Chart (SFC)

The processor shall be able to program in all four languages in one processor. Standard Boolean logic for coils, timers/counters, etc., shall only be limited by the amount of memory in the processor.
2. Data Manipulation:
   a. All memory locations shall be tag based with the ability to add and delete online without taking the processor offline. In addition the tags shall have the ability to be named to reflect usage based on user conventions. The tags shall also have the ability to be aliased to other tag names if required.
   b. Compare, move, block move, copy, and PID.
   c. Table read/write/sort/compare/search/average.

3. Math:
   a. Add, subtract, multiply, and divide.
   b. Square root, exponentiation, and logarithms (base ten and natural).
   c. Floating point number accuracy of four places.
   d. Engineering unit scaling function block for analog values.

4. Documentation:
   a. Address descriptions four lines by seven characters with edit, copy, and delete capability.
   b. Rung descriptions with edit, copy, and delete capability.
   c. Cut and paste logic capability.
   d. Ability to import/export all documentation to/from standard text files.

5. PID Blocks: support both dependent and independent equations.

6. Support user defined data structures with mixed numeric types.

7. Ability to store and retrieve instruction comments, program comments, rung comments, and other comments and notes in the PLC processor.

8. Communications: support peer to peer message read and write.
9. The PLC programming software shall have the following tools for monitoring and troubleshooting the PLC program.

   a. A breakpoint capability to automatically halt the program just before a certain sequence is initiated.

   b. Ability to advance the program step by step to insure proper operation.

   c. Ability to create watch points for desired variables. These watch points shall display the real time value of the variable.

   d. Ability to create a table that will track a chosen variety of variables.

10. The PLC shall be programmed using a single programming software package. The programming software package shall have integrated tools for PLC programming, network configuration, and communication capabilities. PLC’s that use separate programming, communication, and network configuration software will not be accepted. The programming software shall run on general purpose personal computers with Windows 10 (or latest) operating systems.

B. Editor

   1. The PLC programming software package shall include an IEC 61131-3 compliant editor.

   2. The logic editor shall support the creation of routines in all of the following four programming languages: LD, FBD, ST, and SFC.

   3. The editor and operating system shall support the import or export of specific, user-selected portions of logic, into and out of both a running controller as well as an offline controller configuration file. When performing this function online, the controller shall have a “test edit” function, such that the programmer can disqualify, or cancel the edit before fully accepting the changes.

C. Security

   The PLC system shall have capability to password protect access to the PLC. The system shall ensure security by authenticating users against a set of defined user accounts and access privileges.
2.03 PLC HARDWARE

A. General

The PLC shall be an integrated, modular, chassis type system designed for mounting the CPU (processor) module, I/O modules, communication modules, and power supply unit. The PLC shall be Allen Bradley 1756 ControlLogix or 1769 CompactLogix System (no substitutes).

B. Processor (CPU)

1. The PLC system shall execute logic in a single processor module. The processor shall be capable of executing all monitoring and control functions required by the Specifications and Drawings.

2. The processor shall have the ability to run multiple tasks with the ability to run each task at a particular scan rate that may be updated while running with the ability to prioritize each task.

3. Processor Features:

   a. Unless specified otherwise, the processor shall have a minimum of 4 MB of base program and data memory. Specified memory capacity shall be available entirely for storing the operational control program. Specified spare capacity and executive or “housekeeping” programs shall not be counted in memory size rating.

   b. A non-volatile memory card (EEPROM or Flash Memory) shall store the entire user program and configuration, and shall be capable of reloading the program into RAM if a fault in the program is detected or if the program is lost due to loss of battery power or other means. Unless specified otherwise, the non-volatile memory card shall have a minimum of 8 MB of memory.

   c. As a minimum, the processor shall be provided with one built-in USB port. The required 10BASE-T/100BASE-TX RJ45 Ethernet/IP ports shall be provided as built-in ports and/or via separate communication modules.

   d. The processor will be capable of being programmed with a general purpose laptop computer.
e. The PLC shall use a lithium battery to back up the PLC RAM. A BAT light shall indicate when it is time to replace the battery.

f. The PLC shall have status lights to indicate various functions, including run, processor fault, I/O fault, and communication activity.

C. I/O Modules

1. General Requirements

PLC I/O modules shall be provided as required to accept signals as indicated on the Drawings, as specified in Specifications for equipment, and as specified herein. I/O modules shall be provided to accept all active signals and all specified spares. PLC I/O modules, including installation in the PLC enclosure shall conform to the following:

a. All I/O modules shall be enclosed in a plastic housing. I/O modules shall be plugged into a modular type I/O rack with common backplane. All cables required to connect to all other PLC system components shall be provided.

b. I/O modules shall be capable of being removed and inserted into the I/O rack under power without affecting any other I/O modules in the rack.

c. I/O of a particular type (digital inputs, digital outputs, analog inputs, and analog outputs) shall be grouped together.

d. All I/O wiring shall be to removable terminal blocks that permit removal and replacement of a module without disturbing the wiring or any other I/O module. Removable terminal blocks shall be suitable for accepting #14 AWG I/O wiring.

e. Identify on I/O modules and associated terminal blocks, the specific I/O points as they have been addressed in the PLC system.

f. All field wiring shall be terminated on terminal blocks within the PLC enclosure. The field terminal blocks shall be sized to accommodate all active I/O points and required spares. Field terminals shall be provided for the individual termination of each analog signal shield. The PLC shall be factory prewired between the field terminal blocks and I/O module removable terminal blocks.
g. Unless specified otherwise, provide interposing relays for all discrete outputs. Relays shall be rated a minimum of 10A at 120VAC. Relays shall have LED status indicating lights.

h. Discrete I/O modules shall be provided with LED status indicating lights on the front of the module. One LED shall indicate I/O status of the field device (yellow – input/output is “on”). The other LED shall indicate module operating status (steady green – normal operating state, flashing green – not performing connected communication, and steady red – module failure).

i. Analog I/O modules shall be provided with LED status indicating lights on the front of the module. One LED shall indicate the module calibration status (green flashing – in calibration). A second LED shall indicate module operating status (steady green – normal operating state, flashing green – not performing connected communication, and steady red – module failure).

2. Basic I/O Modules

The manufacturer shall have available a variety of I/O modules for the PLC. I/O modules shall be selected as required for the particular project application. Unless specified otherwise, basic I/O modules shall conform to the following:

a. Discrete Inputs

1) Voltage rating shall match circuit voltage. Isolated I/O shall be provided for applications where module interfaces with devices utilizing different sources of power.

2) Discrete input modules shall be provided with individually isolated digital inputs, or non-isolated digital inputs (8 points per group), depending upon the application.

3) Discrete input modules shall be sixteen (16) channel 120VAC.

b. Discrete Outputs

1) Voltage rating shall match circuit voltage. Isolated I/O shall be provided for applications where module interfaces with devices utilizing different sources of power.
2) Discrete output modules shall be provided with individually isolated digital outputs, or non-isolated and mechanically fused digital outputs (8 points per group), depending upon the application.

3) Discrete output modules shall be sixteen (16) channel 120VAC relay.

4) Provide one (1) external fuse per common or per isolated output. Provide blown fuse indication. Fuses shall be in accordance with module manufacturer’s specifications.

c. Analog Inputs

1) Analog input modules shall be provided with individually isolated analog inputs.

2) Analog input modules shall be eight (8) channel, 4-20mA DC (+/- 10V), with input impedance of 250 ohms per channel.

3) Analog input modules shall be provided with analog/digital (A/D) conversion resolution of 16 bits.

4) I/O chassis supplied power for powering connected field instruments.

d. Analog Outputs

1) Analog output modules shall be provided with individually isolated analog outputs.

2) Analog output modules shall be eight (8) channel, with each channel capable of driving a 4-20mA DC signal (+/- 10V) into a 0 to 600 ohm load.

3) Analog output modules shall be provided with digital/analog (D/A) conversion resolution of 16 bits.

e. Specialized I/O Modules:

1) Where required for the application, specialized I/O modules such as counter modules or high speed counter modules shall be provided.
2) All input/output signals and power supplies required for proper counter operation shall be provided.

D. Communications

1. Communications shall be capable of using Modbus, and open industry standard Ethernet/IP and OPC protocols.

2. The PLC shall be capable of peer-to-peer communications that provide for the direct transfer of process data between controllers without the use of gateways or servers.

3. Communication Capabilities: PLC chassis shall be capable of containing one or more communication modules to provide communication interfaces to other devices, including, but not limited to: remote work stations, HMIs, and PLCs by other manufacturers. As a minimum, the PLC shall support the following without the need for third-party modules:
   a. Ethernet (10/100MB).
   b. Serial protocols including Modbus and ASCII.

The PLC shall be provided with an Ethernet module equipped with multiple ports (a minimum of 2 ports, unless specified otherwise). Each port shall be capable of communicating both TCP/IP and Ethernet/IP simultaneously. Modules requiring the ports to be configured for one protocol will not be acceptable. The communication module shall also support daisy chain wiring.

4. Surge protection shall be provided on all connections to communication ports.

E. Chassis

The PLC shall be provided with a chassis to mount the processor module, I/O modules, communication modules, and other applicable modules. The chassis shall be modular, capable of accepting any module into any slot. The chassis backplane shall provide a high speed communication path between modules and distribute power to each of the modules within the chassis. Modules shall be secured to the chassis via a screw connection. The chassis shall be available in various slot configurations, up to a total of 17 slots.
F. **Power Supply Unit**

PLC Power Supply Unit: Each PLC shall be provided with a regulated power unit designed to operate the PLC system. The power supply unit shall conform to the following:

1. Mount directly to the chassis and connect to the chassis backplane.
2. Provide power to:
   a. The PLC system, including the controller processor, I/O modules, communication modules, and other applicable modules.
   b. All associated two-wire field instruments.
   c. Other devices as indicated on the Drawings and/or Specifications.
3. Capable of supplying PLC system power when all the specified spare I/O capacity is utilized.
4. Sized to carry no more than 75 percent of total unit capacity under normal loads, including all spare capacity.
5. Provide constant voltage level DC distribution to all devices. Power distribution shall be immune to transients and surges resultant from input power noise.
6. A single power supply unit shall be provided for each chassis.
7. Unless specified otherwise, the input power to the power supply shall be 120VAC, +/- 10 percent, 60 Hz.
8. A separate line fuse shall be provided for each power supply unit.

G. **Uninterruptable Power Supply (UPS)**

Uninterruptable Power Supply (UPS): Unless specified otherwise, each PLC shall be provided with a UPS. The UPS shall conform to the following:

1. Ensure that transient power surges and dips do not affect the operation of the PLC system.
2. Utilize low maintenance, rechargeable, sealed batteries, maintained at a float point charge during normal power conditions.
3. Provide a synchronized 60 Hz sine wave output, in-phase with the utility line power sine wave. The sine wave output shall be synchronized during switching from utility AC power source to battery source and during switching from battery source back to utility AC power source. The UPS switch to and from battery in less than 4 milliseconds.

4. Provide silencing audible and visible alarms indicating utility AC line power failure and low battery.

5. Provide a serial port interface to communicate with the panel PLC. This interface shall provide information to alert Plant and/or District SCADA of a low battery warning, power alarm, or UPS failure.

6. Sized to sustain full power to the following loads for a minimum of 15 minutes after loss of primary power:
   a. PLC power supply unit, including all chassis mounted PLC modules and associated two-wire field instruments.
   b. PLC Human-Machine Interface.
   c. All power supplies furnished with the PLC and associated loads.

7. Unless specified otherwise, the input power to the UPS shall be 120VAC, +/- 10 percent, 60 Hz. Output power from UPS shall be 120VAC, +/- 5 percent, 60 Hz. An AC circuit breaker shall be provided for the line power to the UPS.

8. The UPS shall be Model Smart-UPS, as manufactured by APC, or equal.

2.04 HUMAN-MACHINE INTERFACE (HMI)

Where specified, each PLC shall be provided with a door mounted Human-Machine Interface (HMI). Unless specified otherwise, each HMI shall meet or exceed the following requirements:

A. Display Size: 12 inches
B. Display Type: Touchscreen, backlit, color TFT LCD, 18-bit color graphics
C. Operating System: Microsoft Windows CE 6.0 R3
D. Architecture: Open
E. Processor Frequency: 1.0 GHz

F. RAM: 512 MB

G. Internal Storage: 512 MB (80 MB non-volatile)

H. Operating Temperature: 0 - 55°C

I. Enclosure: NEMA 4X, 12, and 13

J. Input Power: 18-30VDC

K. Interfaces: 1-SDHC card slot (store data/reload interface applications), 1-USB-A and 1-USB-B (v2.0 high speed)

L. Communication Interfaces: 1-RJ45 10/100 MB, Auto MDI/MDI-X Ethernet port

M. Standard Software: FactoryTalk (Machine and Viewpoint) or equal, PDF Viewer, Active X Controls, Remote Terminal Control, FTP Server

N. Manufacturer/Model: Allen Bradley, PanelView Plus 7, or equal.

2.05 PLC ENCLOSURE AND APPURTENANCES

A. The PLC enclosure shall be of sufficient size to house all PLC and HMI hardware, power supplies, instruments, relays, devices, terminal blocks, wireways, and appurtenances as specified herein and required for each equipment system application.

B. Unless specified otherwise, PLCs located outdoors or indoors in corrosive or wet locations shall be provided with NEMA 4X enclosures constructed of Type 316 stainless steel. Unless specified otherwise, PLCs located indoors in non-corrosive and dry locations shall be provided with NEMA 12 enclosures. Enclosures shall be free-standing or wall mountable.

C. NEMA 4X enclosures shall be provided with solid exterior door(s) and interior hinged swing-out door(s) for mounting HMIIs, instrument displays, lights, switches, pushbuttons, etc. All PLC enclosures shall be supplied with removable equipment mounting back panels and padlockable doors equipped with 3-point latching systems, inner drawing holders, and neoprene seals.
D. The interior and exterior of NEMA 4X stainless steel enclosures shall be unpainted. The interior of NEMA 12 enclosures shall be painted white and the exterior shall be painted gray. All enclosure interior mounting brackets, panels, and plates shall be painted white. Enclosures equipped with single doors shall be hinged to swing from right to left and shall be easily removable.

E. Each PLC panel shall be provided with LED lighting fixtures of sufficient size and quantity to provide 50 foot-candles of illumination within the panel. The lighting fixtures shall be horizontal LED tube type fixtures and shall be mounted to the top of the enclosure. The light fixtures shall be wired to a UL-approved switch mounted inside the panel.

F. Each PLC panel shall be provided with a duplex, 120VAC, 15A, 3-wire grounded GFCI type convenience receptacle.

G. Unless indicated otherwise on the Drawings, the light fixture(s) and convenience receptacle shall be powered from a separate voltage source than the PLC equipment.

2.06 INTERPOSING RELAY SUBASSEMBLIES

A. 24 VDC interposing relays shall be utilized on all digital outputs which are required to interact with the motor control center, VFDs, valves and external hardwired logic circuitry. Octal socket plug-in relays containing two form “C” 10 amp contacts shall be supplied. Each relay shall contain an internal LED indicating when the relay has been energized. Relay coils shall be wired to the load side (output) of the supplied PLC field terminal block and labeled to reflect the I/O address which drives it. A 1 amp, 100V (1N4001) surge suppression diode shall be wired across the relay coil socket pins. Interposing relay contacts shall be wired with yellow wire to the line side (input) of a separate isolated field terminal block dedicated to interposing signals. All wires between relay contacts and the interposing signal terminal block shall be labeled to reflect the relay/pin number.

B. Interposing relays shall be provided in subassemblies consisting of 4 relay sockets mounted onto an interposing relay mounting plate, and prewired with a color-coded wire harness for connection to terminal blocks, as described above. All hardware for mounting the subassembly into the PLC enclosure shall be provided, and a nameplate tag for relay identification shall be provided for each relay socket. Mounting of interposing relay subassemblies shall be simplified while maintaining the integrity of the enclosure’s NEMA rating, maintaining serviceability without the removal of other equipment, and preventing interference with the removal or serviceability of other equipment.
2.07 WIRING

A. All terminal blocks shall slide onto a single symmetrical steel DIN mounting rail. The terminal system shall be a finger-safe, multi-circuit (3 circuit minimum), compact, high-density design utilizing a stainless steel screw with nickel plated copper or brass pressure plate wire terminating construction. The terminal block system shall allow for installation ease where the addition of terminals simply requires sliding clear a space on the rail and snapping into place the new terminal modules. All terminals shall be rated for 600 volts with a maximum current of 20 amps, UL rated, and shall accommodate wires ranging between #24 to #12 AWG. All terminals shall have a place for marking the wire number associated with them. All terminal blocks shall be manufactured by Phoenix Contact, no substitutes.

B. All analog inputs and outputs shall be terminated onto fused signal isolation terminal modules in order to protect the PLC I/O modules from accidental field wiring errors, ground loops, disparate supply voltages and short circuits. Power feeds, external power supply outputs, and other power distribution wiring to external equipment shall be terminated on a fused terminal. All fused terminal blocks shall be equipped with fuses, including all spare terminal blocks.

PART 3 – EXECUTION

3.01 FABRICATION

A. The PLC chassis shall be mounted at the top of the enclosure back panel. Provide spacing around the PLC as required by the PLC manufacturer to ensure: adequate cooling, clearance space for cabling, and access for servicing. PLC communication ports, and memory card slots shall be accessible at all times. PLC lights shall be visible at all times when the enclosure door is opened.

B. The field wiring terminal block subassemblies shall be located at the bottom of the enclosure back panel for easy access and routing of external wiring.

C. The UPS and UPS power receptacle shall be located at the bottom of the enclosure

D. The interposing relay subassemblies shall be mounted on the enclosure back panel or enclosure sides, whichever is most convenient for serviceability and panel size minimization while maintaining the NEMA rating. All relay sockets shall be prewired to terminals as described above.
E. I/O modules shall be prewired with cable subassemblies to terminal blocks with color-coded (individually shielded pairs for analog signals) and neatly routed in an orthogonal fashion along the bottom of the PLC modules, panel sides and top of the terminal block subassemblies. Slotted wire ducts with removable covers shall be used for wire and cable routing. The number of cable subassemblies and type shall correspond to the number and type of I/O.

F. Each PLC component shall include a clearly visible faceplate with appropriate data such as the manufacturer’s model number. In addition, nameplates engraved with the name/function of each PLC component shall be provided. Each nameplate shall be mounted adjacent to the respective component in a clearly visible location.

G. Each I/O point shall be identified on the door of the PLC I/O module.

H. All cables and connectors required for proper operation of all PLC components and accessories shall be furnished by the manufacturer, and shall be factory installed and tested.

3.02 INSTALLATION

A. Install the PLC panel in the location shown on the Drawings. Installation shall be in accordance with the manufacturer’s written installation instructions and as specified herein.

B. The PLC panel shall be rigidly support, plumb and level, and in such a manner as to provide accessibility and freedom from interference with other equipment, piping, or electrical work.

C. Install free-standing PLC panels on a 3-inch high concrete housekeeping pad.

D. Anchor panels in accordance with the manufacturer’s recommendations, and equipment seismic anchorage calculations/details (where specified).

E. All field wiring and cabling shall be connected to the PLC field terminal blocks in accordance with the approved shop drawings.

F. All grounding shall be connected as shown on the approved shop drawings.
3.03 FIELD QUALITY CONTROL

The ICS or packaged equipment system manufacturer shall provide a qualified service representative to perform the following:

A. Inspect the PLC, wiring, components, connections, and equipment installation. Perform all necessary pre-testing, operational checks, and adjustments of the supplied programmable controller, components, and equipment to ensure that the PLC is ready for operation.

B. Assist in field testing of PLC and equipment system, including all programming for monitoring and control of the equipment.

C. Provide a written report documenting all field testing and results.

D. Provide written certification that the PLC system has been properly installed, started up, fully tested, and is ready for operation by the District.

3.04 FIELD TESTING

A. After the PLC system installation has been certified and all analog points have been tested and calibrated, the entire system shall be tested to verify that on discrete and analog inputs and outputs are functioning correctly.

B. I/O points shall be tested from end-to-end without simulation, to the maximum degree feasible without causing damage to the equipment. Simulated testing will only be allowed when no practical alternative exists.

C. SCADA workstations shall be verified for correctness at the same time as the PLC testing.

D. I/O checklists shall be provided by the ICS or packaged equipment manufacturer to record the test results, with a copy provided to the District upon completion of testing.

E. Upon completion of the individual I/O points, system operational testing shall be performed. System operational testing shall demonstrate proper operation of the various process systems monitored and controlled by the PLC, including automatic control modes and control system interlocks. All specified functional requirements shall be verified for compliance.

F. Tests that fail to demonstrate the required operation shall be repeated in their entirety after corrective action has been completed.
G. During system testing, the ICS or packaged equipment manufacturer shall have a representative onsite continuously who is capable of troubleshooting and modifying the control system programming.

H. Upon satisfactory completion of all field testing, the ICS or packaged equipment manufacturer shall submit a system testing report to the District documenting all performed testing and testing results.

3.05 TRAINING

A. Upon satisfactory completion of all field testing and commission procedures, the ICS or packaged equipment manufacturer shall provide the services of a factory trained representative to provide onsite training of District personal in the operating and maintenance of the furnished equipment.

B. Training shall include classroom and hands-on instruction. As a minimum, training shall address:

1. PLC system hardware overview.
2. PLC and HMI software overview.
3. Service and maintenance.
4. Troubleshooting.
5. Operation, including program initiation, changing set points, manual overrides, passwords, etc.

END OF SECTION 17010
PART 1 - GENERAL

1-1. SCOPE. This section provides functional descriptions of the programmable logic controller (PLC) and operator interface terminal (OIT) software requirements for the Odor Control System as indicated on the Drawings. These descriptions are intended to provide an overview of the operating concept of the plant process equipment rather than describing in detail every operating feature or interlock.

1-1.01. Control System. The Instrumentation and Control System, Odor Control Fans, Odor Control Dampers and Valves, Demister and Carbon Absorption Unit sections shall apply to all systems described in this section. All I/Os into the existing Supervisory Control and Data Acquisition (SCADA) system shall be coordinated with the District. The District will terminate the designated signals and alarms into the existing SCADA system. Contractor shall provide coils of signal/alarm cables within the SCADA panel for District termination and programming.

PART 2 – PRODUCTS

2-1. GENERAL. The descriptions are applicable to the software specified in the Programmable Logic Controller section.

PART 3 - EXECUTION

3-1. PLC PROGRAMMING FUNCTIONAL REQUIREMENTS. The following paragraphs describe general configuration tasks that are required for the system PLC. These tasks shall be programmed in any applicable PLC. The PLC may have multiple instances of each of these tasks or may have no instances of some or all of these tasks. The input/output listed (located in Odor Control System section and depicted on the Drawings) and detailed equipment control descriptions (included herein) shall be referenced to determine the requirements for the PLC.

The following paragraphs cover functional requirements of the software, which are generic and may or may not be related to any specific control loop.

3-1.01. Available Process Values. All PLC-generated process alarm, equipment status, and process variable values transferred to the existing Plant RTU shall be available at any operator workstation.

3-1.02. Flow Values. Not used.
3-1.03. **System Failure.** Failure of the PLC shall result in safe shutdown of associated process equipment. Interposing relays shall be provided where required to assure that equipment will revert to its fail-safe condition. Failure of any PLC or its communication shall be alarmed on the operator interface terminal (OIT).

3-1.04. **OITs.** The OIT shall function as a monitoring system, not as a controller, for the process equipment. The OIT shall download setpoints and other information to the PLC, and the PLC shall perform all control algorithms, so a temporary failure of the OIT will not disrupt control.

3-1.05. **Rack/Module Configuration.** The rack and module definitions for the PLC, as well as the PLC communications configuration shall be completely configured to allow proper addressing of all field connected I/O points. This shall include configuration of any remote input/output (RIO) racks.

3-1.06. **PLC Database Definition.** The PLC database will include both field I/O points and internally generated points required for programming. All field I/O points and internal programming points shall be fully defined according to database naming conventions approved by Owner. As a minimum, each database point shall be provided with a tag name, engineering unit, alarm parameters, and description.

3-1.07. **Analog Scaling.** Each analog input and output will be appropriately scaled for use in internal PLC programming, monitoring by the OIT, or transmission to other RTUs/PLCs. Requirements for raw count values shall be coordinated with the OIT software to ensure compatibility.

3-1.08. **Equipment Runtimes.** For each equipment item whose "run" status is monitored by a PLC, an internal equipment runtime shall be accumulated by the respective PLC. The runtime procedure will monitor the status of the equipment "run" contact and, when the equipment is running, increment a software timer that maintains equipment runtime to within a one-minute resolution. The timer shall stop incrementing, but not reset, when the "run" contact indicates that the equipment is not running. The timer value shall increment an hour counter that maintains an integer value representing the equipment run time in hours. The counter value shall be available for display on the OIT. A manual reset of the runtime value shall be available at the OIT for personnel at the supervisor level and above.

3-1.09. **Change-of-State Alarms.** While equipment is controllable from the PLC ("in remote"), discrete output commands shall be compared to their respective process feedback status signal (where available) to verify proper execution. If the feedback status does not match the most recent output command (after an adjustable 2 to 300 second time delay), an alarm message shall be displayed on the OIT and the condition
shall be logged as an alarm, requiring operator acknowledgment. The alarm shall remain energized until the proper discrete condition is sensed or until the operator resets the alarm through the OIT.

3-1.10. **Equipment Availability.** In general, equipment with PLC control has been provided with a local selector switch that transfers control to the PLC. The PLC shall monitor the position of this switch to determine if the equipment is available for PLC control. If the equipment is not available, the PLC program shall not attempt to implement remote manual or automatic status changes for the equipment. The PLC program may, however, need to implement special routines if equipment unavailability affects a sequence (as described in the detailed equipment descriptions).

3-1.11. **Maintained/Momentary Outputs.** The need for maintained or momentary control outputs shall be determined from the electrical schematics. In general, equipment with only one control output shall be programmed for a maintained control output. Equipment with two (or more) control outputs shall be programmed for momentary outputs. Provisions shall be made, in either case, to remove the active state (start, open, forward, initiate, etc.) control output when an equipment failure is sensed or when the equipment transitions from available to unavailable (local switch change).

3-1.12. **Equipment Mode Changes.** Unless otherwise indicated in the equipment control descriptions, equipment in automatic mode shall be transitioned to manual mode (and stopped) if the equipment fails or becomes unavailable or if the PLC processor resets.

3-1.13. **Manual/Auto Bumpless Transfer.** Unless otherwise indicated in the equipment control descriptions, equipment changes from automatic to manual control shall be bumpless. Equipment running or stopped in automatic mode shall remain running or stopped when manual mode is selected.

3-2. **OIT FUNCTIONAL REQUIREMENTS.** The following paragraphs describe general configuration tasks that are required for the OIT and related software.

3-2.01. **Database.** The system database, including field I/O and internal points shall be established according to the database point naming conventions approved by Owner. Database generation for field I/O shall include all required coordination with PLC level addresses. If no Owner database point naming conventions are available, the database names shall utilize an ISA or ISA-like tag name.

In the default scheme, the format of the tag name is XXX-YYY-ZA.

XXX is the ISA function designation.
YYY-ZA is the unique loop designation defined by the P&IDs.
Where possible YYY-ZA will correspond to the loop numbers on the P&IDs. Otherwise, a unique number shall be assigned. Z is a number (1, 2, 3) to designate similar loops associated with trains of equipment. A is a letter (A, B, C) to designate identical functions within the same loop. For instance, if there are two ferric sulfate metering pumps and the loop number chosen is 222, the remote status input for pump number one might be HS-222-1 and the remote status input for pump number two might be HS-222-2. If there is more than one switch input for either pump the tag name would be HS-222-1A and the second switch would be HS-222-1B.

Function designations currently defined are listed below:

**AI's (Analog Inputs)**

- AIT - Analytical Input
- EIT - Voltage Input
- EIIT - VAR Input
- FIT - Flow Input
- IIT - Current Input
- JIT - Power Input
- LIT - Level Input

- PDIT - Differential Pressure Input (Headloss)
- PIT - Pressure Input
- ST - Speed or Rate Input
- TIT - Temperature Input
- WIT - Weight Input
- ZT - Position Input

**AO's**

- AC - Residual Proportioning Control
- FC - Flow Proportioning Control

- SC - Speed or Rate Control
- ZC - Position Control

**DI's**

- AAH - Analytical Alarm High
- AAL - Analytical Alarm Low
- FSH - High Flow Status
- FSL - Low Flow Status
- HS - Hand Switch Status
- JA - Electrical Alarm

- PDSH - High Differential Status
- PS - Pressure Alarm Hi/Lo or Unspecified
- PSL - Low Pressure Status
- PSLL - Low Pressure Cutoff Alarm
- WAL - Low Weight Alarm
- XA - General or Unspecified Alarm
Initially, the facility database shall be configured so all database points are defined as belonging to a specific area (as allowed by the graphical interface software). The areas designated for the facility shall be coordinated with Owner. If Owner has no existing standards for area designations, all points can be placed in appropriate areas selected by System Supplier.

3-2.02. Trend Displays. Not used.

3-2.03. Alarms. Complete system alarming shall be configured. This shall include configuration of graphical alarm displays, and configuration of audible alarms through the OIT speakers. All process or system alarms shall appear on an alarm summary screen and the alarm banner of each process graphic. Alarms and events shall be color coded on the alarm summary screen, with initial colors based on Owner conventions or the default colors associated with the graphics package. The colors may be adjusted after meeting with Owner. Alarm prioritizing and area assignments (if any) shall be coordinated with Owner at the first configuration meeting.

For LOW or LOW-LOW analog or discrete alarms which do not apply if associated equipment is not operating, provisions shall be made to prevent/Lock generation of the alarm unless the associated equipment is operating. This shall include alarms such as low amperage alarms for pumps that are not running. This may also include low flows or pressures when associated pumps are not operating (this will only apply if periodic operation of the equipment is considered normal).

All alarms/events shall be time stamped when displayed or printed. Unacknowledged alarms shall not automatically clear from the alarm summary if they return to normal before being acknowledged.

3-2.04. Reporting. Not used.
3-2.05. **Historical Data Collection.** Not used.

3-2.06. **Manual Entry of Data.** The OIT shall allow manual entry of variables, such as setpoints, which shall then be available for display and use in PLC program.

3-3. **EQUIPMENT CONTROL AND CONTROL MODE OVERVIEW.** The following paragraphs explain the general format and control modes that are used in the detailed equipment descriptions. These paragraphs apply to the attached, project specific, equipment control descriptions included herein.

3-3.01. **General.** Appended to this section are the equipment control programming requirements, with requirements for both PLC programming and the minimum operator interface functions. The OIT requirements represent the anticipated display generation requirements and shall be adjusted if the PLC programming warrants adjustment.

3-3.02. **Control Modes.** There are two general control modes available for the process equipment: 1) remote manual, and 2) remote auto. Remote manual control provides a means for operators to adjust equipment status or setpoint, through the OIT, using manually initiated commands. Remote automatic control provides a means for automatically changing equipment status or setpoint based on measured process parameters, calculated values, or operator setpoints. Some equipment may have more than one remote auto mode.

Descriptions for local control are included in the detailed equipment control descriptions. They are provided primarily for documentation purposes and for information. These controls are hardwired and require no programming effort.

3-4. **DETAILED EQUIPMENT CONTROL DESCRIPTIONS.** The following paragraphs describe specific function requirements for various software control blocks in the control system. These descriptions are intended to provide an overview of the operational concept for the facilities, rather than describing in detail every operating feature or interlock.

3-4.01. **Loop Description Title: Odor Control System.** This Loop Description Is For Information Purposes Only. The Contractor and odor control system supplier shall coordinate with the equipment suppliers to determine the exact controls for the equipment provided. The Odor Control System PLC and the Lift Station RTU communicate via MODBUS RTU.

A. **Associated Equipment.** Demister, Odor Control Fans 1 & 2 and Carbon Absorption Unit
B. **Associated PLC.** OCP-1 PLC

C. **Associated P&ID.** I2

D. **Local Manual Mode.** Local Manual control of the Odor Control System shall be provided at the Odor Control Panel (OCP-1), Odor Control Fan VFDs and the Electrical Control Panel. When in local manual control the operator shall use hardwired controls at OCP-1, the VFDs and Electrical Control Panel to operate the Odor Control System.

The Odor Control Fans have H-O-A selector switches at their respective VFD in the Electrical Room. In Hand, the fans run and have their speed adjusted from the VFD. In Off, the fans stop. The duty fan runs to draw foul air from the wetwells through the Demister and push the treated air through the Carbon Absorption Unit for final scrubbing and release to the atmosphere.

E. **Local Auto Mode.** Local auto control of the Odor Control system shall be provided through OCP-1. When in local auto control the OCP-1 PLC shall control the operation of the Odor Control System.

The Odor Control Fans shall be operated in a Duty-Standby configuration. If both fans are In-Auto; the Standby fan shall assume the “Duty Fan” role upon a Duty fan failure.

In Auto, the Odor Control Fans shall be started, stopped and have their speed adjusted through the OCP-1 PLC. The PLC shall adjust fan speed to maintain a flow or pressure setpoint. The duty Odor Control Fan speed shall vary but, not to a point where the air flow rate exceeds the maximum permitted rate of 6,000 scfm.

F. **Remote Manual Mode.** None.

G. **Remote Auto Mode.** None.

H. **Alarms.** The PLC shall receive Odor Control Fan No. 1 Fail and Odor Control Fan No. 2 Fail signals from the fans’ VFDs. The fail signals shall include high motor winding temperature, high bearing temperature, high discharge pressure, VFD failure and motor overload, as applicable.

The emergency eye wash/emergency showers have water flow alarms.

The PLC shall generate the following local alarms based on the corresponding analog inputs:
Software Control Block Descriptions
17550-8

Wetwell Exhaust Air H₂S high and high-high
Fans Discharge Air pressure low-low, low, high, high-high
Carbon Absorption Unit Exhaust H₂S high and high-high

The PLC outputs an Odor Control System Common Alarm to the existing RTU for remote monitoring at a Human Machine Interface (HMI).

I. **Status Indications.** The HMI shall indicate the following statuses:

- Odor Control System In-Auto
- Odor Control System Running
- Odor Control System Common Alarm
- Wetwell Exhaust H₂S
- Fan No. 1 In-Auto
- Fan No. 2 In-Auto
- Fans Discharge Air Pressure
- Carbon Absorption Unit Exhaust H₂S

J. **PLC Power Up.** On PLC power up, control of the Odor Control System shall be set to local manual mode.

K. **Power Failure.** Control shall resume with the control mode established prior to the power failure.

L. **HMI Requirements.** The Odor Control System shall be depicted on a separate process screen. The display shall be provided similar to the P&ID. Fans, carbon absorption unit, tanks and instruments shall be depicted on the process overview display with current statuses, instantaneous analytical values and instantaneous flow rates depicted. There are no HMI entered setpoints associated with the Odor Control System. All setpoints are entered locally at OCP-1.

M. **Trending.** The following signals shall be recorded for trending at the OIT at a minimum:

- Odor Control System Running
- Wetwell Exhaust H₂S
- Fans Discharge Air Pressure
- Carbon Absorption Unit Exhaust H₂S

END OF SECTION
PART 1 - GENERAL.

1-1. SCOPE. The Panel Mounted Instruments section covers the furnishing of all panel mounted instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings.

1-2. DESIGN CRITERIA. The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings. The instruments shall be installed at the locations indicated on the Drawings.

Where possible, each instrument shall be factory calibrated to the calibration ranges indicated on the Drawings. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. For "smart" devices, calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Drawings.

1-3. SUBMITTALS. Submittals shall be as specified in the Instrumentation and Control System section.

PART 2 - PRODUCTS

2-1. GENERAL. The following paragraphs describe minimum device stipulations. The Drawings shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01 Programming Device. For systems that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section).
The programming device shall include appropriate operation manuals and shall be included in the training stipulations. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.02 Configuration Software/Serial Interface. Devices indicated as requiring a serial interface shall be provided with all accessories to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under the Windows 10 operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

2-2. PANEL FRONT MOUNTED DEVICES.

2-2.01 Annunciators. Not used.

2-2.02 Totalizers. Not used.

2-2.03 Digital Panel Indicators. Not used.

2-2.04 Electronic Bar Graph Indicators. Not used.

2-2.05 Edgewise Panel Indicators. Not used.

2-2.06 Manual Loading Stations. Not used.

2-2.07 Ratio Stations. Not used.

2-2.08 1/4 DIN Single-Loop Control Stations. Not used.


2-2.10 Large Case Recorders. Not used.

2-2.11 Strip Chart Recorders. Not used.


2-2.13 Digital and Panel Clocks. Not used.

2-2.14.01. Selector Switches. Selector switches shall be 30.5-mm, heavy-duty, oil-tight type with gloved-hand or wing lever operators. Position legends shall be engraved on the switch faceplate. Switches for electric circuits shall have silver butting or sliding contacts, rated 10 amperes continuous at 120 V ac. Contact configuration shall be as indicated on the Drawings or for the application. Switches used in electronic signal circuits shall have contacts suitable for that duty. Switches shall be Eaton/Cutler-Hammer "10250T", General Electric "CR104P", or Allen Bradley “800T”.

2-2.14.02. Indicating Lights. Indicating lights shall be 30.5-mm, heavy-duty, oil-tight type, with full voltage LED lamps. Legends shall be engraved on the lens or on a legend faceplate. Lights shall be push-to-test type. Indicating lights shall be Eaton/Cutler-Hammer "10250T", General Electric "CR104P", or Allen Bradley “800T”.

2-2.14.03. Push Buttons. Push buttons shall be 30.5-mm, heavy-duty, oil-tight type. Legends shall be engraved on the push-button faceplate. Contacts shall be rated 10 amperes continuous at 120 V ac. Push buttons shall be Eaton/Cutler-Hammer "10250T", General Electric "CR104P", or Allen Bradley “800T”.

2-2.15. Alarm Horns. Horns shall be high-decibel, panel-mount, vibrating type designed for heavy-duty use. Horn volume shall be field-adjustable from 78 to 103 dB at 10 feet. Horns shall operate at 120 volts ac. Horns shall be weatherproof NEMA Type 4X. Horns shall be panel front mounted and shall be supplied with gasket. Horns shall be Edwards Signals “870P Series.”

2-3. PANEL INTERIOR MOUNTED DEVICES.

2-3.01. Integrators. Not used.

2-3.02. Power Supplies. Regulated dc power supplies for instrument loops shall be designed and arranged so that loss of one supply does not affect more than one instrument loop or system. Power supplies shall be suitable for an input voltage variation of ±10 percent, and the supply output shall be fused or shortcircuit protected. Output voltage regulation shall be by the instrumentation equipment supplied. Multiloop or multisystem power supplies will be acceptable if backup power supply units are provided which will automatically supply the load upon failure of the primary supply. The backup supply systems shall be designed so either the primary or the backup supply can be removed, repaired, and returned to service without disrupting the instrument system operation. Multiloop power supply connections shall be individually fused so a fault in one instrument loop will be isolated from the other loops being fed from the same supply. Fuses shall be clearly labeled and shall be located for easy access.
Panel Mounted Instruments
17561-4

Multiloop supply systems shall be oversized for an additional 10 percent future load. Failure of a multiloop supply shall be indicated on the respective instrument panel or enclosure.

Power supplies shall be Allen Bradley, Phoenix Contact, PULS, or equal.

2-3.03. Relays. Relays indicated to be provided in panels, enclosures, or systems furnished under this section shall be of the plug-in socket base type with dustproof plastic enclosures unless noted otherwise. Relays shall be UL recognized and shall have not less than double-pole, double-throw contacts. Control circuit relays shall have silver cadmium oxide contacts rated 10 amperes at 120 V ac. Electronic switching-duty relays shall have gold-plated or gold alloy contacts suitable for use with low-level signals. Relays used for computer input, alarm input, or indicating light service shall have contacts rated at least 3 amperes. Time delay relays shall have dials or switch settings engraved in seconds and shall have timing repeatability of ±2 percent of setting. Latching and special purpose relays shall be for the specific application. Unless otherwise indicated, all relays shall have an integral pilot light that illuminates to indicate an energized condition. Relays shall be IDEC "Series RR"; Potter & Brumfield "Series KRP, CB"; or Struthers-Dunn "Series 219, 246".


2-3.05. Electronic Signal Booster/Isolators. Not used.

2-3.06. Electronic Signal Selectors. Not used.


2-3.10. Strip Heaters. Electric strip heaters shall be provided as indicated on the Drawings, as specified, and for the application. Strip heaters shall be sized to prevent condensation within the enclosure and to maintain the equipment above its minimum operating temperature. Strip heaters shall be located to avoid overheating electronic hardware or producing large temperature fluctuations. Strip heaters shall be controlled by adjustable thermostats with adjustment ranges of 30° to 90°F [-1° to +32°C]. A circuit disconnect switch shall be provided within the enclosure.

2-3.12. **Surge Suppressors.** Surge and lightning suppressors shall be non-faulting, non-interrupting, and shall protect against line-to-line and line-to-ground surges. Devices shall be solid-state metal oxide varistor (MOV) or silicon junction type, with a response time of less than 50 nanoseconds. Surge protective devices shall be applied for the following:

a. All 120 VAC power connections to PLCs and instruments. Surge arresters shall be Transtector "ACP-100-HW Series", Power Integrity Corporation “ZTA Series”, Phoenix Contact “Mains PlugTrab”, or MCG Surge Protection “400 Series”.

b. All analog signal circuits where any part of the circuit is outside of the building envelope. Circuits shall be protected at both the transmitter and the control system end of the circuit. Surge protection devices shall not impede or interfere with the use of smart transmitter calibration/communication. Protection devices located near the transmitter shall be Telematic “TP48.” Protection devices in control panels shall be Transtector “PDS Series or FSP Series”, Telematic “SD Series”, Phoenix Contact “PipeTrab Series”, or Citel “BP1-24.”

c. All metallic pair (twisted and untwisted) conductor local area network and data highway termination points, where any part of the data highway cable is routed outside of the building envelope. Single-port protective devices shall be Phoenix Contact “PlugTrab Series”, Transtector “FSP Series”, or Telematic “NP Series.”

2-3.13. **Ethernet Network Hardware.** Ethernet network hardware shall be provided as specified and/or as shown on the Drawings. All specified functionality of provided Ethernet network equipment shall adhere to the IEEE 802 standards. Ethernet Hubs will not be accepted for network systems. Ethernet switches shall be provided to connect multiple network segments together, selectively forwarding traffic between the segments.

2-3.13.01. **Industrial (Panel-Mounted) Ethernet Switches.** Each switch mounted in process areas shall include the following functionality:

a. Ports: Switch shall support the quantity of 10/100BaseTX ports and 100BaseFX fiber ports to meet the functionality indicated on the Drawings, with a minimum of 20% spare auto-negotiating 10/100Base-T, RJ-45 ports, and two multimode fiber uplink ports. A minimum of four UTP ports shall be provided.

b. Each switch connection shall automatically sense the network speed of the devices to which it is connected.
c. Capable of ring-based media redundancy with 30 ms recovery time.
e. Prioritization: IEEE 802.1p QoS Support.
f. Network Segregation: Port VLAN.
g. Management: SNMPv3 and Browser-based management shall be supported.
h. IGMP snooping supported.
i. LED indication of the link activity for each port.
j. Environmental: Suitable for installation in industrial environments. Operating Temperature Range: 0 to 60°C. Optional -40 to 60°C rating availability.
k. Redundant 24 VDC power supply inputs
l. Conformal coating option for use in hazardous environments.
m. Mounting: DIN-rail mounted suitable for panel installation.
n. All necessary memory upgrades, software feature sets, and cables needed for proper operation of these switches shall be furnished with each switch.

Switches shall be GarretCom Magnum 6K Series, Hirschmann RS-20 series, Moxa 508A series, N-Tron 708FX series, SIXNET SL-8MG Series with POE Injector, or equal.

2-3.13.02. Ethernet Connectors. Ethernet wiring connectors shall be RJ-45 male modular plug connectors.

2-3.13.02.01. Standard RJ45 Connectors. Standard connectors shall be polycarbonate, clear connectors. Connectors shall conform to RJ-45 and ISO 8877 standards. Contacts shall be gold plated with a 0.5A current rating and a -25º to 60º C temperature rating. Connectors shall accept unshielded Cat-5e or Cat-6, AWG 24, solid conductor cable.

2-3.13.02.02. Industrial RJ45 Connectors. Industrial connectors shall be an eight position industrial connector for use in manufacturing environments. Connectors shall meet the TIA/EIA-568-B.2 standard for Cat-5e or Cat-6 requirements. The connector shall incorporate an IP67 rated seal and shall provide protection from dust and temporary immersion in water. A tethered protective cap shall be provided. The connector shall accept a non-shielded Cat-5e or Cat-6 solid twisted pair cable. Connectors shall be Panduit Industrial TX5e, or equal.

2-3.13.02.03. Industrial RJ45 Receptacles. Industrial receptacles shall be an eight position industrial, panel mounted pass through receptacle. Receptacles shall meet the TIA/EIA-568-B.2 standard for Cat-5e or Cat-6 requirements.
The receptacle shall incorporate an IP67 rated seal and shall provide protection from
dust and temporary immersion in water. A tethered protective cap shall be provided.
The receptacle shall accept a non-shielded Cat-5e or Cat-6 solid twisted pair cable.
Receptacles shall be Panduit Industrial TX5e, or equal.

shall be provided for a complete and working system, and/or as shown on the Drawings.
Cable for Ethernet wiring shall be UTP Cat-6 cable. Jacket color coding for cables shall
be as follows:

a. Standard Cat-6. Yellow
b. Crossover cables. Red

Cable shall meet the following characteristics:

2-3.14.01. Category 6 UTP Cable. Cat-6 cable shall meet the following requirements:

a. 24 AWG
b. 4 pair solid strand FEP Teflon insulation
c. 100 Ohm impedance
d. 1-250 MHz frequency range
e. Min attenuation 19.9 Db
f. 100 Ohm impedance
g. Min NEXT 44.3dBi/100MHz
h. Min PS-NEXT 42.3dBi/100MHz
i. Min ELFEXT 27.8dB/100MHz
j. Min PS-ELFEXT 24.8dB/100MHz
k. Min return loss 20.1 dB/100 MHz
l. Max delay skew 45 ns
m. Max propagation delay 540 ns

Plenum rated cable shall have FEP insulation jacketing and FEP insulation for
conductors. Non plenum rated cable shall have PVC insulation jacketing and
polyethylene insulation for conductors. Cat-6 cable shall be Belden 1872 or equal.
2-3.14.02. **Ethernet Patch Cables.** Pre-wired and terminated patch cables with RJ-45 connectors and lever protecting boot shall be furnished for all connections to computers, network equipment and programmable logic controller equipment except where physical conditions (i.e. length over 12 ft. or conduit size) require unterminated wire to be installed. Straight through cables shall be wired using the T568-B standard for both connectors as shown in section 3-1.01. Crossover cables shall be wired using the T568-A standard for one connector and the T568-B standard for the opposite end.

2-3.15. **Power Entrance.** The power entrance to each panel shall be provided with a surge protection device. Refer to the Instrumentation and Controls section for surge suppression requirements.

2-3.16. **Power Wiring.** Power distribution wiring on the line side of panel fuses shall be minimum 12 AWG. Secondary power distribution wiring shall be minimum 14 AWG. Wiring for ac power distribution, dc power distribution, intrinsically safe, and control circuits shall have different colors and shall agree with the color-coding legend on System Supplier's panel wiring diagrams. With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, insulated for not less than 600 volts, with a moisture resistant and flame retardant covering rated for not less than 90°C.

2-3.17. **Instrument and Control Wiring.** All internal panel wiring shall be type MTW stranded copper wiring rated not less than 600 volts. Electronic analog circuits shall be twisted and shielded pairs rated not less than 300 volts. Analog circuits shall be separated from ac power circuits. Intrinsically safe circuits shall be physically separated from other circuits in accordance with applicable codes. Wires within the panel shall conform to the minimum size as shown in the table below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Min. Wire Size</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Control</td>
<td>16 AWG</td>
<td>Red</td>
</tr>
<tr>
<td>DC Control</td>
<td>16 AWG</td>
<td>Blue</td>
</tr>
<tr>
<td>Analog Circuits</td>
<td>18 AWG Twisted Pair</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

All wiring shall be grouped or cabled and firmly supported inside the panel. Each individual wire in power, control, and instrumentation circuits shall be provided with identification markers at each point of termination. The wire markers shall be positioned to be readily visible for inspection and the identification numbers shall match the identification on the supplier's panel wiring drawings. Wiring shall be bundled in groups and bound with nylon cable ties or routed in Panduit or similar nonmetallic slotted ducts. Ducts shall be readily accessible within the panel, with removable covers, and with space equal to at least 40 percent of the depth of the duct remaining available for future use after completion of installation and field wiring.
Panel Mounted Instruments
17561-9

Sufficient space shall be provided between cable groups or ducts and terminal blocks for easy installation or removal of cables.

2-3.18. **Terminal Blocks.** Terminal blocks for external connections shall be suitable for 12 AWG wire and shall be rated 30 amperes at not less than 300 volts. Terminal blocks shall be fabricated complete with marking strip, covers, and pressure connectors. Terminals shall be labeled to agree with identification shown on the supplier's submittal drawings. A terminal shall be provided for each conductor of external circuits, plus one ground for each shielded cable. Not less than 8 inches of clearance shall be provided between the terminal strips and the base of vertical panels for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. Each control loop or system shall be individually fused, and all fuses or circuit breakers shall be clearly labeled and located for easy maintenance.

PART 3 – EXECUTION

3-1 **FIELD SERVICES.** Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section. Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

END OF SECTION
PART 1 - GENERAL.

1-1. **SCOPE.** This section covers the furnishing of all process analytical instruments and accessories required for the Instrumentation and Control System as specified herein or as indicated on the Drawings.

Equipment and services provided under this section shall be subject to the Instrumentation and Control System section. This section shall be used and referenced only in conjunction with the Instrumentation and Control System section. Supplementing the Instrumentation and Control System section, instrument data, special requirements, and options are indicated on the Drawings.

When multiple instruments of a particular type are specified, and each requires different features, the required features are described on the Drawings.

1-2. **DESIGN CRITERIA.** Each device shall be a pre-assembled, packaged unit. Upon delivery to the work site, each device or system shall be ready for installation with only minor piping and electrical connections required by Contractor.

Primary elements shall derive any required power from the transmitter, unless otherwise indicated.

The instruments shall be installed to measure, monitor, or display the specified process at the ranges and service conditions indicated on the Drawings. The instruments shall be installed at the locations indicated on the Drawings.

Where possible, each instrument shall be factory calibrated to the calibration ranges on the Drawings. Transmitters or similar measurement instruments shall be calibrated using National Institute of Standards and Technology (NIST) approved bench calibration procedures, when such procedures exist for the instrument type. Calibration data shall be stored digitally in each device, including the instrument tag designation indicated on the Drawings.

1-3. **SUBMITTALS.** Submittals shall be made as specified in the Instrumentation and Control System Section.
1-4. **SHIPMENT, PROTECTION, AND STORAGE.** Equipment provided under this section shall be shipped, protected, and stored as specified in the Instrumentation and Control System section. Identification of packaging shall be as described in as specified in the Instrumentation and Control System section.

1-4.01. **Cleaning.** Instruments indicated to be utilized in oxygen, ozone, or similar service shall be cleaned for oxygen service, labeled appropriately, and bagged or packaged as necessary to ensure the instrument will remain suitable for insertion in the process during installation. Any special mounting or installation requirements associated with such instruments shall be detailed on tags attached to the instrument.

**PART 2 - PRODUCTS**

2-1. **GENERAL.** The following paragraphs provide minimum device stipulations. The Drawings shall be used to determine any additional instrument options, requirements, or service conditions.

2-1.01. **Interconnecting Cable.** For instruments where the primary element and transmitter are physically separated, interconnecting cable from the element to the transmitter shall be provided. The cable shall be the type approved by the instrument manufacturer for the intended purpose of interfacing the element to the transmitter. Length of cable shall be a minimum of three meters or as indicated in the Drawings.

2-1.02. **Programming Device.** For instruments that require a dedicated programming device for calibration, maintenance, or troubleshooting, one such programming device shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). The programming device shall include appropriate operation manuals and shall be included in the training requirements. For systems that allow the programming device functions to be implemented in software, running on a laptop computer, the software shall be provided instead of the programming device.

2-1.03. **Configuration Software/Serial Interface.** Devices indicated as requiring a serial interface shall be provided with all accessories required to properly communicate over the serial link. An appropriate cable shall be provided to allow the transmitter serial interface to be connected to a personal computer. One licensed copy of the diagnostic/interface software shall be provided for each Owner facility (quantity required shall be as indicated in the Instrumentation and Control System section). Software shall be capable of running under Microsoft’s Windows 10 operating system. If the software furnished performs the same functions as the programming device, specified elsewhere, then the programming device shall not be furnished.

2-2. **PROCESS LIQUID ANALYTICAL INSTRUMENTATION.** Not used.
2-3. PROCESS GAS ANALYTICAL INSTRUMENTATION.

2-3.01. Gas Detector Systems. Gas detector systems shall be furnished complete with sensors, power supplies, alarm modules, enclosures, and appurtenant devices suitable for detecting gases as indicated on the Drawings or as listed in this section. Detector systems shall be located as indicated on the Drawings.

Gases to be detected and associated detector sensor ranges and nominal alarm setpoints shall be as follows:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Nominal Range</th>
<th>Nominal “Warning” and &quot;Alarm&quot; Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Sulfide (H₂S)</td>
<td>0-10 ppm</td>
<td>or 0.5 ppm/1 ppm</td>
</tr>
<tr>
<td></td>
<td>0-50 ppm</td>
<td></td>
</tr>
</tbody>
</table>

Accuracy of each gas detector system shall be 2 percent of full scale, and zero drift shall not exceed 5 percent per year. Gas detector systems shall be suitable for an operating temperature range of 0 to 122°F [50°C].

Gas detector systems shall be Scott Instruments Freedom 5000/Series 7400; Thermo GasTech "SafeTnet" series; or MSA Ultima X Series.

2-3.01.01. Sensors. Sensors shall be of the remote mounted diffusion cell type contained in corrosion resistant weatherproof housings. Sensors shall be rated either intrinsically safe or explosion proof, and shall be suitable for the environment in which they will be located. Sensors shall not require any addition of chemical reagents and shall require no routine maintenance other than calibration checks. Combustible gas sensors shall not be adversely affected by exposure to hydrogen sulfide gases. Minimum sensor life shall be 1 year. A sufficient length of cable shall be provided for connecting the sensor to the alarm module enclosure. The transmitter shall be provided with a serial output for instrument diagnostics and process monitoring.

2-3.01.02. Receiver-Alarm Modules. Each gas detector system shall be provided with a receiver-alarm module for each sensor. The receiver-alarm modules shall be housed in weatherproof NEMA 4X enclosures suitable for an operating temperature of -4°F [-20°C] to 122°F [50°C], with a relative humidity of 5 to 95 percent. Each alarm module shall have a separate, three-digit LED or LCD readout with units of the corresponding sensor engraved on the module face or included on the LCD readout. Each module shall have two independently adjustable alarm points, one labeled "warning" and one labeled "alarm".
Each alarm point, plus a module fail alarm point shall actuate separate relays with single-pole, double-throw contacts, rated 3 amp [A] at 120 V ac, and shall illuminate three alarm lights on the module face. Modules shall be of the ac-powered type and shall be designed with failsafe circuitry, so the alarm contacts fail in the alarm condition upon power or sensor failure. Each alarm module shall actuate a local alarm horn or buzzer at the unit, which can be silenced with a button on the unit. Each alarm module shall have an isolated 4-20 mA dc output signal representing the calibrated range of the detector system and capable of driving an external 250 ohm load.

2-3.01.03. **Gas Detector Calibration Kit.** A calibration kit shall be provided for use in field calibration of each gas detector. The calibration kit shall contain all necessary fittings, calibration gases, and hoses required for not less than 12 field calibration checks of each gas detector, after final acceptance of the system.

2-3.01.04. **Spare Sensors.** One spare sensor shall be provided for each sensor in the gas detector system. Spare sensors shall be provided in addition to any replacement sensors required during the warranty period, even if the warranty period exceeds the normal expected life of the sensor. Delivery schedule for the spare sensors shall be as recommended by the manufacturer and as coordinated with Owner.

2-3.02. **Low Concentration Ozone Analyzers.** Not used.

2-3.03. **High Concentration Ozone Analyzers.** Not used.

2-3.04. **Oxygen Purity Analyzers.** Not used.

2-3.05. **Dewpoint Analyzers.** Not used.

2-3.06. **Hydrocarbon Analyzers.** Not used.

2-4. **MISCELLANEOUS INSTRUMENTATION.**

2-4.01. **Instrument Shutoff Valves.** Instrument shutoff valves shall be provided for instruments as indicated on the Drawings and as detailed in the specifications. The indicated shutoff valves shall be provided by System Supplier for all instruments furnished. Shutoff valves shall be compatible with the measured process and shall be selected in accordance with the manufacturer’s recommendations for the specified process. Unused ports of multi-port gauge valves shall be plugged. An instrument shutoff valve schedule shall be submitted indicating the quantity, material, size, and associated instrument. Permanent tagging of the instrument valves is not required. However, temporary hand-written tags or other means of identification shall be provided to ensure that the appropriate valve is installed for a given instrument.
Instrument shutoff valves shall be D/A Manufacturing, Anderson-Greenwood, or equal.

PART 3 - EXECUTION

3-1. FIELD SERVICES. Manufacturer's field services shall be provided for installation, field calibration, startup, and training as specified in the Instrumentation and Control System section.

Instruments shall not be shipped to the Work Site until two weeks prior to the scheduled installation. System Supplier shall be responsible for coordinating the installation schedule with the Installation Contractor. Each shipment shall contain a listing of protective measures required to maintain sensor operation, including a listing of any common construction or cleaning chemicals that may affect instrument operation.

END OF SECTION
Appendix A

APPROVED MATERIALS LIST
(Capital & Developer Projects)

UPDATED
10.19.2018
### Purpose and General Notes

#### I. GENERAL

1. BACKFLOW PREVENTION & DETECTOR ASSEMBLIES ........................................ 5
2. FIRE HYDRANTS ............................................................................................... 6
3. GASKETS & GROMMETS ................................................................................ 8
4. METER BOXES & VAULTS ................................................................................. 9
5. METERS & METER COMPONENTS ................................................................. 11
6. NUTS & BOLTS ............................................................................................... 13
7. PAINT SCHEDULE ............................................................................................. 14
8. SERVICE SADDLES & TAPPING SLEEVES ..................................................... 15
9. UNDER-GROUND UTILITY MARKING TAPE ................................................... 18
10. WATER PIPE & TUBING ................................................................................ 19

#### II. FITTINGS

1. BRASS SERVICE FITTINGS ............................................................................. 22
2. DUCTILE IRON FITTINGS ................................................................................ 24
3. FLANGES ......................................................................................................... 25
4. FLEX COUPLINGS & FLEXIBLE EXPANSION JOINTS ................................ 26
5. PIPELINE FITTINGS ......................................................................................... 27
6. VICTAULIC COUPLINGS & FITTINGS ............................................................ 29
7. WELDED STEEL FITTINGS ............................................................................. 30

#### III. VALVES

1. AIR VALVES ..................................................................................................... 32
2. APPURTENANCES ............................................................................................ 33
3. BALL VALVES .................................................................................................. 34
4. BUTTERFLY VALVES ....................................................................................... 35
5. CHECK VALVES ............................................................................................... 36
6. CONTROL VALVES .......................................................................................... 37
7. GATE VALVES .................................................................................................. 39
8. PLUG VALVES .................................................................................................. 42

#### IV. SEWER

1. MANHOLES & CLEAN-OUTS ......................................................................... 44
2. SEWER PIPE & FITTINGS ................................................................................ 46

#### V. ELECTRICAL

1. WIRING & BASIC ELECTRICAL MATERIALS ................................................ 49
Purpose and General Notes

The purpose of the Approved Materials List is to streamline the materials submittal and review process during construction. Contractors are strongly encouraged to use materials from the Approved Materials List as these will be expedited and do not require a full technical submittal for review by the District prior to material approval, except for pipe submittals. All pipe materials shall be submitted for review and approval. However, Contractors must submit and identify that materials to be used comply with the approved list and/or current Specifications.

Use of “or equal” materials will require a formal and complete submittal subject to review by the Materials Approval Committee (MAC) prior to approval. Any schedule delays as a result of a submittal or use of “or equal” materials will be the sole responsibility of the Contractor.

In the event of a conflict between approved/contract drawings and the Approved Materials List, the approved/contract drawings shall take precedence.

All materials used for potable water systems must meet California Health and Safety Code 116875 (previously AB1953). All materials that come into contact with potable water must be NSF certified or approved (http://www.nsf.org/). All potable water material submittals must include evidence of NSF certification. Please contact staff if any Model numbers listed are out of date or no longer available.

Vendors and Manufacturers wishing to add materials or products to the Approved Materials List shall follow the Vendor Submittal Requirements (http://www.emwd.org/home/showdocument?id=2980) to make a formal submittal to the MAC. Please contact staff for more information.
I. GENERAL
### 1. BACKFLOW PREVENTION & DETECTOR ASSEMBLIES

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Double Check Assemblies (¾” thru 10”) (For Non-Toxic Service)</td>
<td>AMES</td>
</tr>
<tr>
<td>2. Double Check Detector Assemblies (¾” thru 10”) Std. Dwg. No. B-657 (For Automatic Sprinkler Systems Containing Non-Toxic Substance)</td>
<td>FEBCO</td>
</tr>
<tr>
<td>3. R.P. – Reduced Pressure Assemblies (¾” thru 10”) (For High Hazard Service)</td>
<td>MUELLER</td>
</tr>
<tr>
<td>4. R.P. – Reduced Pressure Detector Assemblies (2 ½” thru 10”) (For Automatic Fire Sprinkler Systems Containing Toxic Substances)</td>
<td>PRATT-WATTS</td>
</tr>
<tr>
<td></td>
<td>WILKINS</td>
</tr>
<tr>
<td>Note: Backflow prevention materials and detector assemblies shall be one of the above listed manufacturers and shall be listed per latest edition of USC-Foundation for Cross-Connection Control and Hydraulic Research “List of Approved Backflow Prevention Assemblies” A web link to the USC list is located at:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><a href="http://www.usc.edu/dept/fccchr/list.html">http://www.usc.edu/dept/fccchr/list.html</a></td>
</tr>
</tbody>
</table>
## 2. FIRE HYDRANTS

### 1 of 2

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. BLOW-OFF HYDRANT</strong></td>
<td>JONES</td>
</tr>
<tr>
<td>Model: J-344 – 4” x 1-2 ½”</td>
<td>Model: J-344 – 4” x 1-2 ½”</td>
</tr>
<tr>
<td>(EMWD Std. Drawings B-568 &amp; B-561)</td>
<td>(EMWD Std. Drawings B-568 &amp; B-561)</td>
</tr>
<tr>
<td>Model: J-342 – 2” x 1-2 ½”</td>
<td>Model: J-342 – 2” x 1-2 ½”</td>
</tr>
<tr>
<td>(EMWD Std. Drawing B-374)</td>
<td>(EMWD Std. Drawing B-374)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>2. BREAK-OFF CHECK VALVE</strong></th>
<th>LONG BEACH IRON WORKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 400 (for special locations only as determined by Water Operations)</td>
<td></td>
</tr>
</tbody>
</table>

| **3. INTERMEDIATE HYDRANT** | CLOW                                |
| 6” x 2-2 ½”                | Model: Clow Rich Ranger 945        |
| Std. Drawings B-360 & B-354 |                                   |
| JONES                       | Model: J-3720                      |
|                             | LONG BEACH IRON                    |
|                             | Model: 601-613 Rich East Bay      |

| **4. STANDARD HYDRANT**     | AVK                                 |
| 6” x 1-4” x 12 ½”          | Model: 70 (24-70) Series 24        |
| Std. Drawings B-362 & B-356 |                                   |
| CLOW                        | Model: El Rancho 2050 Bronze       |
|                             | Model: Ranger 850                  |
|                             | Model: F850, F860 Cast Iron        |
| JONES                       | Model: J-3700 Bronze               |
|                             | Model: J-4040, J-4060 Cast Iron    |
|                             | LONG BEACH IRON                    |
|                             | Model: Series 125 Bronze (New Pattern) |
|                             | Model: 611 East Bay                |
## 2. FIRE HYDRANTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5. SUPER HYDRANT</strong></td>
<td></td>
</tr>
<tr>
<td>6” x 1-4” x 2-2 ½”</td>
<td>AVK</td>
</tr>
<tr>
<td>Std. Drawings B-516 &amp; B-517</td>
<td>Model: 90 (24-90) Series 24</td>
</tr>
<tr>
<td></td>
<td>CLOW</td>
</tr>
<tr>
<td></td>
<td>Model: El Rancho 2060 Bronze</td>
</tr>
<tr>
<td></td>
<td>Model: 860</td>
</tr>
<tr>
<td></td>
<td>JONES</td>
</tr>
<tr>
<td></td>
<td>Model: J-3765 Bronze</td>
</tr>
<tr>
<td></td>
<td>LONG BEACH IRON</td>
</tr>
<tr>
<td></td>
<td>Model: LBIW 615</td>
</tr>
<tr>
<td></td>
<td>Model: Series 130 Bronze (New Pattern)</td>
</tr>
<tr>
<td><strong>6. WARFHEAD HYDRANT</strong></td>
<td>JONES</td>
</tr>
<tr>
<td>4” x 1-2 ½”</td>
<td>Model: J-344 HP</td>
</tr>
<tr>
<td>Std. Drawings B-368 &amp; B-357</td>
<td></td>
</tr>
</tbody>
</table>
### 3. GASKETS & GROMMETS

#### Detailed Provisions Section 15081

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hand Hole Liner Grommets</td>
<td>DIVE/CORR, INC.</td>
</tr>
<tr>
<td>For reservoir roof openings</td>
<td></td>
</tr>
<tr>
<td>2. Meter Gaskets</td>
<td>JONES</td>
</tr>
<tr>
<td>For water meter installations</td>
<td>Model 136: ¾” x 1/16” Leather Meter Washers</td>
</tr>
<tr>
<td></td>
<td>Model 137: 1” x 1/16” Leather Meter Washers</td>
</tr>
<tr>
<td></td>
<td>1 ½” &amp; 2” Rubber-Cloth-Inserted Drop-In Meter</td>
</tr>
<tr>
<td></td>
<td>Gasket</td>
</tr>
<tr>
<td>3. Ring and Full Face Gaskets</td>
<td>GARLOCK</td>
</tr>
<tr>
<td>Gaskets for steel and cast iron flanges</td>
<td>Blue-Gard Style 3000, compressed non-asbestos</td>
</tr>
<tr>
<td>shall conform to the requirements of EMWD</td>
<td>(CNA)</td>
</tr>
<tr>
<td>Std. Drawing B-288 and shall be standard full</td>
<td>TRIPAC</td>
</tr>
<tr>
<td>face for pipe 27” diameter and larger.</td>
<td>Style 5000, non-asbestos</td>
</tr>
</tbody>
</table>

---

**Appendix A**

Rev: 10/19/18
# 4. METER BOXES & VAULTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Meter Boxes</td>
<td>EISEL ENTERPRISES (H &amp; C)</td>
</tr>
<tr>
<td>Concrete or Polymer</td>
<td></td>
</tr>
<tr>
<td>Concrete EMWD Std.</td>
<td>17” x 30” Model No. 666B</td>
</tr>
<tr>
<td>Drawing B-590, B-591, B-342, B-344</td>
<td>30” x 48” Model No. 68MB</td>
</tr>
<tr>
<td>J &amp; R CONCRETE</td>
<td></td>
</tr>
<tr>
<td>12” x 20” Model No. 4 ½ (No. 37) Polymer Concrete</td>
<td>13” x 24” Model No.W5 ¼ P (No.38) Polymer Concrete</td>
</tr>
<tr>
<td>17” x 30” Model No. 6B</td>
<td>30” x 48” Model No. 8</td>
</tr>
<tr>
<td>BROOKS PRODUCTS</td>
<td></td>
</tr>
<tr>
<td>17” x 30” Model No. 66</td>
<td>30” x 48” Model No. 68</td>
</tr>
<tr>
<td>ARMORCAST PRODUCTS</td>
<td></td>
</tr>
<tr>
<td>12” x 20” A6000485SA (No.37) Polymer Concrete</td>
<td>13” x 24” A6001946PC-12 (No.38) 1” Polymer Concrete</td>
</tr>
<tr>
<td>ASSOCIATED CONCRETE PRODUCTS</td>
<td></td>
</tr>
<tr>
<td>12” x 20” Cat #WPB111812C21 (#437) Polymer Concrete</td>
<td>13” x 24” Cat #WPB132412A21 (#438) Polymer Concrete</td>
</tr>
<tr>
<td>12” x 20” Cat #WPC1118RLC11</td>
<td></td>
</tr>
<tr>
<td>13” x 24” Cat #WPC1324RLC11</td>
<td></td>
</tr>
<tr>
<td>2. Meter Box Lid Covers</td>
<td>J&amp;R CONCRETE</td>
</tr>
<tr>
<td>Domestic Meter Box Lid Covers (PC 412 QRP)</td>
<td>ARMOR CAST PRODUCTS</td>
</tr>
<tr>
<td>Domestic Meter Box Lid Covers (A6000484-H1)</td>
<td></td>
</tr>
</tbody>
</table>
## 4. METER BOXES & VAULTS

### 3. Utility Vaults

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SIZE</strong></td>
<td><strong>BROOKS CONCRETE PRODUCTS</strong></td>
</tr>
<tr>
<td>4’ x 4’</td>
<td>#W-300 Series</td>
</tr>
<tr>
<td>4’ x 6’6”</td>
<td>#W-500 Series</td>
</tr>
<tr>
<td>4’6” x 8’6”</td>
<td>#W-510 Series</td>
</tr>
<tr>
<td>4’ x 7’9”</td>
<td>#W-600 Series</td>
</tr>
<tr>
<td>4’6” x 10’6”</td>
<td>#W-610 Series</td>
</tr>
<tr>
<td>6’ x 8’</td>
<td>#W-680 Series</td>
</tr>
</tbody>
</table>

### 4. Valve Boxes

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BROOKS CONCRETE PRODUCTS</strong></td>
<td><strong>EISEL ENTERPRISES</strong></td>
</tr>
<tr>
<td>#1-RD</td>
<td>#1R-VB-CC</td>
</tr>
<tr>
<td>#1-RT</td>
<td>#2VB-VC</td>
</tr>
<tr>
<td>#3-RT</td>
<td>#10VB-VC</td>
</tr>
<tr>
<td>#4-TT</td>
<td>#4TT VB-VC</td>
</tr>
<tr>
<td>#1-SP</td>
<td>#1RVB-CC</td>
</tr>
</tbody>
</table>

### 5. Vaults

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BEST CONCRETE PRODUCTS</strong></td>
<td><strong>ASSOCIATE CONCRETE</strong></td>
</tr>
<tr>
<td>Models MCT-4 and MCT-5</td>
<td>As approved by Engineering</td>
</tr>
</tbody>
</table>
## 5. METERS & METER COMPONENTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Compound Meters 3” thru 6” (cubic feet register)</td>
<td>SENSUS TECH. INC. Omni C-2 (AMI/AMR Sensus Flex Net, ERC Register)</td>
</tr>
<tr>
<td>2. Electromagnetic Meter 4” thru 10” (domestic) (cubic feet register)</td>
<td>SENSUS TECH. INC. Model Series DRFS &amp; CFS (Must be with ECR 2 or 3 registers &amp; Absolute Encoder Technology)</td>
</tr>
</tbody>
</table>
| 3. Fire Service Meters (Cubic feet registers) strainer required | ENDRESS & HAUSER Promag 53 W Electromagnetic FlowmeterRemote Mounted Transmitter  
   i) Input/Output Signal Type: Current/HART, frequency, relay, and status input (flexible module)  
   ii) NEMA 4X/remote wall mounted housing or Panel mount depending on application/location  
   iii) 120 VAC, with display, touch control operation |
| 4. Mag Meters  
  These are the model #’s with options required.  
  Additional specification, i.e. liner, electrodes, size, etc., will be required depending on the meter application | ABB Electromagnetic Flowmeter WaterMaster FEP/FET300  
Flowmeter system, optimized full bore  
Remote Mounted Transmitter  
   i) Three line back-lit graphical display  
   ii) NEMA 4X / remote wall mounted housing or Panel mount depending on application/location  
   iii) Power Supply: 120 VAC  
   iv) Input/Output Signal Type: HART + 20 mA + pulse + contact output |
| | SIEMENS Sensor SITRANS F M MAG 5100 W MAG 6000, Polyamid, 120 VAC  
Remote Mounted Transmitter  
   i) Remote Mounted Transmitter  
   ii) NEMA 4X / remote wall mounted housing or Panel mount depending on application/location  
Cables Required  
   FDK001STCAB_ _ _  
   FDK001SPCAB_ _ _  
   iii) MODBUS RTU/RS 485  
Input/Output Signal Type: 4-20 mA output, pulse/frequency and relay output |

All meters must be grounded in accordance with manufacturer’s recommendations.
### 5. METERS & METER COMPONENTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
</table>
| 5. Multi-Jet Water Meter | MASTER METER  
AWWA (cubic-feet register) Std. Drawings B-590, B-591, B-342, & B-344  
3/8” x ¼”: BLO5-2VA-NAA-2 MJ Meters with Acculinx Registers Lead Free Body w/Plastic Bottom, Cubic Feet W/Sensus 520m TP6 Potted  
1” meter: BLO5-2VA-NNA-2 MJ. w/Acculinx register, Lead free body w/bronze bottom, CCF registration, w/Sensus 520M TP6 Potted  
1½” meter: MJ11-2VA-NNA-2 w/Acculinx register. Lead free body w/bronze bottom, CCF registration, w/Sensus 520M TP6 Potted  
2” meter: MJ13-2VA-NNA-2 w/Acculinx register. Lead free body w/bronze bottom, CCF registration, w/Sensus 520M TP6 Potted |
| 6. Propeller Flow Meters-Pumping Plants & Agriculture | MCCROMETER  
(ECR Register AMI/AMR, FlexNet compatible, acre-feet register)  
MG-900-series  
MW-900-series  
MW-500-series  
SENSUS Tech, Inc.  
101  
102 |
| 7. Sports Hydrant Meters | PERFORMANCE METER INC.  
Model No. FHS20 (Must be with a 2” inch gate valve) |
| 8. Turbine Meters | SENSUS TECH. INC.  
Model Omni T2 (Turbine) 1.5” thru 6” (ECR Register AMI/AMR Flex Net)  
PERFORMANCE METER INC.  
Model No. FHS20 (Must be with a 2” inch gate valve) |

A. Landscape  
Strainer required  
2” & smaller to have cubic feet registers  
3” & larger to have acre feet register

B. Domestic  
Cubic feet register
6. **NUTS & BOLTS**  
**Detailed Provisions Section 15089**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nuts &amp; Bolts For Flanged Fittings</td>
<td></td>
</tr>
<tr>
<td>Shall be bare steel conforming to SAE-J429 Grade 5 or ASTM A449 medium carbon steel quenched and tempered, meeting the following requirements, and shall have hex heads and lite pattern hex nuts</td>
<td></td>
</tr>
<tr>
<td><strong>¾” thru 1” Diameter</strong></td>
<td></td>
</tr>
<tr>
<td>Proof Strength – 85,000 PSI</td>
<td></td>
</tr>
<tr>
<td>Yield Strength – 92,000 PSI</td>
<td></td>
</tr>
<tr>
<td>Tensile Strength – 120,000 PSI</td>
<td></td>
</tr>
<tr>
<td><strong>1” thru 1 ½” Diameter</strong></td>
<td></td>
</tr>
<tr>
<td>Proof Strength – 74,000 PSI</td>
<td></td>
</tr>
<tr>
<td>Yield Strength – 81,000 PSI</td>
<td></td>
</tr>
<tr>
<td>Tensile Strength – 105,000 PSI</td>
<td></td>
</tr>
<tr>
<td>2. Nuts &amp; Bolts for 1 ½” &amp; 2” Meter Installations</td>
<td>RELIANCE</td>
</tr>
<tr>
<td>½ x 2 ½” Silicon Bronze Hex head. Bolts w/ Bronze Hex Nuts</td>
<td></td>
</tr>
<tr>
<td>3. Zinc Caps</td>
<td>MARS</td>
</tr>
</tbody>
</table>
# 7. PAINT SCHEDULE

<table>
<thead>
<tr>
<th>Item</th>
<th>Color*</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aerator &amp; Clarifier Spray Headers, Effluent Pumps, &amp; Piping</td>
<td>OSHA Safety Red</td>
<td>Sherwin-Williams</td>
</tr>
<tr>
<td>2. Air Valve Assemblies</td>
<td>Koala Bear</td>
<td></td>
</tr>
<tr>
<td>3. Chlorine</td>
<td>OSHA Safety Orange</td>
<td></td>
</tr>
<tr>
<td>4. Electrical</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>5. Fire Hydrants</td>
<td>OSHA Safety Yellow</td>
<td></td>
</tr>
<tr>
<td>6. Fire Hydrant Tops and Nozzle Caps</td>
<td>Red = 500 gpm or less Orange = 500-999 gpm Green = 1000-1499 gpm Light Blue = 1500 gpm or greater</td>
<td></td>
</tr>
<tr>
<td>7. Natural Gas Pipe</td>
<td>OSHA Safety Yellow</td>
<td></td>
</tr>
<tr>
<td>8. Hydrogen Peroxide (H₂O₂) Equipment</td>
<td>OSHA Safety Yellow</td>
<td></td>
</tr>
<tr>
<td>9. High &amp; Low Pressure Air</td>
<td>OSHA Safety Green</td>
<td></td>
</tr>
<tr>
<td>10. Oil</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>11. Potable Water – Pumps, Piping and Appurtenances</td>
<td>Pale Blue / Desert Tan</td>
<td></td>
</tr>
<tr>
<td>12. Reclaimed Water – Piping and Appurtenances</td>
<td>Pantone Purple #513 C or #522 C</td>
<td></td>
</tr>
<tr>
<td>13. Sludge Sewage - Pumps, Piping, and Appurtenances</td>
<td>Rich Brown</td>
<td></td>
</tr>
<tr>
<td>14. Steam Lines</td>
<td>Pale Blue</td>
<td></td>
</tr>
<tr>
<td>15. Water Storage Tanks</td>
<td>Fawn / Buffalo</td>
<td></td>
</tr>
<tr>
<td>16. Water Valve Caps</td>
<td>Pale Blue</td>
<td></td>
</tr>
</tbody>
</table>

*Color shall be selected by Engineering Department staff such that facility blends in with the surrounding (existing terrain) or to ensure permit requirements/conditions of approval are satisfied.
## 8. SERVICE SADDLES & TAPPING SLEEVES

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. *Service Saddles for A.C. Pipe 4” thru 12”</td>
<td>JONES</td>
</tr>
<tr>
<td></td>
<td>Model: J-975</td>
</tr>
<tr>
<td></td>
<td>Model: J-979</td>
</tr>
<tr>
<td>2. Service Saddle for C-900 Pipe ¾” thru 2”</td>
<td>CAMBRIDGE BRASS</td>
</tr>
<tr>
<td></td>
<td>Model: 800 Series Hinged Bronze Saddle</td>
</tr>
<tr>
<td>3. *Service Saddles for C-900 Pipe 4” thru 12”</td>
<td>JONES</td>
</tr>
<tr>
<td></td>
<td>Model: J-996-R</td>
</tr>
<tr>
<td></td>
<td>Model: J-996</td>
</tr>
<tr>
<td></td>
<td>McDONALD</td>
</tr>
<tr>
<td></td>
<td>Model: 3805</td>
</tr>
<tr>
<td></td>
<td>MUELLER</td>
</tr>
<tr>
<td></td>
<td>Model: H-13000</td>
</tr>
<tr>
<td></td>
<td>ROMAC IND.</td>
</tr>
<tr>
<td></td>
<td>Model: B-101</td>
</tr>
<tr>
<td></td>
<td>Model: B-202</td>
</tr>
<tr>
<td></td>
<td>FORD</td>
</tr>
<tr>
<td></td>
<td>Model: S902 and S912 (Style B2 piece bolted design)</td>
</tr>
<tr>
<td>4. *Service Saddles for Ductile Iron Pipe 4” thru 36”</td>
<td>FORD</td>
</tr>
<tr>
<td></td>
<td>Model: F-101</td>
</tr>
<tr>
<td></td>
<td>Model: F-202</td>
</tr>
<tr>
<td></td>
<td>ROMAC IND.</td>
</tr>
<tr>
<td></td>
<td>Model: Romac 101</td>
</tr>
<tr>
<td></td>
<td>Model: Romac 202</td>
</tr>
<tr>
<td></td>
<td>SMITH-BLAIR</td>
</tr>
<tr>
<td></td>
<td>Model: Rockwell 311</td>
</tr>
<tr>
<td></td>
<td>Model: Rockwell 313</td>
</tr>
</tbody>
</table>

*Note: Size 10” & above require double-strap service saddles.*
## 8. SERVICE SADDLES & TAPPING SLEEVES

### 2 of 3

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5. Service Saddles for Steel Pipe Connections</strong></td>
<td></td>
</tr>
<tr>
<td>Weld Saddles 1 - ( \frac{3}{4} )” x 4” thru 48”</td>
<td>INTERNATIONAL FABRICATORS</td>
</tr>
<tr>
<td>Weld Saddles 2 - ( \frac{1}{2} )” x 4” thru 48”</td>
<td>NORTHWEST PIPE COMPANY (AMERON)</td>
</tr>
<tr>
<td>Refer to Std. Drawing B-271</td>
<td>SOUTHLAND PIPE CO.</td>
</tr>
<tr>
<td></td>
<td>WEST COAST PIPE</td>
</tr>
<tr>
<td><strong>6. Tapping Sleeves for A.C., PVC, &amp; D.I.</strong></td>
<td></td>
</tr>
<tr>
<td>4” thru 24”</td>
<td>FORD PRODUCTS</td>
</tr>
<tr>
<td></td>
<td>Model: Fast-Sleeve” 18-8 All Stainless Steel</td>
</tr>
<tr>
<td></td>
<td>JCM IND.</td>
</tr>
<tr>
<td></td>
<td>Model: JCM-432 All Stainless Steel</td>
</tr>
<tr>
<td></td>
<td>Model: JCM-452 All Stainless Steel (14” &amp; above)</td>
</tr>
<tr>
<td></td>
<td>POWERSEAL PRODUCTS</td>
</tr>
<tr>
<td></td>
<td>Model: 3490 All Stainless Steel</td>
</tr>
<tr>
<td></td>
<td>ROMAC IND.</td>
</tr>
<tr>
<td></td>
<td>Model: SST 18-8 All Stainless Steel</td>
</tr>
<tr>
<td></td>
<td>SMITH BLAIR. INC.</td>
</tr>
<tr>
<td></td>
<td>Model: 663 (4” thru 24”)</td>
</tr>
<tr>
<td></td>
<td>Model: 665 (6” thru 12”)</td>
</tr>
<tr>
<td></td>
<td>ROBAR</td>
</tr>
<tr>
<td></td>
<td>Model: 6606</td>
</tr>
</tbody>
</table>
7. **Weld Saddles**  
   Std. Drawing B-271  
   Epoxy, Coated Fabricated Steel Outlet  
   Scotch 3M – #206N  
   Schedule 40 Pipe on 4” thru 10”  
   ¼” Wall Pipe on 12” & above

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Weld Saddles</td>
<td>INTERNATIONAL FABRICATORS</td>
</tr>
<tr>
<td>Std. Drawing B-271</td>
<td>NORTHWEST PIPE COMPANY (AMERON)</td>
</tr>
<tr>
<td>Epoxy, Coated Fabricated Steel Outlet</td>
<td>SOUTHLAND PIPE CO.</td>
</tr>
<tr>
<td>Scotch 3M – #206N</td>
<td>WEST COAST PIPE</td>
</tr>
<tr>
<td>Schedule 40 Pipe on 4” thru 10”</td>
<td></td>
</tr>
<tr>
<td>¼” Wall Pipe on 12” &amp; above</td>
<td></td>
</tr>
</tbody>
</table>
9. **UNDER-GROUND UTILITY MARKING TAPE**  
(Non-Detectable Only)

<table>
<thead>
<tr>
<th>Description</th>
<th>Color Code: A.P.W.A.</th>
<th>Manufacturers</th>
</tr>
</thead>
</table>
Thor |
| Underground utility marking tape shall be in accordance with the A.P.W.A. National Color Code and shall be imprinted with an appropriate legend to define the type of utility line it protects. | SAFETY BLUE – Potable Water Systems | REEF INDUSTRIES  
Terra Tape |
| | SAFETY GREEN – Sanitary and Storm Sewer Systems | |
| | SAFETY ORANGE – Telephone, Cable & Telegraph Systems | |
| | SAFETY PURPLE – Reclaimed Water Lines | |
| | SAFETY RED – Electric Power & Systems | |
| | SAFETY YELLOW – Gas & Oil | |
| Tape shall be of a pigmented polyolefin film with a printed message on one side. The ink used to print the materials shall be permanent and cannot be removed by normal handling or upon underground burial. | | |
| The polyethylene shall be chemically inert and shall not degrade when exposed to alkalies, acids, and other destructive substances commonly found in soils. | | |
| Tape shall consist of a 4.0 mil overall thickness or as approved by Engineering. | | |
## 10. WATER PIPE & TUBING

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ductile Iron Pipe</td>
<td>PACIFIC STATES, U.S. PIPE</td>
</tr>
<tr>
<td></td>
<td><a href="#">Detailed Provisions Section 15057</a></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AWWA C-600, C-151, C-150, &amp; C-104</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>High Density Polyethylene Pipe</td>
<td>J-M MANUFACTURING COMPANY, INC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CHEVRON PHILLIPS CHEMICAL COMPANY</td>
</tr>
<tr>
<td>3</td>
<td>High Density Polyethylene Pipe</td>
<td>J-M MANUFACTURING COMPANY, INC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CHEVRON PHILLIPS CHEMICAL COMPANY</td>
</tr>
<tr>
<td>4</td>
<td>Polyvinyl Chloride (PVC)</td>
<td>CARLON PIPE</td>
</tr>
<tr>
<td></td>
<td><a href="#">Detailed Provisions Section 15064</a></td>
<td>CERTAIN-TEED CORP.</td>
</tr>
<tr>
<td></td>
<td>4” thru 36” – C900</td>
<td>JOHN-MANSVILLE CO. – “JM”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NORTH AMERICAN PIPE CORP.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PW PIPE CO.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VINYL-TECH – “White Knight”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DIAMOND PLASTICS CORP. 4” thru 24”</td>
</tr>
<tr>
<td>5</td>
<td>Steel Pipe (Bare)</td>
<td>CONTINENTAL PIPE MAN</td>
</tr>
<tr>
<td></td>
<td>3” thru 10” – standard wall thickness</td>
<td>ROSCOE MOSS</td>
</tr>
<tr>
<td></td>
<td>12” thru 54”, ¼” wall thickness minimum</td>
<td>MID AMERICA PIPE</td>
</tr>
<tr>
<td></td>
<td><a href="#">Steel Certification Required</a></td>
<td>NORTHWEST PIPE COMPANY (AMERON)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WEST COAST PIPE</td>
</tr>
<tr>
<td>6</td>
<td>Steel Pipe (CML&amp;C)</td>
<td>CONTINENTAL PIPE MAN</td>
</tr>
<tr>
<td></td>
<td><a href="#">Detailed Provisions Section 15061</a></td>
<td>ROSCOE MOSS</td>
</tr>
<tr>
<td></td>
<td>AWWA C-200, C-205 &amp; C-303 (all classes)</td>
<td>MID AMERICA PIPE</td>
</tr>
<tr>
<td></td>
<td>4” thru 54”</td>
<td>NORTHWEST PIPE COMPANY (AMERON)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WEST COAST PIPE</td>
</tr>
</tbody>
</table>
# 9. WATER PIPE & TUBING

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Copper Tubing – Type K Soft Water Service Installations ASTM B-88 3⁄4 thru 2”</td>
<td></td>
</tr>
<tr>
<td>2. Copper Tubing – Type L Rigid Backflow Installations ASTM B-88 3⁄4 thru 3”</td>
<td></td>
</tr>
<tr>
<td>3. Liner Insert (Stainless Steel)</td>
<td>FORD CO. #72 JONES CO. J-2806 MUELLER CO. #505142 MCDONALD #6136</td>
</tr>
<tr>
<td>4. Polyethylene Water Service Pipe 1”</td>
<td>DRISCO #5100 Ultraline WESTFLEX Gold Label – Class 200</td>
</tr>
</tbody>
</table>
II. FITTINGS
## 1. BRASS SERVICE FITTINGS

**Std. Drawings B-590 – B-591A**

1” thru 2” B-342 – B344B

<table>
<thead>
<tr>
<th>Item</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ¾-BEND (90 Ell)</td>
<td>CAMBRIDGE</td>
</tr>
<tr>
<td>105 (Series)</td>
<td>105 (Series)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Angle Meter Stop</td>
<td>210 (Series)</td>
</tr>
<tr>
<td></td>
<td>105 (Series)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Corp Stop Ballcorp</td>
<td>FB700-NL (series)</td>
</tr>
<tr>
<td></td>
<td>FB1000-NL (series)</td>
</tr>
<tr>
<td></td>
<td>FB1100-NL (series)</td>
</tr>
<tr>
<td>4. Corp Stop Keycorp</td>
<td>301 (Series)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Liner Inserts</td>
<td>Ford-72</td>
</tr>
<tr>
<td>6. Meter Bushings 1 ¼”x 1”</td>
<td>FORD-34-NL</td>
</tr>
<tr>
<td>7. Meter Flange</td>
<td></td>
</tr>
<tr>
<td>8. Meter Tail Piece (Meter Couplings)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ASTM – 43 Copper Service
### 1. BRASS SERVICE FITTINGS

Std. Drawings B-590 – B-591A  
1” thru 2” B-342 – B344B

#### Item 10. Splicing Couplings

<table>
<thead>
<tr>
<th>Item</th>
<th>CAMBRIDGE</th>
<th>FORD</th>
<th>JONES</th>
<th>MCDONALD</th>
<th>MUELLER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Splicing Couplings</td>
<td>C44-44-NL</td>
<td>C22-66-NL</td>
<td>J-2609</td>
<td>4758</td>
<td>H-15403</td>
</tr>
<tr>
<td></td>
<td>C44-66-NL</td>
<td>C44-66-NL</td>
<td>J-2610</td>
<td>4758-22</td>
<td>H-15456</td>
</tr>
<tr>
<td></td>
<td>C22-77-NL</td>
<td>C22-77-NL</td>
<td>J-1528</td>
<td>4758-33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C44-77-NL</td>
<td>C44-77-NL</td>
<td></td>
<td>4756</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C84-44-NL</td>
<td>C84-44-NL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C66-44-NL</td>
<td>C66-44-NL</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ASTM – 43 Copper Services
## 2. DUCTILE IRON FITTINGS

**Detailed Provisions Section 15057**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
</table>
| Fittings shall be Ductile Iron and shall conform to ANSI/AWWA C153 / A21.53, ANSI/AWWA C111/A21.11, and ANSI/AWWA C110/A21.10. | ONE BOLT, INC.  
ASTM / A536 Restraint Joint |
| Fittings shall be Mechanical Joints or Push-on Joints.                       | PACIFIC STATES                                     |
| Fittings shall be Tar (seal) coated and Cement Mortar lined per ANSI A21.4 (AWWA C104). | PIPELINE COMPONENTS, INC.  
M.J. Compact Fittings – All Sizes  
M.J. Full Body Fittings – All Sizes  
Push On Fittings – 4” thru 8” |
|                                                                            | SERAMPORE INDUSTRIES PRIVATE LTD, INC.            |
|                                                                            | SIP Industries C110 MJ                              |
|                                                                            | SIGMA CORPORATION                                  |
|                                                                            | Sigma/Nappco                                      |
|                                                                            | STAR PIPE PRODUCTS                                 |
|                                                                            | TYLER UNION                                       |
|                                                                            | TufGrip Dual Wedge, Series 1500                    |
|                                                                            | U.S. PIPE                                         |
3. **FLANGES**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
</table>
| 1. Companion Flange  
Cast Iron, Threaded | **JONES**  
Model: J-129. Size: 1 ½” & 2” |
| 2. Ring Flange  
Std. Drawing B-288  
1 ½” thru 54” | **RETECH INC. & CONTINENTAL MANUFACTURING**  
No. A-36 Steel Ring Flange  
No. A-283 “C” Steel Flange  
No. A-283 “D” Steel Flange |
| 3. Meter Flange  
Bronze  
Std. Drawing B-342 thru B-344-B | **MCDONALD**  
#610-F. Size: 1 ½” & 2”  
3” Class “D” Plate Flange with four ⅝” I.D. Bore  
For use on 3” Compound Meter Connection. |
| 4. Meter Flange  
Steel  
Std. Drawing B-633 |
4. **FLEX COUPLINGS & FLEXIBLE EXPANSION JOINTS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
</table>
| 1. Flex Couplings (Compression)  
Steel & Cast Iron  
½” thru 36” | FORD METER PRODUCTS  
Model: F-Ringwall Series  
ROMAC  
Model: Romac 501 Series  
Model: Macro HP 4” thru 12”  
Alpha Series  
SMITH-BLAIR  
Model: SB-411, SB-441 |
| 2. Flex Expansion Joints  
3” thru 36”  
min. offset: 11” for ≤ 12” diameter  
min. offset: 18” for > 12” diameter | EBBA IRON  
Flex-tend |
## 5. PIPELINE FITTINGS

### Description | Manufacturers
---|---
1. Joint Restraints | EBAA IRON  
   2000 PV Series: 4” thru 24” (C-900)  
   Model 1100 Series: 3” thru 48”  
   2100 Series: 4” thru 12” (C-900)  
   2800 Series: 14” thru 36” (C-900)  
   FORD  
   Uni-flange Series Model 200, 900, 1300 & 1400  
   Uni-flange Series Model 1500 restraint joint for PVC pipe 4” thru 12”  
   Uni-flange Series Model 1390 restraint joint for PVC pipe  
   NAPPCO/SIGMA CORP.  
   Model PV-Lok PVM: 2” thru 12”  
   Model PV-Lok PVP: 2” thru 12”  
   Model ONE LOK: 4” thru 36”  
   ROMAC INDUSTRIES  
   Grip Ring 4” thru 12”  
   Alpha Restrained Joints 4” thru 12”  
   Flanged Coupling Adaptor, Coupling, and End Cap  
   SIP INDUSTRIES  
   EZ-Grip  
   SMITH BLAIR  
   Model C111/C120  
   STAR  
   Allgrip 3600: 4” thru 12” for C900 and ductile iron pipe  
   Series 1000: 4” thru 12” for C900  
   Series 1100: 4” thru 48” for C900 PVC Grip 3500: 4” thru 16” for C-900  
   Stargrip 3000: 4” thru 36” for D.I.P.  
   PVC Stargrip 4000: 4” thru 36” for C900  
   U.S. PIPE  
   Field Lok Gaskets: 4” thru 12”
## 5. PIPELINE FITTINGS

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Pipeline Adapters</td>
<td>CERTAIN-TEED CORP.</td>
</tr>
<tr>
<td></td>
<td>ROBAR</td>
</tr>
<tr>
<td></td>
<td>Models 1506, 1508, 1908</td>
</tr>
<tr>
<td></td>
<td>ROMAC IND.</td>
</tr>
<tr>
<td></td>
<td>Model 500 Series</td>
</tr>
<tr>
<td></td>
<td>Alpha Series</td>
</tr>
<tr>
<td></td>
<td>SIGMA CORP.</td>
</tr>
<tr>
<td></td>
<td>Model Sigma/NAPPCO</td>
</tr>
<tr>
<td></td>
<td>SMITH-BLAIR</td>
</tr>
<tr>
<td></td>
<td>Model SB-900 Series</td>
</tr>
<tr>
<td></td>
<td>TYLER UNION</td>
</tr>
</tbody>
</table>
### 6. VICTAULIC COUPLINGS & FITTINGS

**Detailed Provisions Section 15077**, Std. Drawing No. A-192

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Grooved Victaulic Couplings and Fittings</td>
<td><strong>GUSTIN-BACON</strong></td>
</tr>
<tr>
<td></td>
<td>Model: 100-IPS</td>
</tr>
<tr>
<td></td>
<td>Model: 500-Ductile Iron</td>
</tr>
<tr>
<td></td>
<td><strong>VICTAULIC CO.</strong></td>
</tr>
<tr>
<td></td>
<td>Style 31 – Coupling - 3” to 36”</td>
</tr>
<tr>
<td></td>
<td>Style 307 – Transition Coupling – 3” to 12”</td>
</tr>
<tr>
<td></td>
<td>Style 341 – Flange Adaptor – 3” to 24”</td>
</tr>
<tr>
<td></td>
<td>Style 107N – QuickVic Rigid Coupling – 2” to 12”</td>
</tr>
<tr>
<td></td>
<td>Style 177N – QuickVic Flexible Coupling – 2” to 12”</td>
</tr>
<tr>
<td></td>
<td>Style W07 – AGS Rigid Coupling – 14” to 50”</td>
</tr>
<tr>
<td></td>
<td>Style W77 – AGS Flexible Coupling – 14” to 72” w/ Grade “E” Gasket</td>
</tr>
<tr>
<td></td>
<td>Style W741 – AGS Vic-Flange Adapter</td>
</tr>
</tbody>
</table>
### 7. WELDED STEEL FITTINGS

**Detailed Provisions Section 15059**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Steel Fittings</td>
<td></td>
</tr>
<tr>
<td>Domestic Steel</td>
<td></td>
</tr>
<tr>
<td>Various Sizes</td>
<td></td>
</tr>
<tr>
<td>Shall be fabricated as shown on the contract drawings, and/or as specified in the Special Conditions.</td>
<td></td>
</tr>
<tr>
<td>Flanges shall conform to the requirements of EMWD Std. Drawing B-288 made a part hereof by reference.</td>
<td></td>
</tr>
<tr>
<td><strong>Steel Certification Required</strong></td>
<td></td>
</tr>
</tbody>
</table>

Appendix A
Rev: 10/19/18
III. VALVES
## 1. **AIR VALVES**  
*Detailed Provisions Section 15136*

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
</table>
| **1. Air Release Valve**  
¾” | APCO VALVE CO.  
Model: APCO #65 |
| **2. Air Release and Vacuum Valve Std.**  
Dwgs. B-598 & B-367  
1” & 2” | APCO VALVE CO.  
Model: 143C and 145C  
CLA-VAL CO.  
Model: 361-CAV564B and 362-CAV332  
CRISPIN VALVE CO.  
Model: UL-10 and UL-20  
EMPIRE VALVE CO.  
Model: 940  
VALVMATIC VALVE CO.  
Model: 201C and 202C |
| **3. Air Release and Vacuum Valve Std.**  
Drawing B-578  
4” & 6” | APCO VALVE CO.  
Model: 149-C and 150-C  
CLA-VAL CO.  
Model: 364-CAV332 and 366-CAV732-3  
CRISPIN VALVE CO.  
Model: UL-41 (4”) and AL-61/PL-10 (6”) |
| **4. Air Valve Suction Screens**  
Std. Dwgs. B-598 & B-367 | FLOW EZY FILTERS, INC.  
M-6-8 (¾”) – Stainless Steel  
M-8-8 (1”) – Stainless Steel  
M-16-8 (2”) – Stainless Steel |
| **5. Pump Air Valve** | ARMSTRONG MACHINE WORKS – Model: 21 |
## 2. APPURTENANCES

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Hose Bibbs (Brass)</strong>&lt;br&gt;300-lbs working water pressure&lt;br&gt;For Treatment Plants</td>
<td><strong>CALIFORNIA BRASS MFG. CO.</strong>&lt;br&gt;Calco Fig. 101&lt;br&gt;&lt;br&gt;<strong>FAIRBANKS VALVE CO.</strong>&lt;br&gt;Model: 150-S</td>
</tr>
<tr>
<td><strong>2. Valve Cap &amp; Riser</strong>&lt;br&gt;Std. Drawing B-668</td>
<td></td>
</tr>
<tr>
<td>6” C.I. Valve Cap&lt;br&gt;Marked “Water” for Potable Water&lt;br&gt;Marked “Recycled” for Recycled Water&lt;br&gt;Galv. Split Valve Can Top Section – 6” O.D. x 22Ga. Slip Can length 12”, 18” or 24”, as required.</td>
<td></td>
</tr>
<tr>
<td>Valve Can – 6 ¾” O.D. x 10 Ga. Double-Dip Pipe</td>
<td></td>
</tr>
</tbody>
</table>
### 3. **BALL VALVES**

*Detailed Provisions Section 15104*

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ball Valves</td>
<td>LUNKENHEIMER COMPANY</td>
</tr>
<tr>
<td>AWWA C507</td>
<td>MARPAC, INC.</td>
</tr>
<tr>
<td></td>
<td>VALVE TECHNOLOGY CO.</td>
</tr>
<tr>
<td></td>
<td>Models: D7410 – 7420 Series</td>
</tr>
<tr>
<td></td>
<td>Models: D7421 – 7432 Series</td>
</tr>
<tr>
<td>2. Meter Ball Valves (with Handles)</td>
<td>A.Y. MCDONALD</td>
</tr>
<tr>
<td></td>
<td>Model: 6101 MWH (¾” and 1”)</td>
</tr>
<tr>
<td></td>
<td>JAMES JONES CO.</td>
</tr>
<tr>
<td></td>
<td>Jones Model: J1908W (¾” and 1”)</td>
</tr>
<tr>
<td></td>
<td>THE FORD METER BOX CO., INC.</td>
</tr>
<tr>
<td></td>
<td>Model: B13-332 W (¾”)</td>
</tr>
<tr>
<td></td>
<td>Model: B13-444 (1”)</td>
</tr>
</tbody>
</table>
## 4. BUTTERFLY VALVES

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Class 150</td>
<td><strong>AMERICAN FLOW CONTROL</strong></td>
</tr>
<tr>
<td></td>
<td>Model: A.D. 150 Size: 4”-48”</td>
</tr>
<tr>
<td></td>
<td><strong>CLOW CO.</strong></td>
</tr>
<tr>
<td></td>
<td>Model: Clow BFV. Class 150, Size: 4” thru 72”</td>
</tr>
<tr>
<td></td>
<td><strong>CRISPIN (Previously CMB Industries)</strong></td>
</tr>
<tr>
<td></td>
<td>K-FLO Model: 500 Series, 3” thru 20”</td>
</tr>
<tr>
<td></td>
<td>K-FLO Model: 47 Series, 24” thru 48”</td>
</tr>
<tr>
<td></td>
<td><strong>DEZURIK CO.</strong></td>
</tr>
<tr>
<td></td>
<td>Model: Dezurik BFV. Class 150, Size: 4” thru 20”</td>
</tr>
<tr>
<td></td>
<td><strong>KENNEDY</strong></td>
</tr>
<tr>
<td></td>
<td>Model: Kennedy BFV. Class 150 Size: 4” thru 72”</td>
</tr>
<tr>
<td></td>
<td><strong>KUBOTA</strong></td>
</tr>
<tr>
<td></td>
<td>Model: Kubota BFV. Class 150, Size: 24” thru 48”</td>
</tr>
<tr>
<td></td>
<td><strong>M &amp; H CO.</strong></td>
</tr>
<tr>
<td></td>
<td>Model: 4500, Class 150, Size 4” thru 24”</td>
</tr>
<tr>
<td></td>
<td>Model: 1450, Class 150B, Size 30” thru 48”</td>
</tr>
<tr>
<td></td>
<td><strong>MUELLER CO.</strong></td>
</tr>
<tr>
<td></td>
<td>Model: Mueller Lineseal III, Size: 4” thru 24”</td>
</tr>
<tr>
<td></td>
<td>Model: Mueller Lineseal III, Size: 30” thru 48” (with Ductile Iron Disc.)</td>
</tr>
<tr>
<td></td>
<td><strong>PRATT VALVE CO.</strong></td>
</tr>
<tr>
<td></td>
<td>Model: Pratt Ground Hog BFV. Class 150 with no Power Operation Allowed, Size: 4” thru 12”</td>
</tr>
<tr>
<td></td>
<td>Model: Pratt Ground Hog with Power operation allowed with knowledge of turns. Size: 14” thru 48”</td>
</tr>
<tr>
<td></td>
<td>Model: Pratt Triton XR-70 with Handwheel. Size: 24” thru 48”</td>
</tr>
<tr>
<td>2. Class 250</td>
<td><strong>CRISPIN (Previously CMB Industries)</strong></td>
</tr>
<tr>
<td></td>
<td>Model: K-FLO 500 Series</td>
</tr>
<tr>
<td></td>
<td><strong>DEZURIK</strong></td>
</tr>
<tr>
<td></td>
<td>Model: BAW Series</td>
</tr>
<tr>
<td></td>
<td><strong>PRATT</strong></td>
</tr>
<tr>
<td></td>
<td>Model: H.P. 250</td>
</tr>
</tbody>
</table>

Coatings: valves shall have all ferrous parts epoxy coated per AWWA-C550 (fusion bonded)

---

Appendix A  
Rev: 10/19/18  
35 of 50 PAGES  
EMWD
## 5. CHECK VALVES

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bronze Threaded Swing Check Valve ¾” thru 2”</td>
<td>HAMMOND VALVE CO.</td>
</tr>
<tr>
<td></td>
<td>Model: 946 Bronze</td>
</tr>
<tr>
<td></td>
<td>MILWAUKEE VALVE CO.</td>
</tr>
<tr>
<td></td>
<td>Model: 510 &amp; 511</td>
</tr>
<tr>
<td></td>
<td>STOCKHAM VALVE CO.</td>
</tr>
<tr>
<td></td>
<td>Model: B-320</td>
</tr>
<tr>
<td>2. Flanged Swing Check Valves shall be single disc type with spring and lever when so specified on the Bidding Sheet.</td>
<td>APCO VALVE CO.</td>
</tr>
<tr>
<td></td>
<td>CLOW CO.</td>
</tr>
<tr>
<td></td>
<td>KENNEDY VALVE CO.</td>
</tr>
<tr>
<td></td>
<td>M &amp; H CO.</td>
</tr>
<tr>
<td></td>
<td>MUELLER CO./PRATT</td>
</tr>
<tr>
<td></td>
<td>STOCKHAM CO.</td>
</tr>
<tr>
<td>3. Wafer Check Valve w/Viton O-Ring Seal 4 thru 12”</td>
<td>PENTAIR</td>
</tr>
<tr>
<td></td>
<td>Keystone Prince Figure No. 810 &amp; Figure No. 813-S &amp; L Short Wafer Body</td>
</tr>
<tr>
<td></td>
<td>Keystone Prince Figure No. F810-004</td>
</tr>
<tr>
<td></td>
<td>Keystone Prince Figure No. F813-519-S&amp;L</td>
</tr>
</tbody>
</table>
### 6. CONTROL VALVES

**Detailed Provisions Section 15120**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control Valves</td>
<td>CLA-VAL CO.</td>
</tr>
<tr>
<td></td>
<td>All control valves shall be flanged diaphragm type globe valves, with Cast-Iron Body, as manufactured by CLA-VAL Co., or approved equal. Epoxy shall be Thermo-Setting, Conforming to AWWA C-550. Delrin Stem. All Control Valves other than pressure reducing valves shall have Bronze Trim. Pressure Reducing Valves shall have Stainless Steel Trim.</td>
</tr>
<tr>
<td>2. Pressure Regulators</td>
<td>AMES CO.</td>
</tr>
<tr>
<td></td>
<td>Model: Ames 900 Series</td>
</tr>
<tr>
<td></td>
<td>Model: Ames 800 Series</td>
</tr>
<tr>
<td></td>
<td>CLA-VAL CO. Model: Clayton 90 Series</td>
</tr>
<tr>
<td></td>
<td>Model: Clayton 610 Series</td>
</tr>
<tr>
<td></td>
<td>PRATT/WATT CO.</td>
</tr>
<tr>
<td></td>
<td>Model: Globe</td>
</tr>
<tr>
<td></td>
<td>Fig. 115 – Class 125</td>
</tr>
<tr>
<td></td>
<td>Fig. 1115 – Class 250</td>
</tr>
<tr>
<td></td>
<td>WATT CO.</td>
</tr>
<tr>
<td></td>
<td>Model: Watts 25 AUB, Bronze</td>
</tr>
<tr>
<td></td>
<td>WILKINS</td>
</tr>
<tr>
<td></td>
<td>Model: Wilkins, 600 Cold Water &amp; Air</td>
</tr>
</tbody>
</table>
### 6. CONTROL VALVES

**Detailed Provisions Section 15120**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Pressure Relief Valves</td>
<td>AMES CO.</td>
</tr>
<tr>
<td></td>
<td>Model: Ames 800 Series</td>
</tr>
<tr>
<td></td>
<td>CLA-VAL</td>
</tr>
<tr>
<td></td>
<td>Model: Series 50 &amp; 51</td>
</tr>
<tr>
<td></td>
<td>PRATT/WATTS CO.</td>
</tr>
<tr>
<td></td>
<td>Model: No. Globe – 116 Class 125, Angle-116 Class 250</td>
</tr>
<tr>
<td>4. Pump Control Valves</td>
<td>AMES</td>
</tr>
<tr>
<td></td>
<td>Model Ames 800 Series</td>
</tr>
<tr>
<td></td>
<td>CLA-VAL</td>
</tr>
<tr>
<td></td>
<td>Model: 61-G</td>
</tr>
<tr>
<td></td>
<td>PRATT/WATTS</td>
</tr>
<tr>
<td></td>
<td>Model: Globe 513, Class 125</td>
</tr>
<tr>
<td></td>
<td>Model: Angle 1513, Class 250</td>
</tr>
</tbody>
</table>
### 7. GATE VALVES

Std. Drawing Nos. B-590 thru B-344-B

1 of 3

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
</table>
| 1. Bronze Threaded NRS-½” | HAMMOND VALVE CO.  
Model: 606-125 PSI  
MILWAUKEE VALVE CO.  
Model: 105-200 PSI  
STOCKHAM VALVE CO.  
Model: B-103-200 PSI |
| 2. Bronze Threaded NRS ¾” thru 1” | AMERICAN VALVE CO.  
Model: Milano, M-300  
FAIRBANKS VALVE  
Model: 125-S 250  
*F&F VALVE  
Model: 710-Brass  
*KITZ VALVE  
Code No. 27 Fig. AKH  
MILWAUKEE VALVE  
Model: 1105M & #105  
NIBCO VALVE  
Model: T-113-Domestic  
*PIONEER ENTERPRISES  
Model: GTI-0102 & 0103  
RED AND WHITE VALVE  
Model: 206  
STOCKHAM VALVE  
Model: B-103  
WOLVERINE VALVE  
Model: 50293 |
| *To be used in customer side of meter installation only. Std. Drawing B-591 |
7. **GATE VALVES**
Std. Drawing Nos. B-590 thru B-344-B

2 of 3

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
</table>
| 3. Bronze Threaded NRS 1 ½” thru 2” | **AMERICAN VALVE**  
Model: 3-F Bronze  
**MILWAUKEE VALVE**  
Model: 1105M & 105  
**NIBCO VALVE**  
Model: T-113, Domestic  
**STOCKHAM VALVE**  
Model: B-103 |
| 4. Cast Iron With 2” Operating Nuts for 2” Blow-offs | **CLOW VALVE CO.**  
**IOWA VALVE**  
Model : List 14  
**MUELLER VALVE**  
Model: A-2380-8 & A-2380-6  
**RENSSELSER VALVE**  
Model: Ludlow, list 13A  
**STOCKHAM VALVE CO.** |
| 5. Flange x Hub End Resilient Gate Valves AWWA C-509 | Ring-tite, Fluid-tite, or Approved Equal |
| 6. Horizontal, Double-Disc Iron Body Bronze-Mounted (IBBM) with By-Pass 24” | **AMERICAN FLOW SYSTEMS**  
Model: A.D. “50-Line”  
**CLOW VALVE CO.**  
Model: Clow F5070  
**MUELLER VALVE CO.**  
Model: A-2380-6 |
### 7. GATE VALVES

*Std. Drawing Nos. B-590 thru B-344-B*

#### 3 of 3

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Resilient Seat Gate Valves Flanged</td>
<td>ACIPCO</td>
</tr>
<tr>
<td>AWWA C-509, C-515 and AWWA C-550</td>
<td>Model: 82-200W-77785-7</td>
</tr>
<tr>
<td><strong>EMWD Detailed Provisions Section 15102</strong></td>
<td>AMERICAN AVK CO.</td>
</tr>
<tr>
<td>4” thru 36”</td>
<td>Model: 25 AVK</td>
</tr>
<tr>
<td></td>
<td>AMERICAN FLOW CONTROL CO.</td>
</tr>
<tr>
<td></td>
<td>Model: AFC-500 for 4” thru 12”</td>
</tr>
<tr>
<td></td>
<td>Or Series 2500 for 4” thru 36”</td>
</tr>
<tr>
<td></td>
<td>CLOW CO.</td>
</tr>
<tr>
<td></td>
<td>Model: Clow RW, Class 150</td>
</tr>
<tr>
<td></td>
<td>KENNEDY</td>
</tr>
<tr>
<td></td>
<td>Model: Kennedy RS-Class 150</td>
</tr>
<tr>
<td></td>
<td>M &amp; H</td>
</tr>
<tr>
<td></td>
<td>Model: M &amp; H #A-4067</td>
</tr>
<tr>
<td></td>
<td>MUELLER CO.</td>
</tr>
<tr>
<td></td>
<td>Model: A-2360</td>
</tr>
<tr>
<td></td>
<td>STOCKHAM CO.</td>
</tr>
<tr>
<td></td>
<td>Model: Stockham #G700-0</td>
</tr>
<tr>
<td></td>
<td>TYLER</td>
</tr>
<tr>
<td></td>
<td>Model: DRS 250</td>
</tr>
<tr>
<td></td>
<td>U.S. PIPE</td>
</tr>
<tr>
<td></td>
<td>Model: Metroseal, RS Class 150</td>
</tr>
<tr>
<td></td>
<td>WATEROUS CO.</td>
</tr>
<tr>
<td></td>
<td>Model: Waterous #AFC-500</td>
</tr>
</tbody>
</table>
## 8. PLUG VALVES

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Eccentric Fullport Non-Lubricated Plug Valves 3” thru 24”</td>
<td>DEZURIK</td>
</tr>
<tr>
<td></td>
<td>Model: G Series</td>
</tr>
<tr>
<td></td>
<td>HENRY PRATT CO.</td>
</tr>
<tr>
<td></td>
<td>Pratt Keystone 580 Series, #898</td>
</tr>
</tbody>
</table>
IV. SEWER
1. **MANHOLES & CLEAN-OUTS**

1 of 2

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clean-Outs (Residential)</td>
<td>BROOKS PRODUCTS</td>
</tr>
<tr>
<td></td>
<td>Model: 1-RD</td>
</tr>
<tr>
<td></td>
<td>CHRISTY CONCRETE PRODUCTS</td>
</tr>
<tr>
<td></td>
<td>Model: F8</td>
</tr>
<tr>
<td></td>
<td>EISEL ENTERPRISES</td>
</tr>
<tr>
<td></td>
<td>Model: 1VB-VC</td>
</tr>
<tr>
<td></td>
<td>J&amp;R CONCRETE</td>
</tr>
<tr>
<td></td>
<td>Model: V1-R</td>
</tr>
<tr>
<td></td>
<td>LONG BEACH IRON WORKS</td>
</tr>
<tr>
<td></td>
<td>Model: Apex</td>
</tr>
<tr>
<td>2. Manhole Covers &amp; Frames</td>
<td>ALHAMBA FOUNDRY</td>
</tr>
<tr>
<td>24” &amp; 36”</td>
<td>Model: A-1251 &amp; A-1254</td>
</tr>
<tr>
<td>Std. Drawing SB-61</td>
<td>EVERETT ENTERPRISES</td>
</tr>
<tr>
<td></td>
<td>Model: GTS – Pont-A-Mousson</td>
</tr>
<tr>
<td></td>
<td>FAMEX FOUNDRY</td>
</tr>
<tr>
<td></td>
<td>Model: F-1251 &amp; F-1254</td>
</tr>
<tr>
<td></td>
<td>NATIONAL CASTING CORP.</td>
</tr>
<tr>
<td></td>
<td>Model: NC-2531</td>
</tr>
<tr>
<td>Note: Cast Iron Lid To Be</td>
<td>NEENAH FOUNDRY</td>
</tr>
<tr>
<td>Marked “EMWD Sewer”</td>
<td>Model: R-1593</td>
</tr>
<tr>
<td></td>
<td>NORFOLK CASTING CORP</td>
</tr>
<tr>
<td></td>
<td>Model: NC-254</td>
</tr>
<tr>
<td></td>
<td>RIVERSIDE FOUNDRY</td>
</tr>
<tr>
<td></td>
<td>Model: 1251 &amp; 1254</td>
</tr>
<tr>
<td></td>
<td>SOUTHBAY FOUNDRY</td>
</tr>
<tr>
<td></td>
<td>Model: SBF-1251 &amp; 1254</td>
</tr>
<tr>
<td></td>
<td>Model: SBF-1348 with Pick Hole for EMWD Standard</td>
</tr>
<tr>
<td></td>
<td>Drawing SB-30</td>
</tr>
</tbody>
</table>
1. **MANHOLES & CLEANOUTS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
</table>
FAMEX FOUNDRY (Model: F-1251)  
LONG BEACH IRON WORKS (Model: RE85R3PD GTS)  
NATIONAL CASTING CORP. (Model: NC-2531)  
NEENAH FOUNDRY (Model: R-1251)  
SOUTHBAY FOUNDRY (Model: SBF-1251) |
| Note: Cast Iron Lid To Be Marked “EMWD Sewer” | |
| 4. Manhole Shafts, Cones, Flat Tops & Grade Rings 24” thru 48” | AMERICAN HIGHWAY PRODUCTS  
AMERICAN PIPE  
ASSOCIATED CONCRETE  
B & W PRECAST CONSTR.  
HOWARD ENTERPRISES  
INLAND CONCRETE  
MANHOLE BUILDERS  
MAR-CON PRODUCTS  
OLESEN PRECAST  
RIALTO CONCRETE  
SAN DIEGO PRECAST  
SOUTHWEST CONCRETE |
| 5. Manhole Steps | SOUTHWEST CONCRETE PRODUCTS  
Model: X040PS  
Model: X038PS |

Appendix A  
Rev: 10/19/18
2. **SEWER PIPE & FITTINGS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reinforced Concrete Pipe</td>
<td>AMERON</td>
</tr>
<tr>
<td></td>
<td>HYDRO CONDUIT</td>
</tr>
<tr>
<td></td>
<td>RIALTO PIPE</td>
</tr>
<tr>
<td>2. Sewer Pipe</td>
<td>ARMCO PIPE - (CONTECH)</td>
</tr>
<tr>
<td>Polyvinyl Chloride (PVC) &amp; Acrylonitrile-Butadiene-Styrene (ABS)</td>
<td>CARLON PIPE</td>
</tr>
<tr>
<td>Fittings and pipe shall be from the same manufacturer when they make both.</td>
<td>CERTAIN-TEED CORP.</td>
</tr>
<tr>
<td>If manufacturer only makes pipe, fittings from 2.a. shall be used.</td>
<td>DIAMOND PLASTICS CORP.</td>
</tr>
<tr>
<td></td>
<td>SDR 35 PVC</td>
</tr>
<tr>
<td></td>
<td>JM EAGLE</td>
</tr>
<tr>
<td></td>
<td>PRIME CONDUIT VYLON</td>
</tr>
<tr>
<td></td>
<td>21” thru 48”</td>
</tr>
<tr>
<td></td>
<td>VINYL TECH</td>
</tr>
<tr>
<td></td>
<td>WHITE KNIGHT</td>
</tr>
<tr>
<td>a. PVC sewer fittings</td>
<td>BUILDING PRODUCTS CO.</td>
</tr>
<tr>
<td>4” thru 8” gravity use only</td>
<td>JCP Compression Joints</td>
</tr>
<tr>
<td></td>
<td>GPK</td>
</tr>
<tr>
<td></td>
<td>JM EAGLE</td>
</tr>
<tr>
<td></td>
<td>MULTI-FITTINGS CORP.</td>
</tr>
<tr>
<td></td>
<td>TIGRE</td>
</tr>
<tr>
<td></td>
<td>SDR 35 PVC</td>
</tr>
<tr>
<td>b. PVC sewer fittings</td>
<td>SYROCO INC</td>
</tr>
<tr>
<td>4” thru 8” gravity use only</td>
<td>SDR 35</td>
</tr>
</tbody>
</table>
### 2. SEWER PIPES & FITTINGS

#### 2 OF 2

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Sewer Repair Couplings</td>
<td>MISSION RUBBER</td>
</tr>
<tr>
<td></td>
<td>PVC</td>
</tr>
<tr>
<td></td>
<td>MR56 44 ARC</td>
</tr>
<tr>
<td></td>
<td>MR56 66 ARC</td>
</tr>
<tr>
<td></td>
<td>MR56 88 ARC</td>
</tr>
<tr>
<td></td>
<td>MR56 1212 ARC</td>
</tr>
<tr>
<td></td>
<td>Clay</td>
</tr>
<tr>
<td></td>
<td>MR01 44 ARC</td>
</tr>
<tr>
<td></td>
<td>MR01 66 ARC</td>
</tr>
<tr>
<td></td>
<td>MR01 88 ARC</td>
</tr>
<tr>
<td></td>
<td>MR01 1212 ARC</td>
</tr>
<tr>
<td>4. Tapping Saddle</td>
<td>JOINTS COUPLINGS</td>
</tr>
<tr>
<td></td>
<td>TAP-N-TEE</td>
</tr>
<tr>
<td></td>
<td>(Conditional/Emergency use only)</td>
</tr>
<tr>
<td>5. Vitrified Clay Pipe (VCP)</td>
<td>BUILDING PRODUCTS CO.</td>
</tr>
<tr>
<td></td>
<td>JCP Compression Joints</td>
</tr>
<tr>
<td></td>
<td>GLADDING McBEAN Co.</td>
</tr>
<tr>
<td></td>
<td>“Speed-Seal”</td>
</tr>
<tr>
<td></td>
<td>MISSION CLAY PRODUCTS</td>
</tr>
<tr>
<td></td>
<td>“Band-Seal”</td>
</tr>
<tr>
<td></td>
<td>PACIFIC CLAY PRODUCTS</td>
</tr>
<tr>
<td></td>
<td>“Wedgelock”</td>
</tr>
<tr>
<td>Note: fittings to be from same</td>
<td></td>
</tr>
<tr>
<td>manufacturer as pipe</td>
<td></td>
</tr>
</tbody>
</table>
V. ELECTRICAL
### 1. **WIRING & BASIC ELECTRICAL MATERIALS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Insulated CP Test Connections &amp; Blow-Off Connections</strong></td>
<td></td>
</tr>
<tr>
<td>Std. Drawing B-660 &amp; B-662</td>
<td></td>
</tr>
<tr>
<td>#4 HMW – PE (High Molecular Wt-Polyethylene Coated)</td>
<td></td>
</tr>
<tr>
<td>Stranded Wire Black</td>
<td></td>
</tr>
<tr>
<td>#12 TW – Solid Wire – Green or Yellow</td>
<td></td>
</tr>
<tr>
<td><strong>2. Locating Wire</strong></td>
<td></td>
</tr>
<tr>
<td>Std. Drawing B-656</td>
<td></td>
</tr>
<tr>
<td>#14-1 UF Black Copper-Insulated Locating Wire</td>
<td></td>
</tr>
</tbody>
</table>
## 1. WIRING & BASIC ELECTRICAL MATERIALS

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Telemetry Cable</td>
<td>ALCATEL DEDW</td>
</tr>
<tr>
<td>Std. Drawing B-533</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Telemetry wire, double-jacketed, filled polyethylene jacket for burial 5-mil copper shield, solid strand 6-pair, 19-gauge copper wire Alcatel DEDW. (Approximately 5,000 ft. Rolls)</td>
</tr>
<tr>
<td>DISTRIBUTORS:</td>
<td>POWER AND TELEPHONE SUPPLY</td>
</tr>
<tr>
<td></td>
<td>Phone No.: 1-800-451-4381</td>
</tr>
<tr>
<td>4. Telemetry Hardware:</td>
<td>3M</td>
</tr>
<tr>
<td></td>
<td>Splice Kit Model No. 72-N2</td>
</tr>
<tr>
<td></td>
<td>CHARLES INDUSTRIES</td>
</tr>
<tr>
<td></td>
<td>Pedestal Model No. CPLM8-1/GTE</td>
</tr>
<tr>
<td></td>
<td>ENTRELEC</td>
</tr>
<tr>
<td></td>
<td>Terminal Model No. M4/6.SNB 0115686.13</td>
</tr>
<tr>
<td></td>
<td>Terminal End Stop Model No. 114836.00</td>
</tr>
<tr>
<td></td>
<td>DIN Rail Model No. 101598.26</td>
</tr>
<tr>
<td>DISTRIBUTORS:</td>
<td>CHARLES INDUSTRIES</td>
</tr>
<tr>
<td></td>
<td>Phone No. (847) 806-6300</td>
</tr>
<tr>
<td></td>
<td>REXEL ESD ELECTRICAL</td>
</tr>
<tr>
<td></td>
<td>Phone No. (760) 747-2211</td>
</tr>
<tr>
<td></td>
<td>ROYAL WHOLESALE ELECTRIC</td>
</tr>
<tr>
<td></td>
<td>Phone No. (951) 683-6625</td>
</tr>
</tbody>
</table>
APPENDIX B

GEOTECHNICAL INVESTIGATION REPORT
GEOTECHNICAL INVESTIGATION REPORT

Odor Control Facility at the EMWD Winchester Lift Station
Northeast of the Intersection of Olive Avenue and La Ventana Road
Winchester Area of Riverside County, California
Converse Project No. 17-81-196-01

March 15, 2018

Prepared For:
Black & Veatch Corporation
300 Rancheros Drive, Suite 250
San Marcos, CA 92069

Prepared By:
Converse Consultants
2021 Rancho Drive, Suite 1
Redlands, California 92373
March 15, 2018

Ms. Shirley Edmonson, PE
Project Engineer, Water
Black & Veatch Corporation
300 Rancheros Drive, Suite 250
San Marcos, CA 92069

Subject: GEOTECHNICAL INVESTIGATION REPORT
Winchester Lift Station - Odor Control Facility
Northeast of the Intersection of Olive Avenue and La Ventana Road
Winchester Area of Riverside County, California
Converse Project No. 17-81-196-01

Dear Ms. Edmonson:

Converse Consultants (Converse) is pleased to submit this geotechnical investigation report to assist with the design and construction of the odor control facility at the Winchester Lift Station. The Winchester Lift Station is located northwest of the intersection of La Ventana Road and Olive Avenue, in the Winchester area of Riverside County, California. This report was prepared in accordance with our revised proposal August 25, 2017 and your Service Contract No. 196510.70.1110, dated September 14, 2017.

Based upon our field investigation, laboratory data, and analyses, the odor control facility is considered feasible from a geotechnical standpoint, provided the recommendations presented in this report are incorporated into the design and construction of the project.

We appreciate the opportunity to be of service to Black & Veatch Corporation and EMWD. Should you have any questions, please do not hesitate to contact us at (909) 796-0544.

CONVERSE CONSULTANTS

Hashmi S. E. Quazi, PhD, PE, GE
Principal Engineer

Dist.: 3/Addressee
HSQ/SM/JB/ZA/kvg
PROFESSIONAL CERTIFICATION

This report has been prepared by the following professionals whose seals and signatures appear hereon.

The findings, recommendations, specifications and professional opinions contained in this report were prepared in accordance with the generally accepted professional engineering and engineering geologic principle and practice in this area of Southern California. We make no other warranty, either expressed or implied.

Zahangir Alam, PhD, EIT
Senior Staff Engineer

Jay Burnham, GIT
Senior Staff Geologist

Hashmi S. E. Quazi, PhD, PE, GE
Principal Engineer

Scot Mathis, PG, CEG
Senior Geologist
EXECUTIVE SUMMARY

The following is a summary of our geotechnical investigation, conclusions and recommendations, as presented in the body of this report. Please refer to the appropriate sections of the report for complete conclusions and recommendations. In the event of a conflict between this summary and the report, or an omission in the summary, the report shall prevail.

- The odor control system will include various mechanical equipment (biotrickling filter, fans, carbon vessel and degreaser and mist eliminator) and buried piping within the lift station. The approximate size of the equipment facility is 95.0’ x 48.5’ which will be supported by a slab on grade with extended concrete footings. We understand the pipe invert depth will be approximately 19 feet below ground surface until it gets to the west side of the site, where it will be above grade at the odor treatment facility.

- The proposed project site is bounded on west by La Ventana Road, on south by Olive Avenue, on north and east by vacant land. The project site is enclosed by a masonry block wall on all sides. The existing lift station is located in the middle of the site and the proposed odor control facility will be located in the northwestern corner. The lift station site surface is paved. The approximate elevation of the site is 1,450 feet above mean sea level (amsl). The proposed site may have been graded (average relative compaction of approximately 90 to 92 percent in the upper 5 feet soils) to construct a lift station. However, details of grading are not currently available for the site.

- Our scope of work included project setup, subsurface exploration, laboratory testing, engineering analysis, and preparation of this report.

- Two exploratory borings (BH-01 and BH-02) were drilled on November 9, 2017 at the site of the proposed odor control system. The borings were advanced to maximum planned depths of 21.5 and 51.5 feet bgs.

- The proposed site is underlain to a depth of at least 5 feet by fill soils consisting of sandy silt. The fill is underlain to a depth of at least 51.5 feet by alluvial sediments consisting of sandy silt, silty sand, sandy clay and sand. Scattered gravels were observed in boring BH-01 between 3 and 5 feet bgs.

- Groundwater was encountered at a depth of 12.5 feet bgs during the investigation. Groundwater will be encountered in excavations deeper than 12 feet bgs.

- The project site is not located within a currently designated State of California or Riverside County Earthquake Fault Zone. There are no known active faults projecting toward or extending across the project site. The potential for surface...
rupture resulting from the movement of nearby major faults is not known with certainty but is considered low.

- The potential impact to the project from surface fault rupture, landsliding, seiches, tsunamis, and earthquake-induced flooding is considered to be low.

- Based on review of Riverside County liquefaction potential maps, the potential impact to the project from liquefaction and lateral spreading is considered to be high. This is due to the presence of shallow groundwater.

- Prior to the start of any earthwork, the site should be cleared of all vegetation, existing fill, and debris (if any). The materials resulting from the clearing and grubbing operations should be removed from the site.

- Based on our subsurface exploration, we anticipate that the proposed site soils will be excavatable with conventional heavy-duty earthworking and trenching equipment.

- Excavated onsite earth materials cleared of deleterious matter can be moisture conditioned and re-used as compacted fill.

- The odor control slab footprint should be overexcavated to a depth of 24 inches below the bottom of the footings or 5 feet from existing ground surface, whichever is greater. The depth of overexcavation should be uniform across the entire slab. The overexcavation should extend to at least 5 feet beyond the footprint of the slab footing.

- Fill soils should be placed on properly prepared excavation bottoms, moisture conditioned, and compacted to at least 90 percent of the laboratory maximum dry density.

- The sulfate and chloride contents of the tested soils correspond to American Concrete Institute (ACI) exposure category S1 and C1, respectively. Design recommendations for these categories are provided in the text of this report.

- The measured value of the minimum electrical resistivities when saturated were 730 and 710 Ohm-cm. This indicates that the tested soils are severely corrosive to ferrous metals in contact with the soil. A corrosion engineer should be consulted for corrosion mitigation measures for ferrous metals in contact with the soil.

- The proposed odor control slab footings may be supported by continuous or isolated spread shallow footings. The footings should be at least 18 inches in width and embedded to at least 18 inches below the lowest adjacent grade. The footing reinforcement should be based on structural design. Footings can be designed based on an allowable net bearing capacity of 2,000 pounds per square foot (psf).
• The total settlement of shallow footings from static structural loads and short-term settlement of properly compacted fill is anticipated to be 1 inch or less. The differential settlement resulting from static loads is anticipated to be 0.5 inches or less.

• The proposed site has the potential for up to 1.1 inches of dynamic settlement during a large earthquake. We recommend that the planned structures be designed conservatively in anticipation of dynamic differential settlement of up to 0.55 inches over 40 horizontal feet. The static and dynamic settlement estimates should not be combined for design purposes.

• Lateral earth pressures, mat foundation and pipeline design parameters are presented in the text of this report.

• Temporary sloped excavations and shoring design parameters are presented in the text of this report.

• Pipes extending 12 feet deep below the existing ground surface will encounter groundwater. Excavation below that depth will likely require dewatering. The dewatering system should be designed by an engineer experienced with this type of construction.

Based on our investigation, it is our professional opinion that the project site is suitable for construction of the proposed odor control facility and associated piping, provided the findings and conclusions presented in this geotechnical investigation report are considered in the planning, design and construction of the project.
## TABLE OF CONTENTS

1.0 INTRODUCTION--------------------------------------------------------------- 1

2.0 PROJECT DESCRIPTION -------------------------------------------------------- 1

3.0 SITE DESCRIPTION------------------------------------------------------------ 1

4.0 SCOPE OF WORK--------------------------------------------------------------- 2
   4.1 PROJECT SET-UP------------------------------------------------------------- 2
   4.2 SUBSURFACE EXPLORATION----------------------------------------------------- 2
   4.3 LABORATORY TESTING--------------------------------------------------------- 2
   4.4 ANALYSIS AND REPORT PREPARATION-------------------------------------------- 3

5.0 SUBSURFACE CONDITIONS------------------------------------------------------- 3
   5.1 EXISTING ASPHALT CONCRETE SECTIONS----------------------------------------- 3
   5.2 SUBSURFACE PROFILE--------------------------------------------------------- 3
   5.3 GROUNDWATER---------------------------------------------------------------- 4
   5.4 EXCAVATABILITY------------------------------------------------------------- 4
   5.5 SUBSURFACE VARIATIONS------------------------------------------------------- 4

6.0 ENGINEERING GEOLOGY---------------------------------------------------------- 4
   6.1 REGIONAL GEOLOGY------------------------------------------------------------ 5
   6.2 LOCAL GEOLOGY---------------------------------------------------------------- 5

7.0 FAULTING AND SEISMICITY----------------------------------------------------- 5
   7.1 FAULTING-------------------------------------------------------------------- 5
   7.2 CBC SEISMIC DESIGN PARAMETERS--------------------------------------------- 7
   7.3 SECONDARY EFFECTS OF SEISMIC ACTIVITY-------------------------------------- 7

8.0 LABORATORY TEST RESULTS------------------------------------------------------ 9
   8.1 PHYSICAL TESTING------------------------------------------------------------ 9
   8.2 CHEMICAL TESTING - CORROSIVITY EVALUATION----------------------------------- 10

9.0 EARTHWORK RECOMMENDATIONS--------------------------------------------------- 10
   9.1 GENERAL--------------------------------------------------------------------- 10
   9.2 ODOR CONTROL FACILITY GRADING--------------------------------------------- 11
   9.3 FILL MATERIALS---------------------------------------------------------------- 11
   9.4 COMPACTED FILL PLACEMENT--------------------------------------------------- 12
   9.5 SITE DRAINAGE---------------------------------------------------------------- 12
   9.6 UTILITY TRENCH BACKFILL----------------------------------------------------- 12

10.0 DESIGN RECOMMENDATIONS------------------------------------------------------ 15
    10.1 GENERAL EVALUATION--------------------------------------------------------- 15
    10.2 SHALLOW FOUNDATION DESIGN PARAMETERS-------------------------------------- 15
10.3 MAT FOUNDATIONS ................................. 16
10.4 UPLIFT PRESSURES ........................................... 16
10.5 LATERAL EARTH PRESSURES AND RESISTANCE TO LATERAL LOADS ......... 16
10.6 SLAB-ON-GRADE ................................. 17
10.7 SETTLEMENT ....................................... 18
10.8 PIPE DESIGN ........................................ 18
10.9 SOIL CORROSIVITY ................................. 19

11.0 CONSTRUCTION RECOMMENDATIONS .......................... 20
11.1 GENERAL ........................................... 20
11.2 TEMPORARY SLOPED EXCAVATIONS .................. 20
11.3 SHORING DESIGN .................................. 21
11.4 DEWATERING AND GROUNDWATER CONTROL ................ 24

12.0 GEOTECHNICAL SERVICES DURING CONSTRUCTION .................. 24

13.0 CLOSURE ........................................... 24

14.0 REFERENCES ........................................ 26

FIGURES

Following Page No.
Figure No. 1, Approximate Project Location Map ........................................ 1
Figure No. 2, Approximate Boring Locations Map ........................................... 2
Figure No. 3, Lateral Earth Pressures for Temporary Braced Excavation .............. 22
Figure No. 4, Lateral Earth Pressures for Temporary Cantilever Wall ............... 23

TABLES

Page No.
Table No. 1, Existing Asphalt Concrete Sections ............................................. 3
Table No. 2, Seismic Characteristics of Nearby Active Faults .................................. 6
Table No. 3, CBC Seismic Parameters ................................................................. 7
Table No. 4, Recommended Foundation Parameters ............................................. 15
Table No. 5, Active and At-Rest Earth Pressures .................................................. 16
Table No. 6, Soil Parameters for Pipe Design ...................................................... 19
Table No. 7, Slope Ratios for Temporary Excavations ......................................... 21
Table No. 8, Lateral Earth Pressures for Temporary Shoring ............................... 22

APPENDICES

Appendix A .......................................................... Field Exploration
Appendix B .......................................................... Laboratory Testing Program
Appendix C .......................................................... Dynamic Settlement Analysis

Converse Consultants
M:\JOBFILE\2017\81\17-81-196 B&V, EMWD Odor Control Facility\Report\17-81-196-01_gir
1.0 INTRODUCTION

This report presents the results of our geotechnical investigation performed for the proposed odor control facility at the Winchester Lift Station, located northeast of the intersection of Olive Avenue and La Ventana Road, in the Winchester area of Riverside County, California. The approximate project site location is shown in Figure No. 1, Approximate Project Location Map.

The purposes of this investigation were to determine the nature and engineering properties of the subsurface soils, and to provide design and construction recommendations for the proposed odor control system.

This report is prepared for the project described herein and is intended for use solely by Black & Veatch Corporation and their authorized agents for design purposes. It should not be used as a bidding document but may be made available to the potential contractors for information on factual data only. For bidding purposes, the contractors should be responsible for making their own interpretation of the data contained in this report.

2.0 PROJECT DESCRIPTION

The odor control system will include various mechanical equipment (biotrickling filter, fans, carbon vessel and degreaser and mist eliminator) and buried piping within the Lift Station. The approximate size of the equipment facility is 95.0' x 48.5' which will be supported by a slab on grade with extended concrete footings. We understand the pipe invert depth will be approximately 19 feet below ground surface until it gets to the west side of the site, where it will be above grade at the odor treatment facility.

3.0 SITE DESCRIPTION

The proposed project site is bounded on west by La Ventana Road, on south by Olive Avenue, on north and east by vacant land. The project site is enclosed by a masonry block wall on all sides. The existing lift station is located in the middle of the site and the proposed odor control facility will be located in the northwestern corner. Based on Winchester Lift Station and Force Main (EMWD, 1997), existing lift station and force main are supported by mat foundation and equipment pad is supported by slab-on-grade. The lift station site surface is paved. The approximate elevation of the site is 1,450 feet above mean sea level (amsl). The proposed site may have been graded (average relative compaction of approximately 90 to 92 percent in the upper 5 feet soils) to construct a lift station. However, details of grading are not currently available for the site.
Approximate Project Location Map

Project: Winchester Lift Station-Odor Control System
Location: Northeast of the Intersection of Olive Avenue and La Ventana Road
Winchester Area of Riverside County, California
For: Black & Veach Corporation

Project No. 17-81-196-01

Figure No. 1
4.0 SCOPE OF WORK

The scope of this investigation included set-up, subsurface exploration, laboratory testing, engineering analysis, and preparation of this report, as described in the following sections.

4.1 Project Set-up

As part of the project setup, we conducted the following.

- Conducted a site reconnaissance and marked the boring locations, such that drill rig access to all the locations is available.
- Notified Underground Service Alert (USA) at least 48 hours prior to drilling to clear the boring location of any conflict with existing underground utilities.
- Engaged a California-licensed driller to drill exploratory borings.

4.2 Subsurface Exploration

Two exploratory borings (BH-01 and BH-02) were drilled on November 9, 2017 within the Winchester Lift Station site in the area of the proposed odor control facility and associated piping. Borings BH-01 and BH-02 were advanced to their maximum planned depths of 51.5 and 21.5 feet bgs, respectively.

Approximate boring locations are indicated in Figure No. 2, Approximate Boring Locations Map. For a description of the field exploration and sampling program see Appendix A, Field Exploration.

4.3 Laboratory Testing

Representative soil samples of the site were tested in the laboratory to aid in the soils classification and to evaluate the relevant engineering properties of the site soils. These tests included the following.

- In-situ moisture contents and dry densities (ASTM D2216)
- Expansion index (ASTM D4829)
- Sand Equivalent (ASTM D2419)
- Soil corrosivity (California Tests 643, 422, and 417)
- Grain size analysis (ASTM D422)
- Maximum dry density and optimum-moisture content (ASTM D1557)
- Direct shear (ASTM D3080)
Approximate Boring Locations Map

Project: Winchester Lift Station-Odor Control System
Location: Northeast of the Intersection of Olive Avenue and La Ventana Road
Winchester Area of Riverside County, California
For: Black & Veatch Corporation

EXPLANATION
BH-02
- Number and Approximate Location of Exploratory Boring

BH-01
BH-02
Boring #1
Boring #2
For *in-situ* moisture and dry density data, see the Logs of Borings in Appendix A, *Field Exploration*. For a description of the laboratory test methods and test results, see Appendix B, *Laboratory Testing Program*.

### 4.4 Analysis and Report Preparation

Data obtained from the field exploration and laboratory testing program were compiled and evaluated. Geotechnical analyses of the compiled data were performed and this report was prepared to present our findings, conclusions and recommendations for the proposed odor control facility and associated pipeline.

### 5.0 SUBSURFACE CONDITIONS

A general description of the subsurface conditions, various materials and groundwater conditions encountered at the site during our field exploration is discussed below.

#### 5.1 Existing Asphalt Concrete Sections

The project site is paved with asphalt concrete. Asphalt concrete and aggregate base thicknesses were measured where encountered and are included in the following table.

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Asphalt Concrete Thickness (in.)</th>
<th>Aggregate Base Thickness (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-01</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>BH-02</td>
<td>3.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

#### 5.2 Subsurface Profile

Based on the exploratory borings and laboratory test results, the proposed site is underlain to a depth of at least 5 feet by fill soils consisting of sandy silt. the fill is underlain to a depth of at least 51.5 feet by alluvial sediments consisting of sandy silt, silty sand, sandy clay and sand. Scattered gravels were observed in boring BH-01 between 3 and 5 feet bgs.

5.3 Groundwater

Groundwater was encountered at 12.5 feet bgs during the investigation. Regional hydrologic conditions were reviewed to estimate expected groundwater conditions in the vicinity of the pump stations.

The National Water Information System (USGS, 2017a) was reviewed for groundwater data in the vicinity of the project site, however, no wells were located within close proximity.

The current depth to groundwater at the project site is approximately 12.5 feet bgs. The historic high groundwater level is not known with certainty. Groundwater may be encountered if construction excavations extend deeper than 12 feet bgs. It should be noted that the groundwater level could vary depending upon the seasonal precipitation and possible groundwater pumping activity in the site vicinity. Shallow perched groundwater may be present locally, particularly following precipitation or irrigation events.

5.4 Excavatability

Based on the exploratory soil borings, the on-site soils should be generally excavatable with conventional heavy duty earthmoving equipment.

The phrase “conventional heavy-duty excavation equipment” is intended to include commonly used equipment such as excavators, scrapers, and trenching machines. It does not include hydraulic hammers (“breakers”), jackhammers, blasting, or other specialized equipment and techniques used to excavate hard earth materials. Selection of an appropriate excavation equipment models should be done by an experienced earthwork contractor.

5.5 Subsurface Variations

Based on results of the subsurface exploration and our experience, some variations in the continuity and nature of subsurface conditions within the project site should be anticipated. Because of the uncertainties involved in the nature and depositional characteristics of the earth material, care should be exercised in interpolating or extrapolating subsurface conditions between or beyond the boring locations.

6.0 ENGINEERING GEOLOGY

The regional and local geology within the proposed project area are discussed below.
6.1 Regional Geology

The project site is located within the central portion of the Perris Block in the northern Peninsular Ranges Geomorphic Province of Southern California. The Peninsular Ranges Geomorphic Province consists of a series of southeast-trending mountain ranges and valleys bounded on the north by the San Bernardino and San Gabriel Mountains, on the west by the Los Angeles Basin, and on the south by the Pacific Ocean.

The province is a seismically active region characterized by a series of southeast-trending strike-slip faults. The most prominent of the nearby fault zones include the Elsinore, San Jacinto, and San Andreas Fault Zones, all of which have been known to be active during Quaternary time.

Topography within the province is generally characterized by broad alluvial valleys separated by linear mountain ranges. This southeast-trending linear fabric is created by the regional faulting within the granitic basement rock of the Southern California Batholith. Broad, linear, alluvial valleys have been formed by erosion of these principally granitic mountain ranges.

The Perris Block is a relatively stable structural block bounded by the active Elsinore and San Jacinto fault zones to the west and east, and the Chino and Temecula basins to the north and south, respectively. The Perris Block has low relief and is roughly rectangular.

6.2 Local Geology

The site is underlain by Holocene alluvial valley deposits transported and deposited by Salt Creek (Morton, 2003; Morton and Miller, 2006). These deposits generally consist of unconsolidated sand, silt, and clay.

The alluvial valley deposits are underlain by granitic bedrock of the Domenigoni Valley pluton, which forms the nearby mountains to the north and south of the site.

7.0 FAULTING AND SEISMICITY

The approximate distance and seismic characteristics of nearby faults as well as seismic design coefficients are discussed in the following subsections.

7.1 Faulting

The project site is not located within a currently designated State of California or Riverside County Earthquake Fault Zone (CGS, 2007; Riverside County, 2017). There
are no known active faults projecting toward or extending across the project site. The potential for surface rupture resulting from the movement of nearby major faults is not known with certainty but is considered low.

The proposed site is situated in a seismically active region. As is the case for most areas of Southern California, ground shaking resulting from earthquakes associated with nearby and more distant faults may occur at the project site. During the life of the project, seismic activity associated with active faults can be expected to generate moderate to strong ground shaking at the site.

The following tables contain a list of active and potentially active faults within one-hundred (100) kilometers of the subject site. The fault parameters and distances presented in the following tables are based on the output from EQFAULT (Blake, 2000), revised in accordance with CGS fault parameters (Cao et. al., 2003).

Table No. 2, Seismic Characteristics of Nearby Active Faults

<table>
<thead>
<tr>
<th>Fault Name</th>
<th>Approximate Distance (miles (km))</th>
<th>Moment Magnitude (Mw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Jacinto-San Jacinto Valley</td>
<td>10.9 (17.5)</td>
<td>6.9</td>
</tr>
<tr>
<td>Elsinore-Temecula</td>
<td>11.7 (18.9)</td>
<td>6.8</td>
</tr>
<tr>
<td>San Jacinto-Anza</td>
<td>12.6 (20.2)</td>
<td>7.2</td>
</tr>
<tr>
<td>Elsinore-Glen Ivy</td>
<td>13.4 (21.5)</td>
<td>6.8</td>
</tr>
<tr>
<td>San Jacinto-San Bernardino</td>
<td>22.9 (36.8)</td>
<td>6.7</td>
</tr>
<tr>
<td>Elsinore-Julian</td>
<td>23.4 (37.6)</td>
<td>7.1</td>
</tr>
<tr>
<td>San Andreas - San Bernardino</td>
<td>26.0 (41.8)</td>
<td>7.5</td>
</tr>
<tr>
<td>San Andreas - Southern</td>
<td>26.0 (41.8)</td>
<td>7.4</td>
</tr>
<tr>
<td>Chino-Central Ave. (Elsinore)</td>
<td>27.4 (44.1)</td>
<td>6.7</td>
</tr>
<tr>
<td>Whittier</td>
<td>31.2 (50.2)</td>
<td>6.8</td>
</tr>
<tr>
<td>Pinto Mountain</td>
<td>34.1 (54.8)</td>
<td>7.2</td>
</tr>
<tr>
<td>North Frontal Fault Zone (West)</td>
<td>38.0 (61.2)</td>
<td>7.2</td>
</tr>
<tr>
<td>Newport-Ingleswood (Offshore)</td>
<td>38.1 (61.3)</td>
<td>7.1</td>
</tr>
<tr>
<td>San Jacinto-Coyote Creek</td>
<td>39.5 (63.5)</td>
<td>6.8</td>
</tr>
<tr>
<td>Cucamonga</td>
<td>39.6 (63.8)</td>
<td>6.9</td>
</tr>
<tr>
<td>Clevelorn</td>
<td>40.5 (65.1)</td>
<td>6.5</td>
</tr>
<tr>
<td>San Andreas - Coachella</td>
<td>40.9 (65.8)</td>
<td>7.2</td>
</tr>
<tr>
<td>North Frontal Fault Zone (East)</td>
<td>41.3 (66.4)</td>
<td>6.7</td>
</tr>
<tr>
<td>Rose Canyon</td>
<td>42.9 (69.1)</td>
<td>7.2</td>
</tr>
<tr>
<td>San Jose</td>
<td>43.7 (70.3)</td>
<td>6.4</td>
</tr>
<tr>
<td>Elysian Park Thrust</td>
<td>45.2 (72.7)</td>
<td>6.7</td>
</tr>
<tr>
<td>Newport-Ingleswood (L.A.Basin)</td>
<td>46.3 (74.5)</td>
<td>7.1</td>
</tr>
<tr>
<td>Burnt Mtn.</td>
<td>46.4 (74.7)</td>
<td>6.5</td>
</tr>
<tr>
<td>Sierra Madre</td>
<td>46.5 (74.8)</td>
<td>7.2</td>
</tr>
<tr>
<td>Earthquake Valley</td>
<td>47.7 (76.7)</td>
<td>6.5</td>
</tr>
</tbody>
</table>
### 7.2 CBC Seismic Design Parameters

Seismic parameters based on the California Building Code (CBSC, 2016) were determined using the Seismic Design Maps application (USGS, 2017b) and are provided in the following table.

**Table No. 3, CBC Seismic Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Coordinates</td>
<td>33.7001N, 117.1280W</td>
</tr>
<tr>
<td>Site Class</td>
<td>D</td>
</tr>
<tr>
<td>Mapped Short period (0.2-sec) Spectral Response Acceleration, $S_s$</td>
<td>1.500g</td>
</tr>
<tr>
<td>Mapped 1-second Spectral Response Acceleration, $S_1$</td>
<td>0.600g</td>
</tr>
<tr>
<td>Site Coefficient (from Table 1613.5.3(1)), $F_a$</td>
<td>1.0</td>
</tr>
<tr>
<td>Site Coefficient (from Table 1613.5.3(2)), $F_v$</td>
<td>1.5</td>
</tr>
<tr>
<td>MCE 0.2-sec period Spectral Response Acceleration, $S_{MS}$</td>
<td>1.500g</td>
</tr>
<tr>
<td>MCE 1-second period Spectral Response Acceleration, $S_{M1}$</td>
<td>0.900g</td>
</tr>
<tr>
<td>Design Spectral Response Acceleration for short period, $S_{DS}$</td>
<td>1.000g</td>
</tr>
<tr>
<td>Design Spectral Response Acceleration for 1-second period, $S_{D1}$</td>
<td>0.600g</td>
</tr>
<tr>
<td>Maximum Peak Ground Acceleration, $PGA_{M}$</td>
<td>0.500g</td>
</tr>
</tbody>
</table>

### 7.3 Secondary Effects of Seismic Activity

In general, secondary effects of seismic activity include surface fault rupture, soil liquefaction, landslides, lateral spreading, and settlement due to seismic shaking,
tsunamis, seiches, and earthquake-induced flooding. The site-specific potential for each of these seismic hazards is discussed in the following sections.

**Surface Fault Rupture:** The site is not located within a currently designated State of California or Riverside County Earthquake Fault Zone (CGS, 2007; Riverside County, 2017). There are no known active faults projecting toward or extending across the project site. The potential for surface rupture resulting from the movement of nearby major faults is not known with certainty but is considered low.

**Liquefaction:** Liquefaction is defined as the phenomenon in which a cohesionless soil mass within the upper 50 feet of the ground surface suffers a substantial reduction in its shear strength, due to the development of excess pore pressures. During earthquakes, excess pore pressures in saturated soil deposits may develop as a result of induced cyclic shear stresses, resulting in liquefaction.

Soil liquefaction generally occurs in submerged granular soils and non-plastic silts during or after strong ground shaking. There are several general requirements for liquefaction to occur. They are as follows:

- Soils must be submerged.
- Soils must be loose to medium-dense.
- Ground motion must be intense.
- Duration of shaking must be sufficient for the soils to lose shear resistance.

The project site has been evaluated by Riverside County (Riverside County, 2017) as having a very high liquefaction potential. Due to the presence of shallow groundwater, the risk of liquefaction-induced settlement is considered high.

**Seismic Settlement:** Seismically-induced settlement occurs in unsaturated, unconsolidated, granular sediments during ground shaking associated with earthquakes. The analysis presented in Appendix C, *Dynamic Settlement Analysis* indicates that the proposed site has the potential for up to approximately 1.1 inches of dynamic settlement.

**Landslides:** Seismically induced landslides and other slope failures are common occurrences during or soon after earthquakes. Due to the relatively flat nature of the project site, the risk of landsliding is considered low.

**Lateral Spreading:** Seismically induced lateral spreading involves primarily lateral movement of earth materials over underlying materials which are liquefied due to ground shaking. It differs from the slope failure in that complete ground failure involving large movement does not occur due to the relatively smaller gradient of the initial ground surface. Lateral spreading is demonstrated by near-vertical cracks with predominantly
horizontal movement of the soil mass involved. Due to the high potential for liquefaction, the risk of lateral spreading is considered high.

**Tsunamis:** Tsunamis are large waves generated in open bodies of water by fault displacement or major ground movement. Due to the inland location of the site, tsunamis are not considered to be a risk.

**Seiches:** Seiches are large waves generated in enclosed bodies of water in response to ground shaking. Due to the distance to large bodies of water, the site is not at risk of seiching.

**Earthquake-Induced Flooding:** Dams or other water-retaining structures may fail as a result of large earthquakes. The project site is not located within a designated dam inundation zone (Riverside County, 2017). The risk for earthquake-induced flooding to affect the project site is considered low.

8.0 LABORATORY TEST RESULTS

Results of physical and chemical tests performed for this project are presented below.

8.1 Physical Testing

Results of the various laboratory tests are presented in Appendix B, Laboratory Testing Program, except for the results of in-situ moisture and dry density tests, which are presented on the Logs of Borings in Appendix A, Field Exploration. The results are also discussed below.

- **In-situ** Moisture and Dry Density – In-situ dry densities and moisture contents of the site soils were determined in accordance with ASTM Standard D2216. Dry densities of the upper 10 feet soils ranged from 98 to 120pcf with moisture contents of 9 to 19 percent. Results are presented in the log of borings in Appendix A, Field Exploration.
- Expansion Index – One representative sample from the upper 10 feet of soils was tested to evaluate the expansion potential in accordance with ASTM Standard D4829. The test result indicated an EI of 4, corresponding to very low expansion.
- Sand Equivalent – Two representative bulk soil samples were tested to evaluate sand equivalent (SE) in accordance with ASTM Standard D2419 test method. The measured sand equivalents were 9 and 14.
- Grain Size Analysis – Three representative soil samples were tested to determine their relative grain size distribution in accordance with ASTM Standard D422. The test results are graphically presented in Drawing No. B-1, Grain Size Distribution Results.
- Maximum Dry Density and Optimum Moisture Content – Typical moisture-density relationships of a representative soil sample were tested, according to ASTM
Standard D1557-B, with the result presented in Drawing No. B-2, *Moisture-Density Relationship Result*, in Appendix B, *Laboratory Testing Program*. The laboratory maximum dry density was 130.0 pounds per cubic feet (pcf), with an optimum moisture content of 10 percent.

- Direct Shear – Two direct shear tests were performed in accordance with ASTM Standard D3080 on relatively undisturbed ring samples. The results of the direct shear test are presented in Drawings No. B-3 and B-4, *Direct Shear Test Results* in Appendix B, *Laboratory Testing Program*.

### 8.2 Chemical Testing - Corrosivity Evaluation

Two representative soil sample was tested to determine minimum electrical resistivity, pH, and chemical content, including soluble sulfate and chloride concentrations. The purpose of these tests was to determine the corrosion potential of site soils when placed in contact with common construction materials. These tests were performed by EG Labs in accordance with California Test Methods 643, 422, and 417. The test results are presented in Appendix B, *Laboratory Testing Program* and are summarized in below.

- The pH measurement of the samples tested were 7.72 and 8.13.
- The sulfate content of the samples tested were 0.268 and 0.029 percent by weight.
- The chloride concentration of the samples tested were 235 and 250 ppm.
- The minimum electrical resistivities when saturated were 730 and 710 ohm-cm.

### 9.0 EARTHWORK RECOMMENDATIONS

Earthwork recommendations for the site are presented in the following sections.

#### 9.1 General

This section contains our general recommendations regarding earthwork and grading for the proposed odor control facility and piping. These recommendations are based on the results of our field exploration, laboratory tests, our experience with similar projects, and data evaluation as presented in the preceding sections. These recommendations may require modification by the geotechnical consultant based on observation of the actual field conditions during grading.

Prior to the start of construction, all underground existing utilities and appurtenances should be located at the project site. Such utilities should either be protected in-place or removed and replaced during construction as required by the project specifications. All excavations should be conducted in such a manner as not to cause loss of bearing and/or lateral support of existing structures or utilities.
All debris, surface vegetation, deleterious material, existing fill, and surficial soils containing roots and perishable materials (if present) should be stripped and removed from the site.

The final bottom surfaces of all excavations should be observed and approved by the project geotechnical consultant prior to placing any fill. Based on these observations, localized areas may require remedial grading deeper than indicated herein. Therefore, some variations in the depth and lateral extent of excavation recommended in this report should be anticipated.

9.2 Odor Control Facility Grading

The odor control system will be mounted on reinforced concrete slab-on-grade which should be uniformly supported by compacted fill. In order to provide uniform support, slab-on-grade areas should be overexcavated, scarified, and recompacted as follows.

The slab footprint should be overexcavated to a depth of 24 inches below the bottom of the footings or 5 feet below the existing ground surface, whichever is greater. The depth of overexcavation should be uniform across the entire slab. The overexcavation should extend to at least 5 feet beyond the footprint of the footing. The overexcavation bottom should be scarified and compacted as described in Section 9.4, Compacted Fill Placement.

If isolated pockets of very soft, loose, or pumping subgrade are encountered, the overexcavation should be locally deepened, as needed, to expose undisturbed, firm, and unyielding soils.

9.3 Fill Materials

The native soils encountered within the project site, free of debris or organic matter are suitable as compacted fill after proper processing and removal of oversize materials to meet the following criteria.

- No particles larger than 3 inches in largest dimension.
- Rocks larger than 1 inch should not be placed within the upper 12 inches of subgrade soils.
- Expansion index should be 20 or less.
- Plasticity Index of 10 or less.
- Contain less than 30 percent by weight retained on ¾-inch sieve.
- Free of all organic matter, debris, or other deleterious material.
Imported soils, if used as fill, should be predominantly granular and meet the above criteria. Any imported fill should be tested and approved by geotechnical representative prior to delivery to the site.

9.4 **Compacted Fill Placement**

All surfaces to receive structural fills should be scarified to a depth of 6 inches. The soil should be moisture conditioned to within ±3 percent of optimum moisture content for coarse soils and 0 to 2 percent above optimum moisture content for fine soils. The scarified soils should be recompacted to at least 90 percent of the laboratory maximum dry density.

Fill soils should be thoroughly mixed and moisture conditioned to within ±3 percent of optimum moisture content for coarse soils and 0 to 2 percent above optimum moisture content for fine soils. Fill soils should be evenly spread in horizontal lifts not exceeding 8 inches in uncompacted thickness.

All fill placed at the site should be compacted to at least 90 percent of the laboratory maximum dry densities as determined by ASTM Standard D1557 test method, unless a higher compaction is specified herein.

Fill materials should not be placed, spread or compacted during unfavorable weather conditions. When site grading is interrupted by heavy rain, filling operations should not resume until the geotechnical consultant approves the moisture and density conditions of the previously placed fill.

9.5 **Site Drainage**

Adequate positive drainage should be provided away from the structures and excavation areas to prevent ponding and to reduce percolation of water into the foundation soils. The buildings pad should have a gradient of at least 2 percent towards drainage facilities. The drainage gradient should be 1 percent for paved areas and 2 percent in landscaped areas. Surface drainage should be directed to suitable non-erosive devices.

9.6 **Utility Trench Backfill**

The following sections present earthwork recommendations for utility trench backfill, including subgrade preparation, pipe bedding, and trench zone backfill.

Open cuts adjacent to existing roadways and/or adjacent structures are not recommended within a 1:1 (horizontal:vertical) plane extending down and away from the roadway or structure perimeter.
Spoils from the trench excavation should not be stockpiled more than 6 feet in height or within a horizontal distance from the trench edge equal to the depth of the trench. Spoils should not be stockpiled behind the shoring, if any, within a horizontal distance equal to the depth of the trench, unless the shoring has been designed for such loads.

9.6.1 Pipeline Subgrade Preparation

The final subgrade surface should be level, firm, uniform, and free of loose materials and properly graded to provide uniform bearing and support to the entire section of the pipe placed on bedding material. Protruding oversize particles larger than 2 inches in dimension, if any, should be removed from the trench bottom and replaced with compacted on-site materials.

Any loose, soft and/or unsuitable materials encountered at the pipe subgrade should be removed and replaced with an adequate bedding material. During the digging of depressions for proper sealing of the pipe joints, the pipe should rest on a prepared bottom for as near its full length as is practicable.

9.6.2 Pipe Bedding

Bedding is defined as the material supporting and surrounding the pipe to 1 foot above the pipe. To provide uniform and firm support for the pipe, compacted granular materials such as clean sand, gravel or ¾-inch crushed aggregate, or crushed rock may be used as pipe bedding material. The sand equivalent of site soils varies from 9 to 14. Typically, soils with sand equivalent value of 30 or more are used as pipe bedding material. The type and thickness of the granular bedding placed underneath and around the pipe, if any, should be selected by the pipe designer. The load on the rigid pipes and deflection of flexible pipes and, hence, the pipe design, depends on the type and the amount of bedding placed underneath and around the pipe.

Bedding materials should be vibrated in-place to achieve compaction. Care should be taken to densify the bedding material below the springline of the pipe. Prior to placing the pipe bedding material, the pipe subgrade should be uniform and properly graded to provide uniform bearing and support to the entire section of the pipe placed on bedding material. During the digging of depressions for proper sealing of the pipe joints, the pipe should rest on a prepared bottom for as near its full length as is practicable.

Migration of fines from the surrounding native and/or fill soils must be considered in selecting the gradation of any imported bedding material. We recommend that the pipe bedding material should satisfy the following criteria:

\[ D_{15} < 2.5 \text{ mm and } D_{50} < 19.0 \text{ mm} \]
where $D_{15}$ and $D_{50}$ represent particle sizes of the bedding material corresponding to 15 percent and 50 percent passing by weight, respectively.

### 9.6.3 Trench Zone Backfill

The trench zone is defined as the portion of the trench above the pipe bedding extending up to the final grade level of the trench surface. Excavated site soils free of oversize particles and deleterious matter may be used to backfill the trench zone. Detailed trench backfill recommendations are provided below.

- Trench excavations to receive backfill should be free of trash, debris or other unsatisfactory materials at the time of backfill placement.
- Trench zone backfill should be compacted to at least 90 percent of the laboratory maximum dry density as per ASTM D1557 test method.
- Particles larger than 1 inch should not be placed within 12 inches of the pavement subgrade. No more than 30 percent of the backfill volume should be larger than ¾-inch in the largest dimension. Gravel should be well mixed with finer soil. Rocks larger than 3 inches in the largest dimension should not be placed as trench backfill.
- Trench backfill should be compacted by mechanical methods, such as sheepsfoot, vibrating or pneumatic rollers or mechanical tampers to achieve the density specified herein. The backfill materials should be brought to within $\pm 3$ percent of optimum moisture content for coarse-grained soil, and between optimum and 2 percent above optimum for fine-grained soil, then placed in horizontal layers. The thickness of uncompacted layers should not exceed 8 inches. Each layer should be evenly spread, moistened or dried as necessary, and then tamped or rolled until the specified density has been achieved.
- The contractor should select the equipment and processes to be used to achieve the specified density without damage to adjacent ground, structures, utilities and completed work.
- The field density of the compacted soil should be measured by the ASTM Standard D1556 (Sand Cone) or ASTM D6938 (Nuclear Gauge) or equivalent.
- Observations and field tests should be performed by the project soils consultant to confirm that the required degree of compaction has been obtained. Where compaction is less than that specified, additional compactive effort should be made with adjustment of the moisture content as necessary, until the specified compaction is obtained.
- It should be the responsibility of the contractor to maintain safe working conditions during all phases of construction.

Trench backfill should not be placed, spread or rolled during unfavorable weather conditions. When the work is interrupted by heavy rain, fill operations should not resume until field tests by the project’s geotechnical consultant indicate that the moisture
content and density of the fill are in compliance with project specifications.

10.0 DESIGN RECOMMENDATIONS

Design recommendations of the odor control system and associated pipelines are presented in the following sections.

10.1 General Evaluation

Based on our field exploration, laboratory testing and analyses of subsurface conditions at the site, the proposed slab may be placed on compacted fills as described in this report.

The various design recommendations provided in this section are based on the assumptions that in preparing the site, the earthwork recommendations presented in this report will be implemented.

10.2 Shallow Foundation Design Parameters

The proposed odor control system will be supported by a slabs-on-grade with extended concrete footings. The design of the shallow foundations should be based on the recommended parameters presented in the table below.

Table No. 4, Recommended Foundation Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum continuous or isolated spread footing width</td>
<td>18 inches</td>
</tr>
<tr>
<td>Minimum continuous or isolated footing depth of embedment below lowest adjacent grade</td>
<td>18 inches</td>
</tr>
<tr>
<td>Allowable net bearing capacity</td>
<td>2,000 psf</td>
</tr>
</tbody>
</table>

The footing dimensions and reinforcement should be based on structural design. The allowable bearing capacity can be increased by overburden pressure of 150 psf for each foot of width or depth of footing embedment to the maximum of 3,000 psf.

The net allowable bearing values indicated above are for the dead loads and frequently applied live loads and are obtained by applying a factor of safety of 3.0 to the net ultimate bearing capacity. If normal code requirements are applied for design, the above vertical bearing value may be increased by 33 percent for short duration loadings, which will include loadings induced by wind or seismic forces.
10.3 Mat Foundations

The proposed odor control system may be supported on mat foundations. The modulus of subgrade reaction (k) for design of flexible mat foundations was estimated from the available soil compressibility data and published charts. For design of flexible mat foundations, the following equation may be used.

\[ k = k_1 \left( \frac{B+1}{2B} \right)^2 \]

Where:
- \( k \) = vertical modulus of subgrade reaction for mat foundation, kips per cubic feet
- \( k_1 = 200 \text{ kcf}, \) normalized modulus of subgrade reaction for 1 square foot footing
- \( B \) = foundation width, feet
- \( E = 1.5 \text{ ksi}, \) Young’s Modulus
- \( \nu = 0.35, \) Poisson’s Ratio

10.4 Uplift Pressures

Slab and pipes (if any) placed below groundwater level should be checked against hydrostatic uplift pressures equal to 62.4H (psf), where H is the depth water level from the bottom of the structures. The slab below groundwater level should be designed in such a way that the weight of the slab should be higher than the uplift pressure. The pipes below groundwater level should be designed in such a way that the weight of the soil (above pipes) and pipes (without liquid) should be greater than the uplift pressure.

10.5 Lateral Earth Pressures and Resistance to Lateral Loads

In the following subsections, the lateral earth pressures and resistance to lateral loads are estimated by using on-site native soils strength parameters obtained from laboratory testing.

10.5.1 Active Earth Pressures

The active earth pressure behind any buried wall or foundation depends primarily on the allowable wall movement, type of backfill materials, backfill slopes, wall or foundation inclination, surcharges, and any hydrostatic pressures. The recommended lateral earth pressures for the site are presented in the following table.

<table>
<thead>
<tr>
<th>Loading Conditions</th>
<th>Lateral Earth Pressure (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active earth conditions (wall is free to deflect at least 0.001 radian)</td>
<td>50</td>
</tr>
<tr>
<td>At-rest (wall is restrained)</td>
<td>72</td>
</tr>
</tbody>
</table>
10.5.2 Passive Earth Pressure

Resistance to lateral loads can be assumed to be provided by a combination of friction acting at the base of foundations and by passive earth pressure. A coefficient of friction of 0.30 between formed concrete and soil may be used with the dead load forces. An allowable passive earth pressure of 220 psf per foot of depth may be used for the sides of footings poured against recompacted soils. A factor of safety of 1.5 was applied in calculating passive earth pressure. The maximum value of the passive earth pressure should be limited to 2,000 psf for compacted fill.

Vertical and lateral bearing values indicated above are for the total dead loads and frequently applied live loads. If normal code requirements are applied for design, the above vertical bearing and lateral resistance values may be increased by 33 percent for short duration loading, which will include the effect of wind or seismic forces.

Due to the low overburden stress of the soil at shallow depth, the upper 1 foot of passive resistance should be neglected unless the soil is confined by pavement or slab.

10.5.3 Seismic Earth Pressure

The equivalent fluid seismic pressure was calculated using Seed and Whitman (1970) procedure. The seismic force applied to the wall is based on a horizontal seismic acceleration coefficient equal to one-third of the peak ground acceleration in accordance with Caltrans Bridge Design Specifications (Caltrans, 2004). An equivalent fluid seismic pressure of 27H pcf may be assumed under active loading conditions at the top of an inverted triangle pressure distribution where H is the height of the backfill behind the wall. Under at-rest conditions, the active equivalent fluid seismic pressure should be increased by 30 percent.

10.6 Slab-on-Grade

Structural design elements of slab-on-grade, including but not limited to thickness, reinforcement, joint spacing, should be selected based on the analysis performed by the project structural engineer considering anticipated loading conditions and the modulus of subgrade reaction of the supporting materials.

An under-slab moisture barrier should be utilized in areas where moisture-sensitive flooring systems may be used. The moisture barrier should consist of a minimum by 6-mil-thick impermeable membrane. All seams and openings should be overlapped and sealed.

Up to 2 inches of sand may be placed beneath the membrane to provide protection from any rocks or debris in the subgrade soil. The sand layer below the membrane may be comprised of onsite earth materials free of rocks or other debris which may damage the
barrier. Up to 2 inches of sand may be placed above the membrane to provide protection during construction and to aid in the concrete curing. The thickness of the sand layers above and below the membrane should be determined by the structural engineer based on the foundation design. With modern moisture barriers, the sand layer above the moisture barrier can be eliminated at the discretion of the structural engineer and concrete can be poured directly on top of the membrane.

Slab should be designed and constructed as promulgated by the American Concrete Institute (ACI) and the Portland Cement Association (PCA). Care should be taken during concrete placement to avoid slab curling. Prior to the slab pour, all utility trenches should be properly backfilled and compacted.

Subgrade for slabs-on-grade should be firm and uniform. All loose or disturbed soils including under-slab utility trench backfill should be recompacted.

10.7 Settlement

The total settlement of shallow footings from static structural loads and short-term settlement of properly compacted fill is anticipated to be 1 inch or less. The differential settlement resulting from static loads is anticipated to be 0.5 inches or less over a horizontal distance of 40 feet.

Our analysis of the potential dynamic settlement is presented in Appendix C, Settlement Analysis. We estimate that the proposed site has the potential for up to 1.1 inches of dynamic settlement during a large earthquake. We recommend that the planned structure be designed conservatively in anticipation of dynamic differential settlement of up to 0.55 inches over 40 horizontal feet.

The static and dynamic settlement estimates should not be combined for design purposes. The maximum combined static and dynamic settlement is not anticipated to exceed the maximum anticipated dynamic settlement.

10.8 Pipe Design

Structural design of pipelines requires proper evaluation of all possible loads acting on pipes. The stresses and strains induced on buried pipes depend on many factors, including the type of soil, density, bearing pressure, angle of internal friction, coefficient of passive earth pressure, and coefficient of friction at the interface between the backfill and native soils. The recommended values of the various soil parameters for the pipe design are provided in Table No. 6, Soil Parameters for Pipe Design in the following table.
Where pipes are connecting to rigid structures near, or at its lower levels, and then are subjected to significant loads as the backfill is placed to finish grade, we recommend that provisions be incorporated in the design to provide support of these pipelines where they exit the structure. Consideration can be given to flexible connections, concrete slurry support beneath the pipes where they exit the structures, overlaying and supporting the pipes with a few inches of compressible material, (i.e. Styrofoam, or other materials), or other techniques. Automatic shut-offs should be installed to limit the potential leakage in the event of damage in a seismic event. Piping and connections should be sized for the estimated dynamic settlement provided in section 10.7 Settlement.

**Table No. 6, Soil Parameters for Pipe Design**

<table>
<thead>
<tr>
<th>Soil Parameters</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total unit weight of compacted backfill (assuming 92% average relative compaction), ( \gamma )</td>
<td>130 pcf</td>
</tr>
<tr>
<td>Angle of internal friction of soils, ( \phi )</td>
<td>26(^\circ)</td>
</tr>
<tr>
<td>Soil cohesion, ( c )</td>
<td>30 pcf</td>
</tr>
<tr>
<td>Coefficient of friction between concrete and native soils, ( f_s )</td>
<td>0.30</td>
</tr>
<tr>
<td>Coefficient of friction between pipe and native soils, ( f_s )</td>
<td>0.25 for metal pipe</td>
</tr>
<tr>
<td></td>
<td>0.30 for CML&amp;C steel pipe</td>
</tr>
<tr>
<td>Bearing pressure against Alluvial Soils</td>
<td>2,000 psf</td>
</tr>
<tr>
<td>Coefficient of passive earth pressure, ( K_p )</td>
<td>2.56</td>
</tr>
<tr>
<td>Coefficient of active earth pressure, ( K_a )</td>
<td>0.39</td>
</tr>
<tr>
<td>Modulus of Soil Reaction, ( E' )</td>
<td>1000 psi</td>
</tr>
</tbody>
</table>

**10.9 Soil Corrosivity**

The results of chemical testing of two representative soil samples from the site were evaluated for corrosivity with respect to common construction materials such as concrete and steel. The test results are presented in Appendix B, *Laboratory Testing Program* and design recommendations pertaining to soil corrosivity are presented below.

The sulfate contents of the sampled soils correspond to American Concrete Institute (ACI) exposure category S1 for these sulfate concentrations (ACI 318-14, Table 19.3.1.1). Maximum water cement ratio is 0.5 and concrete type restrictions are specified for exposure category S1 (ACI 318-14, Table 19.3.2.1). A minimum compressive strength of 4,000 psi is recommended.
We anticipate that concrete structures such as footings, slabs, and flatwork will be exposed to moisture from precipitation and irrigation. Based on the site locations and the results of chloride testing of the site soils, we do not anticipate that concrete structures will be exposed to external sources of chlorides, such as deicing chemicals, salt, brackish water, or seawater. ACI specifies exposure category C1 where concrete is exposed to moisture, but not to external sources of chlorides (ACI 318-14, Table 19.3.1.1). ACI provides concrete design recommendations in ACI 318-14, Table 19.3.2.1, including a compressive strength of at least 2,500 psi and a maximum chloride content of 0.3 percent.

The measured value of the minimum electrical resistivities when saturated were 730 and 710 Ohm-cm. This indicates that the tested soils of the project site are severely corrosive to ferrous metals in contact with the soil (Romanoff, 1957). Converse does not practice in the area of corrosion consulting. A qualified corrosion consultant should provide appropriate corrosion mitigation measures for any ferrous metals in contact with the site soils.

11.0 CONSTRUCTION RECOMMENDATIONS

11.1 General

Prior to the start of construction, all existing underground utilities should be located. Such utilities should either be protected in-place or removed and replaced during construction as required by the project specifications.

Vertical braced excavations are feasible at the project site. Sloped excavations may not be feasible in locations adjacent to existing utilities, structures, or other improvements. Recommendations pertaining to temporary excavations are presented in this section.

Where the side of the excavation is a vertical cut, it should be adequately supported by temporary shoring to protect workers and any adjacent structures.

All applicable requirements of the California Construction and General Industry Safety Orders, the Occupational Safety and Health Act, current amendments, and the Construction Safety Act should be met. The soils exposed in cuts should be observed during excavation by the owner’s representative and the competent person employed by the contractor in accordance with regulations. If potentially unstable soil conditions are encountered, modifications of slope ratios for temporary cuts may be required.

11.2 Temporary Sloped Excavations

Temporary open-cut trenches may be constructed with side slopes as recommended in the table below. Temporary cuts encountering soft and wet fine-grained soils, dry loose,
cohesionless soils, or loose fill from trench backfill may have to be constructed at a flatter gradient than presented below.

Table No. 7, Slope Ratios for Temporary Excavations

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Depth of Cut (feet)</th>
<th>Recommended Maximum Slope (Horizontal:Vertical)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silty Sand and Sandy Clay</td>
<td>0-4</td>
<td>Vertical</td>
</tr>
<tr>
<td>4-10</td>
<td>1:1</td>
<td></td>
</tr>
<tr>
<td>10-20</td>
<td>1.5:1</td>
<td></td>
</tr>
</tbody>
</table>

¹ Slope ratio is assumed to be constant from top to toe of slope, with level adjacent ground.

For steeper temporary construction slopes or deeper excavations, or unstable soil encountered during the excavation, shoring or trench shields should be provided by the contractor as necessary to protect the workers in the excavation.

Surfaces exposed in sloped excavations should be kept moist but not saturated to retard raveling and sloughing during construction. Adequate provisions should be made to protect the slopes from erosion during periods of rainfall. Surcharge loads, including construction materials, should not be placed within 5 feet of the unsupported slope edge. Stockpiled soils with a height higher than 6 feet will require greater distance from trench edges.

11.3 Shoring Design

Temporary shoring will be required where open sloped excavations will not be feasible due to unstable soils or due to nearby existing structures or facilities. Temporary shoring may consist of conventional soldier piles and lagging or sheet piles. The shoring for the pipe excavations may be laterally supported by walers and cross bracing or may be cantilevered. Drilled excavations for soldier piles will require the use of drilling fluids to prevent caving and to maintain an opened hole for pile installation.

The active earth pressure behind any shoring depends primarily on the allowable movement, type of backfill materials, backfill slopes, wall inclination, surcharges, and any hydrostatic pressures.

The lateral earth pressures to be used in the design of shoring is presented in the following table.
Table No. 8, Lateral Earth Pressures for Temporary Shoring

<table>
<thead>
<tr>
<th>Lateral Resistance Soil Parameters*</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Earth Pressure (Braced Shoring) (psf) (A)</td>
<td>30</td>
</tr>
<tr>
<td>Active Earth Pressure (Cantilever Shoring) (psf) (B)</td>
<td>50</td>
</tr>
<tr>
<td>At-Rest Earth Pressure (Cantilever Shoring) (psf) (C)</td>
<td>72</td>
</tr>
<tr>
<td>Passive earth pressure (psf per foot of depth) (D)</td>
<td>220</td>
</tr>
<tr>
<td>Maximum allowable bearing pressure against native soils (psf) (E)</td>
<td>2,000</td>
</tr>
<tr>
<td>Coefficient of friction between sheet pile and native soils, fs (degree) (F)</td>
<td>0.30</td>
</tr>
</tbody>
</table>

* Parameters A through F are used in Figures No. 3 and 4 below.

Restrained (braced) shoring systems should be designed based on Figure No. 3, *Lateral Earth Pressures for Braced Excavation* to support a uniform rectangular lateral earth pressure.

**Figure No. 3, Lateral Earth Pressures for Temporary Braced Excavation**

Unrestrained (cantilever) design of cantilever shoring consisting of soldier piles spaced at least two diameters on-center or sheet piles, can be based on Figure No. 4, *Lateral Earth Pressures on Temporary Cantilever Wall.*
Figure No. 4, Lateral Earth Pressures on Temporary Cantilever Wall

![Lateral Earth Pressures Diagram]

The provided pressures assume no hydrostatic pressures. If hydrostatic pressures are allowed to build up, the incremental earth pressures below the ground-water level should be reduced by 50 percent and added to hydrostatic pressure for total lateral pressure.

Passive resistance includes a safety factor of 1.5. The upper 1 foot for passive resistance should be ignored unless the surface is confined by a pavement or slab.

In addition to the lateral earth pressure, surcharge pressures due to miscellaneous loads, such as soil stockpiles, vehicular traffic or construction equipment located adjacent to the shoring, should be included in the design of the shoring. A uniform lateral pressure of 100 psf should be included in the upper 10 feet of the shoring to account for normal vehicular and construction traffic within 10 feet of the trench excavation. As previously mentioned, all shoring should be designed and installed in accordance with state and federal safety regulations.

The contractor should have provisions for soldier pile and sheet pile removal. All voids resulting from removal of shoring should be filled. The method for filling voids should be selected by the contractor, depending on construction conditions, void dimensions and available materials. The acceptable materials, in general, should be non-deleterious, and able to flow into the voids created by shoring removal (e.g. concrete slurry, “pea” gravel, etc).

Excavations for the proposed pipeline should not extend below a 1:1 horizontal:vertical (H:V) plane extending from the bottom of any existing structures, utility lines or streets.
Any proposed excavation should not cause loss of bearing and/or lateral supports of the existing utilities or streets.

If the excavation extends below a 1:1 (H:V) plane extending from the bottom of the existing structures, utility lines or streets, a maximum of 10 feet of slope face parallel to the existing improvement should be exposed at a time to reduce the potential for instability. Backfill should be accomplished in the shortest period of time and in alternating sections.

### 11.4 Dewatering and Groundwater Control

Pipes extending 12 feet deep below the existing ground surface will encounter groundwater. Excavation below that depth will likely require dewatering. The dewatering system should be designed by an engineer experienced with this type of construction.

### 12.0 GEOTECHNICAL SERVICES DURING CONSTRUCTION

The project geotechnical consultant should be present to observe conditions and test the density and moisture of the backfill during the earthwork for this project. The excavations and backfill should be observed and tested for compliance with project specifications.

### 13.0 CLOSURE

This report is prepared for the project described herein and is intended for use solely by Black & Veatch Corporation and their authorized agents, to assist in the design and construction of the proposed project. Our findings and recommendations were obtained in accordance with generally accepted professional principles practiced in geotechnical engineering. We make no other warranty, either expressed or implied.

Converse Consultants is not responsible or liable for any claims or damages associated with interpretation of available information provided to others. Site exploration identifies actual soil conditions only at those points where samples are taken, when they are taken. Data derived through sampling and laboratory testing is extrapolated by Converse employees who render an opinion about the overall soil conditions. Actual conditions in areas not sampled may differ. In the event that changes to the project occur, or additional, relevant information about the project is brought to our attention, the recommendations contained in this report may not be valid unless these changes and additional relevant information are reviewed and the recommendations of this report are modified or verified in writing. In addition, the recommendations can only be finalized by observing actual subsurface conditions revealed during construction. Converse cannot be held responsible for misinterpretation or changes to our recommendations made by others during construction.
As the project evolves, continued consultation and construction monitoring by a qualified geotechnical consultant should be considered an extension of geotechnical investigation services performed to date. The geotechnical consultant should review plans and specifications to verify that the recommendations presented herein have been appropriately interpreted, and that the design assumptions used in this report are valid. Where significant design changes occur, Converse may be required to augment or modify the recommendations presented herein. Subsurface conditions may differ in some locations from those encountered in the explorations, and may require additional analyses and, possibly, modified recommendations.

Design recommendations given in this report are based on the assumption that the recommendations contained in this report are implemented. Additional consultation may be prudent to interpret Converse's findings for contractors, or to possibly refine these recommendations based upon the review of the actual site conditions encountered during construction. If the scope of the project changes, if project completion is to be delayed, or if the report is to be used for another purpose, this office should be consulted.
14.0 REFERENCES

AMERICAN CONCRETE INSTITUTE (ACI), 2014, Building Code Requirements for Structural Concrete (ACI 318-14), dated September, 2014.


BLAKE, T. F., 2000, EQSEARCH Computer Programs for Performing Probabilistic, and Seismic Coefficient Analysis and Historical Earthquake Search.

CALIFORNIA BUILDING STANDARDS COMMISSION (CBSC), 2016, California Building Code (CBC).


EASTERN MUNICIPAL WATER DISTRICT (EMWD), 1997, Winchester Lift Station and Force Main, dated April 1997.


Appendix A

Field Exploration
APPENDIX A

FIELD EXPLORATION

Our field investigation included a site reconnaissance and a subsurface exploration program consisting of drilling soil borings. During the site reconnaissance, the surface conditions were noted and the boring locations were marked in the field using approximate distances from local street as a guide. It should be considered accurate only to the degree implied by the method used to locate them.

Two exploratory borings (BH-01 and BH-02) were drilled on November 9, 2017 at the site of the proposed odor control facility. The borings were drilled to their maximum planned depths of 21.5 and 51.5 feet bgs.

The borings were advanced using a truck-mounted drill rig equipped with 8-inch diameter hollow-stem augers for soils sampling. Encountered materials were continuously logged by a Converse engineer and classified in the field by visual classification in accordance with the Unified Soil Classification System. Where appropriate, the field descriptions and classifications have been modified to reflect laboratory test results.

Relatively undisturbed samples were obtained using California Modified Samplers (2.4 inches inside diameter and 3.0 inches outside diameter) lined with thin sample rings. The steel ring sampler was driven into the bottom of the borehole with successive drops of a 140-pound driving weight falling 30 inches. Blow counts at each sample interval are presented on the boring logs. Samples were retained in brass rings (2.4 inches inside diameter and 1.0 inch in height) and carefully sealed in waterproof plastic containers for shipment to the Converse laboratory. Bulk samples of typical soil types were also obtained.

Standard Penetration Testing (SPT) was also performed in boring BH-01 in accordance with the ASTM Standard D1586 test method at depths of 20, 30, 40 and 50 feet bgs using a standard (1.4 inches inside diameter and 2.0 inches outside diameter) split-barrel sampler. The mechanically driven hammer for the SPT sampler was 140 pounds, falling 30 inches for each blow. The recorded blow counts for every 6 inches for a total of 1.5 feet of sampler penetration are shown on the Logs of Borings.

The exact depths at which material changes occur cannot always be established accurately. Unless a more precise depth can be established by other means, changes in material conditions that occur between drive samples are indicated on the logs at the top of the next drive sample.

Following the completion of logging and sampling, the borings were backfilled with soil cuttings, tamped and surface patched with asphalt concrete. The surface of the borings may settle over time, so if construction is delayed, we recommend the owner monitor the
boring locations and backfill any depressions that might occur, or provide protection around the boring locations to prevent trip and fall injuries from occurring near the area of any potential settlement.

For a key to soil symbols and terminology used in the boring logs, refer to Drawing No. A-1, *Unified Soil Classification and Key to Boring Log Symbols*. For logs of borings see Drawings No. A-2 and A-3, *Logs of Borings*. 
# Log of Boring No. BH-01

**Dates Drilled:** 11/9/2017  
**Logged by:** Michael Maldonado  
**Checked By:** Scot Mathis  
**Equipment:** 8" HOLLOW STEM AUGER  
**Driving Weight and Drop:** 140 lbs / 30 in  
**Ground Surface Elevation (ft):** 1450  
**Depth to Water (ft):** 12.5

## Summary of Subsurface Conditions

This log is part of the report prepared by Converse for this project and should be read together with the report. This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.

**SITE**

- 4" ASPHALT CONCRETE/ 3" AGGREGATE BASE

**FILL**

- SANDY SILT (ML): fine to coarse-grained sand, yellowish brown.
  - scattered gravel up to 1.5" in largest dimension

**ALLUVIUM**

- SANDY SILT (ML): fine to coarse-grained sand, yellowish brown.

**SILTY SAND (SM):** fine to medium-grained, yellowish brown.

**SANDY CLAY (CL):** fine to medium-grained sand, yellowish brown.

## Graphical Log

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic Log</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/9/8</td>
<td></td>
<td>12 117</td>
</tr>
<tr>
<td>3/10/34</td>
<td></td>
<td>12 107 ds</td>
</tr>
<tr>
<td>10/29/14</td>
<td></td>
<td>9 120 ma</td>
</tr>
<tr>
<td>6/9/12</td>
<td></td>
<td>10 120</td>
</tr>
<tr>
<td>9/18/14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/1/1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/10/10</td>
<td></td>
<td>20 106</td>
</tr>
<tr>
<td>1/2/3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Winchester Lift Station - Odor Control System  
Northeast of the Intersection of Olive Avenue and La Ventana Road  
Winchester Area of Riverside County, California  
For: Black & Veatch Corporation

**Project No.** 17-81-196-01  
**Drawing No.** A-2a

Converse Consultants
**Log of Boring No. BH-01**

Dates Drilled: 11/9/2017  
Logged by: Michael Maldonado  
Checked By: Scot Mathis

Equipment: 8" HOLLOW STEM AUGER  
Driving Weight and Drop: 140 lbs / 30 in

Ground Surface Elevation (ft): 1450  
Depth to Water (ft): 12.5

---

### SUMMARY OF SUBSURFACE CONDITIONS

This log is part of the report prepared by Converse for this project and should be read together with the report. This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.

| Depth (ft) | Graphic Log | ALLUVIUM | SANDY CLAY (CL): fine to medium-grained sand, yellowish brown. | SAND (SP): fine to coarse-grained, some iron stains, brown. | SANDY CLAY (CL): fine to medium-grained sand, brown. | End of boring at 51.5 feet bgs.  
Groundwater encountered at 15.8 feet and stabilized at 12.5 feet after 20 minutes.  
Borehole backfilled with soil cuttings, tamped, and surface asphalt patched.

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>SAMPLES</th>
<th>DRIVE</th>
<th>BULK</th>
<th>BLOWS</th>
<th>MOISTURE</th>
<th>DRY UNIT WT.</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td></td>
<td>8/18/21</td>
<td></td>
<td>19</td>
<td>117</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td></td>
<td>5/11/16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>9/20/30</td>
<td></td>
<td>19</td>
<td>113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>8/14/16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Summary of Subsurface Conditions

This log is part of the report prepared by Converse for this project and should be read together with the report. This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.

#### Fill

**Sandy Silt (ML):** fine to coarse-grained, yellowish brown.

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Drive</th>
<th>BULK</th>
<th>Moisture</th>
<th>Dry Unit Wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/12/21</td>
<td>10</td>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/19/25</td>
<td>19</td>
<td>112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/20/14</td>
<td>17</td>
<td>98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/12/9</td>
<td>20</td>
<td>103</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/6/6</td>
<td>11</td>
<td>108</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/3/3</td>
<td>22</td>
<td>97</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Alluvium

**Sandy Clay (CL):** fine to medium-grained sand, yellowish brown.

End of boring at 21.5 feet bgs.
Groundwater encountered at 20.6 feet and stabilized at 16.5 feet after 15 minutes.
Borehole backfilled with soil cuttings, tamped, and surface asphalt patched.
Appendix B

Laboratory Testing Program
APPENDIX B

LABORATORY TESTING PROGRAM

Tests were conducted in our laboratory on representative soil samples for the purpose of classification and evaluation of their physical properties and engineering characteristics. The amount and selection of tests were based on the geotechnical parameters required for this project. Test results are presented herein and on the Logs of Borings, in Appendix A, Field Exploration. The following is a summary of the various laboratory tests conducted for this project.

In-Situ Moisture Content and Dry Density

Results of these tests performed on relatively undisturbed ring samples were used to aid in the classification and to provide quantitative measure of the in situ dry density and moisture content. Data obtained from these tests provide qualitative information on strength and compressibility characteristics of the site soils. For test results, see the Logs of Borings in Appendix A, Field Exploration.

Expansion Index Test

One representative bulk sample was tested in accordance with ASTM Standard D4829 to evaluate the expansion potential. The test result is presented in the following table.

Table No. B-1, Expansion Index Test Result

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth (feet)</th>
<th>Soil Description</th>
<th>Expansion Index</th>
<th>Expansion Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-01</td>
<td>0-5</td>
<td>Sandy Silt (ML)</td>
<td>4</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

Sand Equivalent

Two representative soil samples were tested in accordance with ASTM Standard D2419 to determine the sand equivalent. The test results are presented in the following table.

Table No. B-2, Sand Equivalent Test Results

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth (feet)</th>
<th>Soil Description</th>
<th>Sand Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-01</td>
<td>0-5</td>
<td>Sandy Silt (ML)</td>
<td>9</td>
</tr>
<tr>
<td>BH-02</td>
<td>0-3</td>
<td>Sandy Silt (ML)</td>
<td>14</td>
</tr>
</tbody>
</table>
Soil Corrosivity Tests

Two representative soil samples were tested to determine minimum electrical resistivity, pH, and chemical content, including soluble sulfate and chloride concentrations. The purpose of these tests was to determine the corrosion potential of the site soils when placed in contact with common construction materials. These tests were performed by EG Labs in accordance to Caltrans Test Methods 643, 422 and 417. Test results are presented in the following table.

Table No. B-3, Summary of Soil Corrosivity Test Results

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth (feet)</th>
<th>pH</th>
<th>Soluble Sulfates (CA 417) (% by weight)</th>
<th>Soluble Chlorides (CA 422) (ppm)</th>
<th>Min. Resistivity (CA 643) (Ohm-cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-01</td>
<td>0-5</td>
<td>7.72</td>
<td>0.268</td>
<td>235</td>
<td>730</td>
</tr>
<tr>
<td>BH-02</td>
<td>15-20</td>
<td>8.13</td>
<td>0.029</td>
<td>250</td>
<td>710</td>
</tr>
</tbody>
</table>

Grain-Size Analyses

To assist in classification of soils, mechanical grain-size analyses were performed on three select samples in accordance with the ASTM Standard D422 test method. Grain-size curves are shown in Drawing No. B-1, Grain Size Distribution Results.

Maximum Dry Density and Optimum Moisture Content Tests

Laboratory maximum dry density-optimum moisture content relationship test was performed on a representative bulk sample. The test was conducted in accordance with the ASTM Standard D1557 test method. The test result is presented in Drawing No. B-2, Moisture-Density Relationship Result, and is summarized in the following table.

Table No B-4, Summary of Moisture-Density Relationship Results

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth (feet)</th>
<th>Soil Description</th>
<th>Maximum Density (lb/cft)</th>
<th>Optimum Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-01</td>
<td>0-5</td>
<td>Sandy Silt (ML), Yellowish Brown</td>
<td>130.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Direct Shear Tests

Two direct shear tests were performed on relatively undisturbed samples in the soaked moisture condition in accordance with the ASTM D3080 procedure. For each test, three samples contained in brass sampler rings were placed, one at a time, directly into the test apparatus and subjected to a range of normal loads appropriate for the anticipated...
conditions. The samples were then sheared at a constant strain rate of 0.001 inch/minute. Shear deformation was recorded until a maximum of about 0.25-inch shear displacement was achieved. Ultimate strength was selected from the shear-stress deformation data and plotted to determine the shear strength parameters. For test data, including sample density and moisture content, see Drawings No. B-3 and B-4, *Direct Shear Test Results*, and the following table.

**Table No. B-5, Summary of Direct Shear Test Results**

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth (feet)</th>
<th>Soil Description</th>
<th>Peak Strength Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-01</td>
<td>5.0-6.5</td>
<td>Sands Silt (ML)</td>
<td>Friction Angle (degrees) 26 Cohesion (psf) 250</td>
</tr>
<tr>
<td>BH-02</td>
<td>15.0-16.5</td>
<td>Sand Clay (CL)</td>
<td>Friction Angle (degrees) 25 Cohesion (psf) 300</td>
</tr>
</tbody>
</table>

**Sample Storage**

Soil samples presently stored in our laboratory will be discarded 30 days after the date of this report, unless this office receives a specific request to retain the samples for a longer period.
GRAIN SIZE DISTRIBUTION RESULTS

Winchester Lift Station - Odor Control System
Northeast of the Intersection of Olive Avenue and La Ventana Road
Winchester Area of Riverside County, California
For: Black & Veatch Corporation

Converse Consultants

Project No. 17-81-196-01
Drawing No. B-1

Project ID: 17-81-196-01.GPJ; Template: GRAIN SIZE
### Curves of 100% Saturation for Specific Gravity Equal to:

- 2.80
- 2.70
- 2.60

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>BORING NO.</th>
<th>DEPTH (ft)</th>
<th>DESCRIPTION</th>
<th>ASTM TEST METHOD</th>
<th>OPTIMUM WATER, %</th>
<th>MAXIMUM DRY DENSITY, pcf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BH-01</td>
<td>0-5</td>
<td>SANDY SILT (ML), Yellowish Brown</td>
<td>D1557-A</td>
<td>10.0</td>
<td>130.0</td>
</tr>
</tbody>
</table>
**DIRECT SHEAR TEST RESULTS**

Winchester Lift Station - Odor Control System  
Northeast of the Intersection of Olive Avenue and La Ventana Road  
Winchester Area of Riverside County, California  
For: Black & Veatch Corporation

<table>
<thead>
<tr>
<th>BORING NO.</th>
<th>BH-01</th>
<th>DEPTH (ft)</th>
<th>5.0-6.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIPTION</td>
<td>SANDY SILT (ML)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COHESION (psf)</td>
<td>250</td>
<td>FRICTION ANGLE (degrees):</td>
<td>26</td>
</tr>
<tr>
<td>MOISTURE CONTENT (%)</td>
<td>11.9</td>
<td>DRY DENSITY (pcf)</td>
<td>107.2</td>
</tr>
</tbody>
</table>

NOTE: Ultimate Strength.
BORING NO. : BH-02
DESCRIPTION : SANDY CLAY (CL)
COHESION (psf) : 300
MOISTURE CONTENT (%) : 10.8

SURCHARGE PRESSURE, psf

DEPT (ft) : 15.0-16.5
FRICTION ANGLE (degrees) : 25
DRY DENSITY (pcf) : 108.3

NOTE: Ultimate Strength.
Appendix C

Dynamic Settlement Analysis
APPENDIX C

DYNAMIC SETTLEMENT ANALYSIS

The subsurface data obtained from the boring (Boring BH-01) drilled during the field investigation were used to evaluate the dynamic settlement due to potential densification of relatively loose sediments subjected to ground shaking during earthquakes.

The dynamic analysis was performed using Liquefy Pro (Civiltech, 2012). An earthquake magnitude of M6.9 and peak ground acceleration (PGA) of 0.50g, where g is the acceleration due to gravity, was selected for this analysis. The PGA was based on the CBC seismic design parameters presented in Section 7.2, CBC Seismic Design Parameters. An analysis considering current groundwater condition at depth 12.5 feet bgs was performed.

The result of our analysis is presented on Plate C-1 and summarized in the following table.

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Groundwater Condition (feet bgs)</th>
<th>Dynamic Settlement (inches)</th>
<th>Differential Dynamic Settlement (inch/40 linear feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH-01</td>
<td>12.5 (feet bgs)</td>
<td>1.02</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Based on our analysis, the existing site has the potential for up to 1.1 inches of dynamic settlement. The differential settlement resulting from dynamic loads is anticipated to be up to 0.55 inches or less over a horizontal distance of 40 feet.