



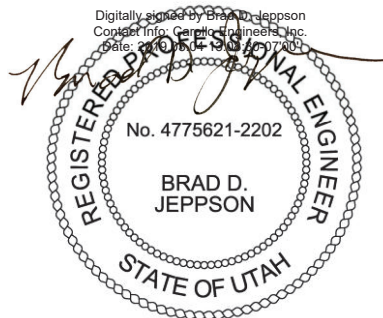
PROJECT 5

CONTRACT DOCUMENTS

**BIDDING REQUIREMENTS, CONTRACT FORMS,
CONDITIONS OF THE CONTRACT,
TECHNICAL SPECIFICATIONS AND DRAWINGS**

VOLUME 3 of 5

DIVISIONS 16 to 17 and GEOTECH REPORT



**Bids will be received at the office of South Valley Water Reclamation Facility
located at**

7495 South 1300 West, West Jordan, Utah 84084

until 2:00 PM Wednesday, May 1, 2019.

**SECTION 00020
CONTRACT DOCUMENTS TABLE OF CONTENTS**

VOLUME 1

**DIVISION 00 - BIDDING REQUIREMENTS, CONTRACT FORMS, AND CONDITIONS
OF THE CONTRACT**

<u>SECTION</u>	<u>PAGE(S)</u>

PART 1 - BIDDING REQUIREMENTS

00010	Title Page.....	00001 - 1 to 1
00020	Contract Documents Table of Contents.....	00020 - 1 to 6
00030	Notice Inviting Bids	00030 - 1 to 2
00100	Instructions to Bidders	00100 - 1 to 5
00300	Bid Forms.....	00300 - 1 to 9
00310	Bid Schedules	00310 - 1 to 6
00436	List of Equipment Manufacturers	00436 - 1 to 2
00444	Experience Modification Rate	00444 - 1 to 1
00453	Bid Preferences	00453 - 1 to 1
00454	Bid Certification for the Payment of State and Local Taxes.....	00454 - 1 to 1
00458	Certification of Drug-Free Workplace Requirements	00458 - 1 to 2

PART 2 - CONTRACT FORMS

00500	Agreement	00500 - 1 to 6
00510	Notice of Award.....	00510 - 1 to 2
00550	Notice to Proceed	00550 - 1 to 1
00602	Escrow Agreement for Security Deposits in Lieu of Retention	00602 - 1 to 3
00610	Surety's Agreement to Assignment.....	00610 - 1 to 1
00620	Payment Bond	00620 - 1 to 1
00632	Request for Information or Interpretation (RFI).....	00632 - 1 to 1

PART 3 - CONTRACT CONDITIONS

00700	General Conditions	00700 - 1 to 38
00800	Supplementary General Conditions	00800 - 1 to 7
00810	Utah State Supplementary General Conditions	00810 - 1 to 4
00823	Escrow Bid Documents.....	00823 - 1 to 5

PART 4 - TECHNICAL SPECIFICATIONS

DIVISION 01 - GENERAL REQUIREMENTS

01110	Summary of Work	01110 - 1 to 2
01116	Contract Document Language	01116 - 1 to 2
01140	Work Restrictions.....	01140 - 1 to 12
01230	Alternates.....	01230 - 1 to 2
01260	Contract Modification Procedures.....	01260 - 1 to 5
01292	Schedule of Values	01292 - 1 to 2
01294	Applications for Payment	01294 - 1 to 2
01312	Project Meetings	01312 - 1 to 4

SECTION**PAGE(S)**

01322	Web Based Construction Document Management.....	01322 - 1 to 4
01324A	Progress Schedules and Reports - Large Projects.....	01324A - 1 to 15
01329	Safety Plan.....	01329 - 1 to 2
01330	Submittal Procedures.....	01330 - 1 to 13
01340	Photographic and Videographic Documentation	01340 - 1 to 4
01353	Special Procedures for Locating and Verifying Concealed Existing Utilities	01353 - 1 to 2
01354	Hazardous Material Procedures	01354 - 1 to 4
01410	Regulatory Requirements	01410 - 1 to 1
01424	Abbreviations and Acronyms	01424 - 1 to 9
01450	Quality Control.....	01450 - 1 to 6
01455B	Special Tests and Inspections	01455B - 1 to 15
01460	Contractor Quality Control Plan	01460 - 1 to 4
01500	Temporary Facilities and Controls	01500 - 1 to 8
01520	Security and Process Safety Management.....	01520 - 1 to 2
01530	Protection of Existing Facilities	01530 - 1 to 5
01573	Erosion and Sediment Control.....	01573 - 1 to 6
01600	Product Requirements	01600 - 1 to 13
01610	Project Design Criteria.....	01610 - 1 to 1
01612	Seismic Design Criteria	01612 - 1 to 2
01614	Wind Design Criteria.....	01614 - 1 to 1
01722	Field Engineering.....	01722 - 1 to 3
01738	Selective Alterations and Demolition	01738 - 1 to 9
01756	Commissioning	01756 - 1 to 23
01759	Water Leakage Test for Concrete Structures	01759 - 1 to 9
01770	Closeout Procedures	01770 - 1 to 6
01782	Operation and Maintenance Data.....	01782 - 1 to 8
01783	Warranties and Bonds	01783 - 1 to 4

DIVISION 02 - SITE CONSTRUCTION

02050	Soils and Aggregates for Earthwork	02050 - 1 to 5
02084	Precast Drainage Structures	02084 - 1 to 4
02085	Precast Concrete Vaults	02085 - 1 to 5
02200	Site Clearing	02200 - 1 to 2
02240	Dewatering for Structures	02240 - 1 to 3
02260	Excavation Support and Protection	02260 - 1 to 6
02300	Earthwork	02300 - 1 to 9
02312	Controlled Low Strength Material (CLSM).....	02312 - 1 to 7
02330	Trenching and Backfilling	02330 - 1 to 9
02553	Temporary Bypass Pumping	02553 - 1 to 7
02581	Soils and Aggregates for Earthwork	02581 - 1 to 13
02742	Asphaltic Concrete Paving	02742 - 1 to 9
02772	Concrete Curbs, Gutters, and Sidewalks.....	02772 - 1 to 4
02939	Seeding	02939 - 1 to 16
02952	Pavement Restoration and Rehabilitation	02952 - 1 to 3

DIVISION 03 - CONCRETE

03055	Adhesive-Bonded Reinforcing Bars and All Thread Rods in Concrete	03055 - 1 to 9
03071	Epoxies.....	03071 - 1 to 3
03072	Epoxy Resin/Portland Cement Bonding Agent.....	03072 - 1 to 3

SECTION**PAGE(S)**

03102	Concrete Formwork	03102 - 1 to 6
03150	Concrete Accessories.....	03150 - 1 to 5
03154	Hydrophilic Rubber Waterstop.....	03154 - 1 to 3
03200	Concrete Reinforcing	03200 - 1 to 12
03300	Cast-In-Place Concrete	03300 - 1 to 25
03366	Tooled Concrete Finishing.....	03366 - 1 to 4
03565	Basin Bottom Grout	03565 - 1 to 4
03600	Grouting.....	03600 - 1 to 6
03923	Concrete Repair Mortar	03923 - 1 to 3
03926	Structural Concrete Repair	03926 - 1 to 4
03931	Epoxy Injection System	03931 - 1 to 5

DIVISION 04 - MASONRY

04055	Adhesive Bonding Reinforcing Bars and All Thread Rods in Masonry	04055 - 1 to 6
04090	Masonry Accessories	04090 - 1 to 3
04100	Mortar and Masonry Grout	04100 - 1 to 4
04220	Concrete Unit Masonry	04220 - 1 to 10

DIVISION 05 - METALS

05120	Structural Steel	05120 - 1 to 10
05140	Structural Aluminum	05140 - 1 to 4
05190	Mechanical Anchoring and Fastening to Concrete and Masonry	05190 - 1 to 19
05500	Metal Fabrications	05500 - 1 to 14

DIVISION 06 - WOOD AND PLASTICS

06100	Rough Carpentry	06100 - 1 to 7
06608	Fiberglass Reinforced Plastic	06608 - 1 to 12
06611	Fiberglass Reinforced Plastic Fabrications.....	06611 - 1 to 3

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

07190	Water Repellents	07190 - 1 to 4
07212	Wall Insulation System	07212 - 1 to 2
07220	Roof and Deck Insulation	07220 - 1 to 4
07554	Fully-Adhered Polyvinyl Chloride Roofing	07554 - 1 to 7
07700	Roof Specialties and Accessories	07700 - 1 to 3
07900	Joint Sealants	07900 - 1 to 7

DIVISION 08 - DOORS AND WINDOWS

08110	Hollow Metal Doors and Frames	08110 - 1 to 6
08320	Floor Access Doors	08320 - 1 to 4
08332	Overhead Coiling Doors	08332 - 1 to 6
08520	Aluminum Windows	08520 - 1 to 5
08710	Door Hardware	08710 - 1 to 9
08800	Glazing	08800 - 1 to 6

VOLUME 2**DIVISION 09 - FINISHES**

09131	Acoustical Ceiling Suspension Assemblies	09131 - 1 to 4
09250	Gypsum Board.....	09250 - 1 to 6
09511	Acoustical Panel Ceilings	09511 - 1 to 3
09910	Painting.....	09910 - 1 to 8
09960	High-Performance Coatings	09960 - 1 to 20
09968	Concrete Repair and Coating	09968 - 1 to 13

DIVISION 10 - SPECIALTIES

10400	Signage	10400 - 1 to 7
10520	Fire Protection Specialties	10520 - 1 to 2
10810	Toilet Accessories	10810 - 1 to 3

DIVISION 11 - EQUIPMENT

11224A	Surface-Mounted Floating Propeller Mixers	11224A - 1 to 7
11224B	Replacement Vertical Mixer Impellers	11224B - 1 to 5
11224C	Platform-Mounted Propeller Mixers	11224C - 1 to 6
11292A	Flap Gates	11292A - 1 to 5
11294C	Fabricates Stainless Steel Slide Gates	11294C - 1 to 5
11312C	Horizontal Recess Impeller Centrifugal Pumps	11312C - 1 to 12
11312P	Submersible Axial Flow Propeller Pumps.....	11312P - 1 to 11
11323	Grit Removal System.....	11323 - 1 to 7
11324	Grit Washer/Dewatering Units	11324 - 1 to 15

DIVISION 13 - SPECIAL CONSTRUCTION

13238A	Aluminum Covers	13238A - 1 to 4
13251	Biofilter Odor Control System	13251 - 1 to 12
13446	Manual Actuators.....	13446 - 1 to 6
13447	Electric Actuators.....	13447 - 1 to 14

DIVISION 14 - CONVEYING EQUIPMENT

14592	Grit Storage Bins	14592 - 1 to 4
14624	Monorail System	14624 - 1 to 6

DIVISION 15 - MECHANICAL

15050	Common Work Results for Mechanical Equipment	15050 - 1 to 17
15052	Common Work Results for General Piping.....	15052 - 1 to 10
15061	Pipe Supports	15061 - 1 to 8
15062	Preformed Channel Pipe Support System.....	15062 - 1 to 4
15075	Equipment Identification	15075 - 1 to 2
15076	Pipe Identification	15076 - 1 to 6
15082	Piping Insulation	15082 - 1 to 9
15084	Ductwork Insulation	15084 - 1 to 3
15110	Common Work Results for Valves.....	15110 - 1 to 6
15111	Ball Valves.....	15111 - 1 to 3
15112	Butterfly Valves.....	15112 - 1 to 7
15114	Check Valves.....	15114 - 1 to 4
15115	Gate, Globe, and Angle Valves	15115 - 1 to 5

SECTION**PAGE(S)**

15116	Plug Valves.....	15116 - 1 to 4
15117	Specialty Valves	15117 - 1 to 9
15118	Pressure Reducing and Pressure Relief Valves.....	15118 - 1 to 5
15119	Air and Vacuum Relief Valves	15119 - 1 to 5
15120	Piping Specialties	15120 - 1 to 8
15121	Pipe Couplings	15121 - 1 to 10
15122	Fire Hydrants	15122 - 1 to 2
15211	Ductile Iron Pipe: AWWA C151	15211 - 1 to 10
15234	Polyethylene (PE) Pipe: ASTM D2513	15234 - 1 to 2
15241	High Density Polyethylene Plastic (HDPE) Pipe: AWWA C906 ..	15241 - 1 to 7
15244	Polyvinyl Chloride (PVC) Pipe: AWWA C900 [and AWWA C905].....	15244 - 1 to 5
15245	Drain, Waste, and Vent Piping	15245 - 1 to 7
15270	Steel Pipe: Galvanized and Black, ASTM A53	15270 - 1 to 6
15274	Plastic Tape Wrap for Pipe	15274 - 1 to 3
15278	Steel Pipe	15278 - 1 to 13
15281	Copper Water Tube: Seamless, ASTM B88	15281 - 1 to 2
15286	Stainless Steel Pipe and Tubing.....	15286 - 1 to 8
15400	Plumbing Fixtures and Equipment.....	15400 - 1 to 7
15740	Heat Pumps.....	15740 - 1 to 8
15763	Makeup Air Unit	15763 - 1 to 9
15812	Metal Ducts.....	15812 - 1 to 5
15814	Fiberglass Reinforced Plastic Ducts	15814 - 1 to 9
15815	Flexible Ducts	15815 - 1 to 3
15816	Corrosive Fume Exhaust Ducts	15816 - 1 to 7
15820	Ductwork Accessories	15820 - 1 to 8
15830	Fans.....	15830 - 1 to 7
15835	Foul Air Fans for Odor Control.....	15835 - 1 to 10
15852	Louvers.....	15852 - 1 to 3
15936	Instrumentation and Control Devices for HVAC	15936 - 1 to 6
15954	Testing, Adjusting, and Balancing for HVAC	15954 - 1 to 5
15956	Piping Systems Testing	15956 - 1 to 7
15958	Mechanical Equipment Testing.....	15958 - 1 to 11

VOLUME 3**DIVISION 16 - ELECTRICAL**

16050	Common Work Results for Electrical	16050 - 1 to 15
16052	Hazardous Classified Area Construction	16052 - 1 to 5
16060	Grounding and Bonding.....	16060 - 1 to 6
16070	Hangers and Supports.....	16070 - 1 to 5
16075	Identification for Electrical Systems	16075 - 1 to 9
16123	600-Volt or Less Wires and Cables	16123 - 1 to 11
16125	Fiber Optic Cable and Appurtenances.....	16125 - 1 to 13
16130	Conduits	16130 - 1 to 17
16133	Duct Banks	16133 - 1 to 6
16134	Boxes.....	16134 - 1 to 8
16136	Wireway.....	16136 - 1 to 5
16140	Wiring Devices.....	16140 - 1 to 7
16150	Low Voltage Wire Connections	16150 - 1 to 5
16222	Low Voltage Motors Up to 500 Horsepower	16222 - 1 to 8

SECTION**PAGE(S)**

16262	Variable Frequency Drives 0.50 - 50 Horsepower.....	16262 - 1 to 12
16272	Dry-Type Transformers	16272 - 1 to 7
16285	Surge Protective Devices	16285 - 1 to 7
16305	Electrical System Studies	16305 - 1 to 10
16411	Disconnect Switches	16411 - 1 to 6
16412	Low Voltage Molded Case Circuit Breakers	16412 - 1 to 4
16422	Motor Starters.....	16422 - 1 to 8
16444	Low Voltage Motor Control Centers	16444 - 1 to 12
16445	Panelboards	16445 - 1 to 7
16491	Transfer Switches.....	16491 - 1 to 7
16510	Lighting: LED Luminaires	16510 - 1 to 10
16710	Fire Alarm and Smoke Detection System.....	16710 - 1 to 11
16920	Pre-Fabricated Walk-In Electrical Enclosures	16920 - 1 to 9
16950	Field Electrical Acceptance Tests.....	16950 - 1 to 23
16990	Conduit Schedule	16990 - 1 to 1

DIVISION 17 - INSTRUMENTATION AND CONTROLS

17050	Common Work Results for Process Control and Instrumentation Systems.....	17050 - 1 to 36
17206	Level Measurement: Ultrasonic	17206 - 1 to 6
17301	Flow Measurement: Switches.....	17301 - 1 to 5
17306	Flow Measurement: Ultrasonic Doppler.....	17306 - 1 to 6
17316	Flow Measurement: Rotameters (Variable Area Flowmeters).....	17316 - 1 to 10
17401	Pressure/Vacuum Measurement: Diaphragm and Annular Seals.....	17401 - 1 to 4
17402	Pressure/Vacuum Measurement: Instrument Valves	17402 - 1 to 5
17403	Pressure/Vacuum Measurement: Switches.....	17403 - 1 to 6
17404	Pressure/Vacuum Measurement: Gauges	17404 - 1 to 6
17405	Pressure/Vacuum Measurement: Direct.....	17405 - 1 to 9
17406	Pressure/Vacuum Measurement: Differential.....	17406 - 1 to 6
17407	Pressure Measurement: Submersible	17407 - 1 to 6
17502	Analyzers: ORP	17502 - 1 to 7
17504	Analyzers: Gas Monitors	17502 - 1 to 7
17506	Analyzers: Dissolved Oxygen (DO)	17506 - 1 to 15
17518	Analyzers: Mixed Liquor Suspended Solids (MLSS)	17518 - 1 to 6
17519	Analyzers: Ammonia.....	17519 - 1 to 6
17710	Control Systems: Panels, Enclosures, and Panel Components..	17710 - 1 to 24
17712	Control Systems: Uninterruptible Power Supplies 10 KVA and Below.....	17712 - 1 to 9
17720	Control Systems: Programmable Logic Controllers.....	17720 - 1 to 8
17733	Control Systems: Network Materials and Equipment	17733 - 1 to 7
17735	Control Systems: Fieldbus Equipment and Devices.....	17735 - 1 to 4
17850	HVAC Instruments.....	17850 - 1 to 5
17903	Schedules: I/O List	17903 - 1 to 1
17950	Testing, Calibration, and Commissioning	17950 - 1 to 37

APPENDIX A GEOTECH REPORT

SECTION 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements applicable to all Electrical Work.
 - 2. General requirements for electrical submittals.
- B. Interfaces to equipment, instruments, and other components:
 - 1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
 - 2. Provide all material and labor needed to install the actual equipment furnished, and include all costs to add any additional conduit, wiring, terminals, or other electrical hardware to the Work, which may be necessary to make a complete, functional installation based on the actual equipment furnished:
 - a. Make all changes necessary to meet the manufacturer's wiring requirements.
 - 3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00700 - General Conditions.
 - 4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the Drawings or in the Specifications from another discipline in the scope of Work:
 - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
 - 5. Loop drawings:
 - a. Provide all electrical information required in the preparation of loop drawings including, but not limited to:
 - 1) Conduit numbers and associated signal(s) contained within each conduit.
 - 2) Wire numbers.
 - 3) Equipment terminal numbers.
 - 4) Junction boxes and signal(s) contained within each junction box.
 - 5) Equipment power sources, and associated circuit numbers.
 - 6) As-built drawings detailing wiring.
- C. All electrical equipment and systems for the entire Project must comply with the requirements of the Electrical Specifications, whether referenced in the individual Equipment Specifications or not:
 - 1. The requirements of the Electrical Specifications apply to all Electrical Work specified in other sections.
 - 2. Inform all vendors supplying electrical equipment or systems of the requirements of the Electrical Specifications.

3. Owner is not responsible for any additional costs due to the failure of Contractor to notify all subcontractors and suppliers of the Electrical Specifications requirements.
- D. Contract Documents:
1. General:
 - a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.
 2. Specifications:
 - a. The General and Supplementary Conditions of the Contract Documents govern the Work.
 - b. These requirements are in addition to all General Requirements.
 3. Contract Drawings:
 - a. The Electrical Drawings show desired locations, arrangements, and components of the Electrical Work in a diagrammatic manner.
 - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only; exercise professional judgment in executing the Work to ensure the best possible installation:
 - 1) The equipment locations and dimensions indicated on the Drawings are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all electrical equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
 - 2) The Contractor has the freedom to select any of the named manufacturers identified in the individual specification sections; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
 - c. Installation details:
 - 1) The Contract Drawings include typical installation details the Contractor is to use to complete the Electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
 - 2) Not all typical installation details are referenced within the Drawing set. Apply and use typical details where appropriate.
 - d. Schematic diagrams:
 - 1) All controls are shown de-energized.
 - 2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
 - 3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
 - 4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.

- 5) Schematic diagrams are to be used in conjunction with the descriptive operating sequences in the Contract Documents. Combine all information and furnish a coordinated and fully functional control system.

E. Alternates/Alternatives:

1. Coordinate with Document 00700 - General Conditions for substitute item provisions.

F. Changes and change orders:

1. As specified in Document 00700 - General Conditions.

1.02 REFERENCES

A. Code compliance:

1. As specified in Section 01410 - Regulatory Requirements.
2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
3. The standards listed are hereby incorporated into this Section.
 - a. American National Standards Institute (ANSI).
 - b. American Society of Civil Engineers (ASCE):
 - 1) ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
 - c. ASTM International (ASTM).
 - d. Illuminating Engineering Society (IES).
 - e. Institute of Electrical and Electronics Engineers (IEEE).
 - f. Insulated Cable Engineers Association (ICEA).
 - g. International Code Council (ICC):
 - 1) International Code Council Evaluation Service (ICC-ES).
 - a) AC 156 - Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
 - h. International Society of Automation (ISA).
 - i. National Electrical Manufacturers Association (NEMA):
 - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
 - j. National Fire Protection Association (NFPA):
 - 1) 70 - National Electrical Code (NEC).
 - k. National Institute of Standards and Technology (NIST).
 - l. Underwriters' Laboratories, Inc. (UL).

B. Compliance with laws and regulations:

1. As specified in Document 00700 - General Conditions.

1.03 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth by:

1. IEEE.
2. NETA.
3. IES.
4. ISA.
5. NEC.
6. NEMA.
7. NFPA.

8. NIST.

B. Specific definitions:

1. FAT: Factory acceptance test.
2. ICSC: Instrumentation and controls subcontractor.
3. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
4. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
5. PCIS: Process control and instrumentation system.
6. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
7. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
8. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
9. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
10. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from:
 - a. The Electrical Drawings are schematic in nature; use the Structural, Architectural, Mechanical, and Civil Drawings for all dimensions and scaling purposes.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of equipment furnished by others as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
3. Provide all Electrical Work, including conduit, field wiring, and connections by the electrical subcontractor under the provisions of the Electrical Specifications for all aspects of the Work.
4. Coordinate all aspects of the Work with the electrical subcontractor and other subcontractors before bidding in order to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the electrical subcontractor, the other subcontractors or suppliers.

5. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
 - a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
 - b. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.
 6. Provide all trenching, forming, rebar, concrete, back filling, hard surface removal and replacement, for all items associated with the Electrical Work and installation:
 - a. As specified in the Contract Documents.
 7. Defective work:
 - a. As specified in Document 00700 - General Conditions.
- B. Existing system:
1. Install a new circuit breaker is ES-5 to supply power to GRB-MCC-1.
 2. Modify existing manholes to accommodate new duct banks as shown on Drawings.
 3. Modify the existing Bioreactor 1-4 MCCs as shown on the Drawings.
- C. New system:
1. Provide the electrical Work shown on the Drawings to support the new Grit Removal Building.
 2. Provide a new powerhouse enclosure to house new motor control centers BR-MCC-2A, BR-MCC-3A, BR-MCC-4A.
 3. Provide conduit and wire to support Bioreactor modifications.
- D. Operating facility:
1. As specified in Section 01140 - Work Restrictions.
 2. The South Valley Water Reclamation Facility is an operating facility. Portions of this facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
 - a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction schedule to meet the requirements of the Owner. All changes in schedule and any needs to reschedule are included in the Work.
 - b. As weather and water demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
 - c. Coordinate the construction and power renovation, bear all costs, so that all existing facilities can continue operation throughout construction.
 3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
 4. The standards of documentation, instrument tagging, cable and conductor ferruling, terminal identification and labeling that apply to the new installation apply equally to the existing installation which forms part of the modified system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.
- B. General:
 - 1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
 - 2. Furnish the submittals required by each section in the Electrical Specifications.
 - 3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on all Equipment Drawings.
 - 4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
- C. Seismic requirements:
 - 1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads based on the seismic design criteria in Section 01612 - Seismic Design Criteria.
 - 2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
 - a. Statement of seismic qualification, and special seismic certification:
 - 1) "Statement of seismic qualification:" Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01410 - Regulatory Requirements, including the requirements of ASCE 7, Chapter 13.
 - 2) "Special seismic certification:" Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with $I_p = 1.5$." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
 - b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
 - c. Anchoring design calculations and details:
 - 1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612 - Seismic Design Criteria.
 - 3. Exemptions: A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:
 - a. Temporary or moveable equipment.
 - b. Equipment anchored to the structure and having a total weight of 20 pounds or less.

- c. Distribution equipment anchored to the structure and having a total unit weight of 3 pounds per linear foot, or less.
- D. Operation and maintenance manuals:
 - 1. As specified in Section 01782 - Operation and Maintenance Data.
 - 2. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before Functional Acceptance Testing.
- E. Material and equipment schedules:
 - 1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
 - a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- F. Schedule of values:
 - 1. In addition to completing all items referred to in the schedule of values, Section 01292 - Schedule of Values, submit per unit material and labor costs used in developing the final bid for the electrical system, for the express purpose of pricing and cost justification for any proposed change orders. In addition to the items shown on the schedule of values, provide per unit material and labor costs for conduit and wire installation for specific types, sizes, and locations as indicated on the Drawings and Conduit Schedule. It is the responsibility of the electrical subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.
- G. Roof penetrations:
 - 1. Submit details of all portions of the electrical installation that penetrate the roof. Include details showing support of the penetrating component, and the sealing means to be utilized.
- H. Record Documents:
 - 1. Furnish as specified in Section 01770 - Closeout Procedures.
- I. Test reports:
 - 1. As specified in Section 01330 - Submittal Procedures.
 - 2. Include the following:
 - a. A description of the test.
 - b. List of equipment used.
 - c. Name of the person conducting the test.
 - d. Date and time the test was conducted.
 - e. All raw data collected.
 - f. Calculated results.
 - g. Each report signed by the person responsible for the test.
 - 3. Additional requirements for field acceptance test reports are specified in Sections 01756 - Commissioning and 16950 - Field Electrical Acceptance Tests.
- J. Calculations:
 - 1. Where required by specific Electrical Specifications:
 - a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.06 QUALITY ASSURANCE

- A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01600 - Product Requirements.

1.08 PROJECT OR SITE CONDITIONS

- A. Site conditions:
 - 1. Provide an electrical, instrumentation and control system, including all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
 - 2. Seismic load resistance:
 - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612 - Seismic Design Criteria.
 - 3. Wind load resistance:
 - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site wind loads as specified in Section 01614 - Wind Design Criteria.
 - 4. Altitude, temperature and humidity:
 - a. As specified in Section 01610 - Project Design Criteria.
 - b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
 - c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines:
 - 1) Provide all power conduits wiring for these devices (e.g. heaters, fans, etc.) whether indicated on the Drawings or not.
 - 5. Site security:
 - a. Abide by all security and safety rules concerning the Work on the Site, as specified in Sections 01329 - Safety Plan and 01500 - Temporary Facilities and Controls.
 - 6. Outdoor installations:
 - a. Provide electrical, instrumentation and control equipment suitable for operation in the ambient conditions where the equipment is located.
 - b. Provide heating, cooling, and dehumidifying devices incorporated into and included with electrical equipment, instrumentation and control panels to maintain the enclosures within the rated environmental operating ranges as specified in this Section for the equipment:
 - 1) Provide all wiring necessary to power these devices.

- B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
 2. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.
 3. NEMA Type 4X: Made from corrosion resistant materials and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion. Provide specific materials as specified or indicated on the Drawings.
 4. NEMA Type 7: Intended for installation in locations where explosive or combustible gas or vapors may be present (Class I Division 1 or Class I Division 2) meeting the requirements outlined in Section 16052 - Hazardous Classified Area Construction.
- C. Plant area Electrical Work requirements:
1. Provide all Electrical Work in accordance with the following table, unless otherwise specifically indicated on the Drawings:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Electrical Rooms	1, 12	GRC	C	Galvanized Steel
Grit Removal Building - Process Areas	4X SS	PCS	D, X	316 Stainless Steel
Grit Basins - under the Cover	7	PCS	H: Class I Div 1	316 Stainless Steel
Grit Removal Building - Odor Control Fan Area	7	PCS	H: Class I Div 2	316 Stainless Steel
Bioreactors	7 (within classified area) 4X SS (outside of classified area)	PCS	H: Class I Div 2 within envelope from water surface to 18 inches above top of tank wall and extending 18 inches beyond exterior wall: envelope 18 inches above grade and extending 10 feet horizontally from exterior tank walls.	316 Stainless Steel
Exterior Locations, nonprocess areas	4X SS	PCS	W, X	316 Stainless Steel

2. Modify exposed conduit runs as specified in Section 16130 - Conduits.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

- A. General:
 - 1. As specified in Sections 01312 - Project Meetings and 01756 - Commissioning.
 - 2. Testing requirements are specified in Section 01756 - Commissioning, 16950 - Field Electrical Acceptance Tests and other sections.
 - 3. General scheduling requirements are specified in Section 01324A - Progress Schedules and Reports - Large Projects.
 - 4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
 - 5. Commissioning requirements as specified in Section 01756 - Commissioning.

1.11 WARRANTY

- A. Warrant the Electrical Work as specified in Document 00700 - General Conditions:
 - 1. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
 - 1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

- A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.
- B. Allowable manufacturers are specified in individual Electrical Specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in Document 00700 - General Conditions.
- C. Stainless steel:
 - 1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
 - 2. Provide exposed screws of the same alloys.
 - 3. Provide finished material free of any burrs or sharp edges.
 - 4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.
 - 5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
 - 6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.

PART 3 EXECUTION

3.01 EXAMINATION

- A. The electrical subcontractor is encouraged to visit the site to examine the premises completely before bidding.
- B. It is the electrical subcontractor's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

- C. Comply with pre-bid conference requirements as specified in Document 00100 - Instructions to Bidders
- D. Review the site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Equipment locations shown on Electrical Drawings may change due to variations in equipment size or minor changes made by others during construction:
 - 1. Verify all dimensions indicated on the Drawings:
 - a. Actual field conditions govern all final installed locations, distances, and levels.
 - 2. Review all Contract Documents and approved equipment shop drawings and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
 - 3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
 - 4. Provide a complete electrical system:
 - a. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical system.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. Cutting and patching:
 - 1. Perform all cutting, patching, channeling, core drilling, and fitting required for the Electrical Work, except as otherwise directed:
 - a. Secure the permission of the Engineer before performing any operation likely to affect the strength of a structural member such as drilling, cutting or piercing:
 - 1) Before cutting, channeling, or core drilling any surface, ensure that no penetration of any other systems will be made:
 - a) Verify that area is clear and free of conduits, cables, piping, ductwork, post-tensioning cables, etc.
 - b) Use tone-locate system or X-ray to ensure that area is clear of obstructions.
 - b. Review the complete Drawing set to ensure that there are no conflicts or coordination problems before cutting, channeling, or core drilling any surface.
 - 2. Perform all patching to the same quality and appearance as the original work. Employ the proper tradesmen to secure the desired results. Seal around all conduits, wires, and cables penetrating walls, ceilings, and floors in all locations with a fire stop material, typically:
 - a. 3M: CP 25WB+: Caulk.
 - b. 3M: Fire Barrier: Putty.
 - 3. Use the installation details indicated on the Drawings as a guide for acceptable sealing methods.

- D. Install all conduits and equipment in such a manner as to avoid all obstructions and to preserve headroom and keep openings and passageways clear:
 - 1. Install all conduits and equipment in accordance with working space requirements in accordance with the NEC.
 - a. This includes any panel, disconnect switch or other equipment that can be energized while open exposing live parts regardless of whether it is likely to require examination or has serviceable parts.
 - 2. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.
 - a. Adjust equipment locations as necessary to avoid any obstruction or interferences.
 - 3. Where an obstruction interferes with equipment operation or safe access, relocate the equipment.
 - 4. Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.
- E. Earthwork and concrete:
 - 1. Install all trenching, shoring, concrete, backfilling, grading and resurfacing associated with the Electrical Work:
 - a. Requirements as specified in the Contract Documents.
- F. Roof penetrations:
 - 1. Seal conduit penetrations in accordance with roofing manufacturer's instructions.
- G. Terminations:
 - 1. Provide and terminate all conductors required to interconnect power, controls, instruments, panels, and all other equipment.
- H. Miscellaneous installation requirements:
 - 1. In case of interference between electrical equipment indicated on the Drawings and the other equipment, notify the Engineer as specified in Document 00700 - General Conditions.
 - 2. Location of manholes and pullboxes indicated on the Drawings are approximate. Coordinate exact location of manholes and pullboxes with Mechanical and Civil Work.
 - 3. Provide additional manholes or pullboxes to those shown where they are required to make a workable installation.
- I. Labeling:
 - 1. Provide all nameplates and labels as specified in Sections 16075 - Identification for Electrical Systems and 16305 - Electrical System Studies.
- J. Equipment tie-downs:
 - 1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing criteria, which apply to the Site.
 - 2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., must be permanently mounted and tied down to structures in accordance with the Project seismic criteria.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.
- B. For Owner and Engineer witnessed FAT:
 - 1. Contractor is responsible for the Owner's and Engineer's costs associated with FAT as specified in Section 01756 - Commissioning.
- C. Owner training:
 - 1. As specified in Section 01756 - Commissioning and in this Section.
- D. Source testing (FAT):
 - 1. Provide source testing and owner training on electrical equipment as defined in the table below:

Table 1: Source Testing and Owner Training Requirements:

Section Number	Section Title	Source Testing	Owner Training Requirements	
			Maintenance (hrs per session)	Operation (hrs per session)
16262	Variable Frequency Drives 0.50 - 50 Horsepower	Witnessed	8	8
16422	Motor Starters	Non-Witnessed	8	8
16444	Low Voltage Motor Control Centers	Witnessed	N/A	N/A
16710	Fire Alarm and Smoke Detection System	Non-Witnessed		2

3.08 FIELD QUALITY CONTROL

- A. Inspection:
 - 1. Allow for inspection of electrical system installation as specified in Section 01450 - Quality Control.
 - 2. Provide any assistance necessary to support inspection activities.
 - 3. Engineer inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect installation for compliance with the Drawings and Specifications.
 - c. Inspect installation for obstructions and adequate clearances around equipment.
 - d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.

- e. Inspect equipment nameplate data to verify compliance with design requirements.
 - f. Inspect raceway installation for quality workmanship and adequate support.
 - g. Inspect cable terminations.
 - 4. Inspection activities conducted during construction do not satisfy inspection or testing requirements specified in Section 16950 - Field Electrical Acceptance Tests.
- B. Field acceptance testing (Functional Testing):
- 1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
 - 2. Perform the field acceptance tests as specified in Section 16950 - Field Electrical Acceptance Tests.
 - 3. Record results of the required tests along with the date of test:
 - a. Use conduit identification numbers to indicate portion of circuit tested.
- C. Workmanship:
- 1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
 - a. Neatly coil and label spare wiring lengths.
 - b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in Section 01770 - Closeout Procedures.
- B. Remove all foreign material and restore all damaged finishes to the satisfaction of the Engineer and Owner.
- C. Clean and vacuum all enclosures to remove all metal filings, surplus insulation and any visible dirt, dust or other matter before energization of the equipment or system start-up:
 - 1. Use of compressors or air blowers for cleaning is not acceptable.
- D. Clean and re-lamp all new and existing luminaries that were used in the areas affected by the construction, and return all used lamps to the Owner.
- E. As specified in other sections of the Contract Documents.

3.11 PROTECTION

- A. Protect all Work from damage or degradation until Substantial Completion.
- B. Maintain all surfaces to be painted in a clean and smooth condition.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16052

HAZARDOUS CLASSIFIED AREA CONSTRUCTION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Executing and completing Work in hazardous and/or classified areas as defined by the NEC Articles 500 through 516, NFPA 820, and as indicated on the Drawings and specified in the Specifications.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
 - 1. For the purposes of these Specifications, the terms "Hazardous" and "Classified" will be considered synonymous.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Regulatory requirements:
 - 1. All wiring in hazardous and/or classified locations shall comply with all applicable articles of the NEC, in particular Articles 500 through 516.
 - 2. Except as modified in Articles 500 through 516, all other applicable rules contained in the NEC shall apply to electric equipment and wiring installed in hazardous and/or classified locations.
 - 3. All devices used in Class I Division 1 or Division 2 areas must have visible manufacturer installed nameplates specifically stating the Class, Division, and Group for which the device is approved.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. A list of hazardous areas is specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Conduit and sealing fittings:
 - 1. As specified in Section 16130 - Conduits.
- B. Conduit boxes and bodies:
 - 1. As specified in Section 16134 - Boxes.
- C. Wiring devices:
 - 1. As specified in Section 16140 - Wiring Devices.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Conduit installation:
 - 1. As specified in Section 16130 - Conduits.
 - 2. Wrench tighten all conduit joints to minimize sparking when fault current flows through the conduit system.
 - 3. Make all conduit connections so that there are a minimum of 5 threads fully engaged in the connection.
 - 4. Flexible conduit:
 - a. Class I Division 1 hazardous areas:
 - 1) Approved and marked suitable for Class I Division 1.
 - 2) Listed for compatibility with the group type atmosphere where used.
 - b. Class I Division 2 areas:
 - 1) Liquidtight metal conduit with approved fittings.
 - c. Maximum length as specified in Section 16130 - Conduits.
- C. Sealing fittings:
 - 1. Provide an approved seal, no more than 12 inches from the enclosure, for all conduits entering an enclosure containing switches, circuit breakers, fuses, relays, resistors, or any other apparatus which may produce arcs, sparks, or high temperatures:
 - a. Only explosion proof unions, couplings, elbows, capped elbows, and conduit bodies similar to "L", "T", and "X" may be installed between the sealing fitting and the enclosure.
 - 2. Provide entire assemblies approved for Class I locations for self-sealing or factory sealed assemblies where the equipment that may produce arcs, sparks, or high temperatures is located in a compartment separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other:
 - a. Seals are required in all conduit connections to the compartment containing splices and must be within 12 inches of the enclosure.
 - 3. Install a conduit seal within 12 inches of the boundary in each conduit run entering or leaving a classified location. No union, coupling, box, or fitting is allowed in the conduit between the sealing fitting and the point at which the conduit leaves the classified location.
 - 4. For underground conduits entering or leaving a classified location or between Class I Division 1 and Division 2 locations:
 - a. Provide a conduit seal at both points where the conduit emerges from the ground:
 - 1) Place the conduit seal within 18 inches of finished grade.
 - 2) No union, coupling, box, or fitting is allowed in the conduit system between the seal fitting and the point at which the conduit enters the ground.

5. Separate all conductors within the conduit system and seal using an approved packing dam installed to both hold the sealing compound and to maintain the separation between the wires:
 - a. Remove the outer jacket of multi-conductor non-shielded cables in the area of the sealing fitting and separate each conductor from the cable and seal individually.
 6. Install seals with drains in all electrical control stations, low points of conduit or any place where moisture may condense and accumulate.
 7. Install the sealing compound with a minimum thickness of 5/8 inch or the trade size of the conduit, whichever is greater.
- D. Boxes and fittings:
1. Class I Division 1 areas:
 - a. Utilize threaded connections for all metallic boxes, fittings, and joints to the conduit system.
 2. Class I Division 2 areas:
 - a. Provide approved grounding bushings on conduits entering and exiting metallic boxes to bond the conduits together.
- E. Outlet boxes and bodies:
1. Provide conduits bodies and boxes suitable for the conduit system as specified in Section 16130 - Conduits.
 2. Class I Division 2 areas:
 - a. Boxes not containing arcing parts:
 - 1) Material and NEMA ratings as specified in Section 16050 - Common Work Results for Electrical.
 - 2) Pressed metal boxes are not allowed.
 - b. Provide heavy duty cast construction type conduit fittings and joints:
 - 1) Explosion proof rated fittings and joints are not necessary.
 - c. Any enclosure containing arcing parts, etc. shall have all construction associated with the enclosure, conduit system, etc. conforming to Class I Division 1 construction.
- F. Motor connections:
1. Conduit installation in Class I Division 1 and Class I Division 2 locations for motors that contain arcing parts, shall proceed as follows:
 - a. First - Conduit.
 - b. Second - Explosion proof flexible coupling.
 - c. Third - Sealing fitting.
 - d. Fourth - Explosion proof union.
 - e. Fifth - Connection to the motor terminal box.
 2. Wiring connections to motor leads shall be as specified in Section 16150 - Low Voltage Wire Connections.
 3. Bond the non-current-carrying metal parts of equipment, raceways and other enclosures as required by the NEC to ensure electrical continuity.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16060
GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Grounding materials and requirements.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
1. B3 - Standard Specification for Soft or Annealed Copper Wire.
 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. Institute of Electrical and Electronics Engineers (IEEE):
1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- D. Underwriters Laboratories, Inc. (UL):
1. 467 - Ground and Bonding Equipment.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Ground equipment and raceway systems so that the completed installation conforms to all applicable code requirements.
- B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
1. Grounding electrodes.
 2. Bonding jumpers.
 3. Ground connections.
- C. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.
- D. The ground system resistance (electrode to ground) of the completed installation, as determined by tests specified in Section 16950 - Field Electrical Acceptance Tests, shall be:
1. 5 ohms or less for industrial systems.
 2. 1 ohm or less for electrical buildings.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Catalog cut sheets.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All grounding components and materials shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Compression connectors: One of the following or equal:
 - 1. FCI Burndy.
 - 2. Thomas & Betts.
- B. Ground rods: One of the following or equal:
 - 1. Erico.
 - 2. Harger.
 - 3. Conex.
- C. Ground cable: One of the following or equal:
 - 1. Nehring.
 - 2. Harger.

3. Southwire.

D. Precast ground well boxes: One of the following or equal:

1. Brooks Products, 3-RT Valve Box.
2. Christy Concrete Products, G12 Valve Box.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

A. Ground rod:

1. Minimum: 3/4-inch diameter, 10 feet long.
2. Uniform 10 mil covering of electrolytic copper metallurgically bonded to a rigid steel core:
 - a. The copper-to-steel bond shall be corrosion resistant.
3. In accordance with UL 467.
4. Sectional type joined by threaded copper alloy couplings.
5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground cable:

1. Requirements:
 - a. Soft drawn (annealed).
 - b. Concentric lay, coarse stranded in accordance with ASTM B8.
 - c. Bare copper in accordance with ASTM B3.
2. Size is as indicated on the Drawings, but not less than required by the NEC.

C. Compression connectors:

1. Manufactured of high copper alloy specifically for the particular grounding application.
2. Suitable for direct burial in earth and concrete.
3. Identifying compression die number inscription to be impressed on compression fitting.

D. Equipment grounding conductors:

1. Conductors shall be the same type and insulation as the load circuit conductors:
 - a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
2. Minimum size in accordance with the NEC.

E. Grounding electrode conductors:

1. Minimum size in accordance with the NEC.

F. Main bonding jumpers and bonding jumpers:

1. Minimum size in accordance with the NEC.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Precast ground well boxes:
 - 1. Minimum 10 inch interior diameter.
 - 2. Traffic-rated cast iron cover.
 - 3. Permanent "GROUND" marking on cover.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
 - 1. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
 - 2. Provide a separate grounding conductor in each individual raceway for parallel feeders.
- C. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
 - 1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.
- D. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
 - 1. Individually bond these raceways to the ground bus in the equipment.
- E. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.
- F. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

- G. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.
- H. Duct bank ground system:
 - 1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
 - 2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.
- I. Grounding at service (600 V or Less):
 - 1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.
- J. Ground connections:
 - 1. All connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
 - 2. Make ground connections in accordance with the manufacturer's instructions.
 - 3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.
- K. Grounding electrode system:
 - 1. Ground ring:
 - a. Provide all trenching and materials necessary to install the ground ring as indicated on the Drawings.
 - b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
 - c. Minimum burial depth 36 inches or as indicated on the Drawings.
 - d. Re-compact disturbed soils to original density in 6-inch lifts.
 - 2. Ground rods:
 - a. Locations as indicated on the Drawings.
 - b. Length of rods forming an individual ground array shall be equal in length.
 - c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
 - d. Pre-crimp all ground rods, as recommended by the manufacturer, before crimping connector to ground rod.
 - 3. Metal underground water pipe:
 - a. Bond metal underground domestic water pipe to grounding electrode system.
 - 4. Metal frame of building or structure:
 - a. Bond metal frame of building or structure to grounding electrode system.
 - 5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
 - 6. Where grounding conductors are not concrete-encased or direct buried, install in Schedule 40 PVC conduit for protection.

7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.
- L. Shield grounding:
 1. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicate otherwise:
 - a. The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
 2. Terminate the shield drain wire on a dedicated terminal block.
 3. Use manufacturer's terminal block jumpers to interconnect ground terminals.
 4. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.
- M. Where indicated on the Drawings, install ground rods in precast ground wells.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.09 ADJUSTING

- A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
 1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16070

HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mounting and supporting electrical equipment and components.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
 - 1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 3. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Conform to the requirements of the Building Code as specified in Section 01410 - Regulatory Requirements.
 - 2. Demonstrate the following using generally accepted engineering methods:
 - a. That the anchors to the structure are adequate to resist the loads generated in accordance with the Building Code and equipment requirements.
 - b. That the required load capacity of the anchors can be fully developed in the structural materials to which they are attached.
 - 3. Design loading and anchoring requirements:
 - a. As indicated in the Building Code unless otherwise specified.
 - b. Seismic loading requirements:
 - 1) Freestanding, suspended or wall-hung equipment shall be anchored in place by methods that will satisfy the requirements for the seismic design specified in Section 16050 - Common Work Results for Electrical.
 - c. Wind loading requirements:
 - 1) All exterior equipment shall be anchored in place by methods that will satisfy the requirements for wind design specified in Section 16050 - Common Work Results for Electrical.
 - d. Minimum safety factor against overturning: 1.5.

- e. The foundation and structures to which hangers and supports are attached shall be capable of withstanding all anchor loads.
- B. Performance requirements:
 - 1. Hangers and supports individually and as a system shall resist all weights and code-required forces without deflections and deformations that would damage the supporting elements, the equipment supported, or the surrounding construction.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Supports:
 - a. Materials.
 - b. Geometry.
 - c. Manufacturer.
 - 2. Hardware:
 - a. Materials.
 - b. Manufacturer.
- C. Shop drawings:
 - 1. Complete dimensioned and scalable shop drawings of all supporting structures, trapezes, wall supports, etc.
 - 2. Complete anchoring details for equipment, lighting and raceway, supporting structures, trapezes, wall supports for all equipment in excess of 200 pounds, and all freestanding supports:
 - a. Stamped by a professional engineer licensed in the state where the Project is being constructed.
 - b. Said submittals, by virtue of the fact that they bear the stamp of a registered engineer, will be reviewed for general consistency with the requirements specified in the Contract Documents, but not for context, accuracy, or method of calculation.
 - 3. Include data on attachment hardware and construction methods that will satisfy the design loading and anchoring criteria.
- D. Installation instructions:
 - 1. Furnish anchorage instructions and requirements based on the seismic and wind conditions of the Site:
 - a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM STARTUP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Thomas & Betts.
 - 2. Power-Strut.
 - 3. Unistrut.
 - 4. Cooper B-Line.
 - 5. Robroy.
 - 6. Aickinstrut.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Use materials appropriate for the area as specified in Section 16050 - Common Work Results for Electrical.
- B. Hot dip galvanized steel:
 - 1. Supports:
 - a. In accordance with ASTM A123 or A153.
 - b. Minimum zinc coating thickness of 2.5 mils.
 - 2. Hardware:
 - a. Electro-galvanized.
 - b. In accordance with ASTM A153.
- C. Stainless steel:
 - 1. Supports:
 - a. In accordance with ASTM A240.
 - b. ANSI Type 316 material.

- 2. Hardware:
 - a. ANSI Type 316 material.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Anchor bolts:
 - 1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Paint and finish all supporting structures as specified in Section 09910 - Painting.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Mount all raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated racks unless otherwise indicated on the Drawings.
 - 1. Provide the necessary sway bracing to keep trapeze type structures from swaying under seismic events or wind loading.
- C. Brace and anchor freestanding equipment supports using methods that provide structural support based on the seismic loads and wind loads:
 - 1. Lateral deflection at top of supports not to exceed support height divided by 240 unless otherwise approved by the Engineer.
- D. Provide fabricated steel support pedestals for wall mounted panels that weigh more than 200 pounds:
 - 1. Fabricate pedestals out of welded angle, tube sections, or preformed channel.
 - 2. If the supported equipment is a panel or cabinet, match the supported equipment in physical appearance and dimensions.
 - 3. Provide auxiliary floor supports for transformers hung from stud walls and weighing more than 200 pounds.

4. Mount all equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
 - a. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.
- E. Corrosion protection:
 1. Isolate dissimilar metals, except where required for electrical continuity.
 - a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.
- F. Raceway:
 1. Furnish all racks and trapeze structures needed to support the raceway from the structure.
 - a. Group raceway and position on racks to minimize crossovers.
 - b. Provide the necessary bracing to keep trapeze type structures from swaying under loads from cable installation, seismic forces, or wind forces.
- G. Anchoring methods:
 1. Solid concrete: Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 2. Metal surfaces: Machine screws or bolts.
 3. Hollow masonry units: Post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
- H. Recoat or seal all drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16075

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Identification of electrical equipment, devices and components.
 - 2. Material, manufacturing and installation requirements for identification devices.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Nameplates:
 - 1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
 - 2. Provide all nameplates of identical style, color, and material throughout the facility.
 - 3. Device nameplates information:
 - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
- B. Wire numbers:
 - 1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
 - a. Wire numbers shall correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
 - b. Wire numbers shall correspond to the terminal block number to which they are attached in the control panel.
 - c. Internal panel wires on a common terminal shall have the same wire number.
 - d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. All multi-conductor and instrumentation cables shall be identified at pull points as described above:
 - 1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers in Section 16130 - Conduits.

2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), motor control centers, (MCC), field starters, field instruments, etc.

(ORIGIN LOC.)–(ORIGIN TERM.)/(DEST. LOC.)–(DEST. TERM.)

OR

(ORIGIN LOC.)–(ORIGIN TERM.)
(DEST. LOC.)–(DEST. TERM.)

Where:

ORIGIN LOC.	= Designation for originating panel or device
ORIGIN TERM.	= Terminal designation at originating panel or device
DEST. LOC.	= Designation for destination panel or device
DEST. TERM.	= Terminal designation at destination panel or device or PLC

I/O address at destination panel:

- a. Identify equipment and field instruments as the origin.
 - b. PCMs are always identified as the destination.
 - c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
 - d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
 - e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
 - f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
 - 1) Discrete Point: W:X:Y/Z.
Analog Point: W:X:Y.Z.
Where:
W = I for input, O for output
X = PLC number (1, 2, 3...)
Y = Slot number (01, 02, 03...)
Z = Terminal number (00, 01, 02...) for a discrete point or a word number for an analog point (1, 2, 3...)
 - g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g. C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g. C0010A).
3. **Case 1:** Vendor control panel (VCP) to process control module (PCM):
Field wire number/label: A-B/C-D

- A = Vendor control panel number without hyphen (VCP#)
- B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)
- C = Process control module number without hyphen (PCM#)
- D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

Examples: VCP#-10/PCM#-I:1:01/01
VCP#-10/PCM#-O:1:10/07
VCP#-10/PCM#-C0100

4. **Case 2:** Field instrument to process control module (PCM):

Field wire number/label: E-F/C-D

- C = Process control module number without hyphen (PCM#)
- D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
- E = Field mounted instrument tag and loop numbers without hyphen (EDV#)
- F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

Examples: TIT#-2,3/PCM#-I:1:01.1
TSH#-1/PCM#-I:2:01/00

5. **Case 3:** Motor control center (MCC) to process control module (PCM):

Field wire number/label: G-B/C-D

- B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)
- C = Process control module without hyphen (PCM#)
- D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
- G = Actual starter designation in the motor control center without hyphen (MMS#)

Examples: MMS#-10/PCM#-I:1:01/01
MMS#-10/PCM#-O:1:10/07
MMS#-10/PCM#-C0100

6. **Case 4:** Motor control center (MCC) to vendor control panel (VCP):

Field wire number/label: G-B/A-B

- A = Vendor control panel number without hyphen (VCP#)
- B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)
- G = Actual starter designation in the motor control center without hyphen (MMS#)

Example: MMS#-X2/VCP#-10

7. **Case 5:** Motor leads to a motor control center (MCC):

Field wire number/label: H-I/G-B

- B = Terminal number within motor control center (manufacturer's standard terminal number)
- G = Actual starter designation in the motor control center without hyphen (MMS#)
- H = Equipment tag and loop number without hyphen (PMP#)
- I = Motor manufacturer's standard motor lead identification (e.g. T1, T2, T3, etc.)

Example: PMP-#-T3/MMS#-T3

8. **Case 6:** Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):
Field wire number/label: J-B/C-D
 - B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)
 - C = Process control module number without hyphen (VCP#)
 - D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
 - J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

Examples: MMS#-10/PCM#-I:1:01/01
MMS#-10/PCM#-O:2:10/07
MMS#-10/PCM#-C0010

9. **Case 7:** Field bus trunk segment:
Field cable number/label: C/K-L/M; C/K-L/H; C/K-L/J
 - C = Process control module without hyphen (PCM#).
 - K = Field bus cable type.
 - L = Field bus segment number.
 - M = Field Bus field network component without hyphen (PTB1) or
 - H = Equipment tag and loop number without hyphen (EMV#) or
 - J = Starter or variable frequency drive tag and loop number without hyphen (VFD60.0112)

Examples: PCM#/PA-1A/PTB1PTB1/PA-1B/PTB2
PCM#/DN-1A/VFD#
PCM#/DP-2A/ EMV#

10. **Case 8:** Field bus spur (drop):
Field cable number/label: E/K-L/M
 - E = Field mounted instrument tag and loop numbers without hyphen (FIT#)
 - K = Field bus cable type.
 - L = Field bus segment number
 - M = Field bus field network component without hyphen (PTB1), identify ports on the device.

Examples: FIT#/PA-1C/PTB1-1
FIT#/PA-1D/PTB1-2

11. Identify all spare conductors as required for other field wires with an "S" prefix:

Example: S MMS#-10/PCM#-C011

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 1. Nameplates:
 - a. Color.
 - b. Size:
 - 1) Outside dimensions.
 - 2) Lettering.
 - c. Material.
 - d. Mounting means.
 2. Nameplate schedule:
 - a. Show exact wording for each nameplate.
 - b. Include nameplate and letter sizes.
 3. Wire numbers:
 - a. Manufacturer's catalog data for wire labels and label printer.
- C. Record documents:
 1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Nameplates and signs:
 - 1. One of the following or equal:
 - a. Brady.
 - b. Seton.
- B. Conductor and cable markers:
 - 1. Heat-shrinkable tubing:
 - a. One of the following or equal:
 - 1) Raychem.
 - 2) Brady.
 - 3) Thomas & Betts.
 - 4) Kroy.
- C. Conduit and raceway markers:
 - 1. Non-metallic, one of the following or equal:
 - a. Almetek: Mini Tags.
 - b. Lapp Group: Maxi System.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Nameplates:
 - 1. Colors:
 - a. Warning nameplates: White-center, red face.
 - b. Other nameplates: Black-center, white face.
 - 2. Laminated plastic engraving stock:
 - a. 3/32-inch thick material.
 - b. 2-ply.
 - c. With chamfered edges.
 - 3. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
 - a. No characters smaller than 1/8-inch in height.
- B. Signs:
 - 1. Automatic equipment and high voltage signs:
 - a. Suitable for exterior use.
 - b. In accordance with OSHA regulations.
- C. Conductor and cable markers:
 - 1. Machine printed black characters on white tubing.
 - 2. 10 point type or larger.
- D. Conduit and raceway markers:
 - 1. Non-metallic:
 - a. UV resistant holder and letters.
 - b. Black letters on yellow background.
 - c. Minimum letter height: 1/2-inch.
 - d. Adhesive labels are not acceptable.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Nameplates:

1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
 - a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Nameplates:

1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
 - a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.

C. Conductor and cable markers:

1. Apply all conductor and cable markers before termination.
2. Heat-shrinkable tubing:
 - a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
 - b. Tubing shall be tight on the wire after it has been heated.
 - c. Characters shall face the open panel and shall read from left to right or top to bottom.

- d. Marker shall start within 1/32 inch of the end of the stripped insulation point.
- D. Conduit markers:
 - 1. Furnish and install conduit markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
 - a. Conduit markings shall match the conduit schedule.
 - 2. Mark conduits at the following locations:
 - a. Each end of conduits that are greater than 10 feet in length.
 - b. The middle of conduits that are 10 feet or less in length.
 - c. Where the conduit penetrates a wall or structure.
 - d. Where the conduit emerges from the ground, slab, etc.
 - 3. Mark conduits after the conduits have been fully painted.
 - 4. Position conduit markers so that they are easily read from the floor.
 - 5. Attach non-metallic conduit markers with nylon cable ties:
 - a. Provide ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.
 - 6. Mark conduits before construction review by Engineer for punch list purposes.
 - 7. Label intrinsically safe conduits in accordance with the requirements of the NEC.
- E. Signs and labeling:
 - 1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
 - a. Fasten warning signs with round head stainless steel screws or bolts.
 - b. Locate and mount in a manner to be clearly legible to operations personnel.
 - 2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc. where the voltage exceeds 600 volts.
 - 3. Furnish and install warning signs on equipment that has more than one source of power.
 - a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
 - 4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
 - a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16123

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. 600 volt class or less wire and cable.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
 - 1. B3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. CSA International (CSA).
- D. Insulated Cable Engineers Association (ICEA):
 - 1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
 - 2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
- E. National Fire Protection Association (NFPA):
 - 1. 72 - National Fire Alarm and Signaling Code.
 - 2. 101 - Life Safety Code.
- F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
 - 1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
- G. Underwriter's Laboratories Inc., (UL):
 - 1. 44 - Thermoset-Insulated Wires and Cables.
 - 2. 1277 - Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - 3. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
 - 4. 1569 - Standard for Metal-Clad Cables.
 - 5. 2196 - Standard for Tests for Fire Resistive Cables.
 - 6. 2225 - Standard for Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

- B. Specific definitions and abbreviations:
 - 1. AWG: American wire gauge.
 - 2. BCCS: Bare copper-covered steel.
 - 3. CPE: Chlorinated polyethylene.
 - 4. FEP: Fluorinated ethylene propylene.
 - 5. FHDPE: Foam high-density polyethylene.
 - 6. FPE: Foam polyethylene.
 - 7. OD: Outside diameter.
 - 8. PVC: Polyvinyl chloride.
 - 9. XHHW: Cross-linked high heat water resistant insulated wire.
- C. Definitions of terms and other electrical considerations as set forth in the:
 - 1. ASTM.
 - 2. ICEA.

1.04 SYSTEM DESCRIPTION

- A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Manufacturer of wire and cable.
 - 2. Insulation:
 - a. Type.
 - b. Voltage class.
 - 3. AWG size.
 - 4. Conductor material.
 - 5. Pulling compounds.
- C. Shop drawings:
 - 1. Show splice locations.
 - a. For each proposed splice location provide written justification describing why the splice is necessary.
- D. Test reports:
 - 1. Submit test reports for meg-ohm tests.
- E. Calculations:
 - 1. Submit cable pulling calculations to the Engineer for review and comment for all cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
 - a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
 - b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER`S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. 600 volt class wire and cable:
 - a. General Cable.
 - b. Okonite Co.
 - c. Southwire Co.
 - d. Service Wire.
 - 2. 600 volt VFD cable:
 - a. General Cable.
 - b. Southwire Co.
 - c. Service Wire.
 - 3. Instrumentation class wire and cable:
 - a. Alpha Wire Co.
 - b. Belden CDT.
 - c. General Cable.
 - d. Okonite Co.
 - e. Rockbestos Surprenant Cable Corp.
 - 4. Network cables:
 - a. Belden CDT.
 - b. General Cable.
 - c. CommScope.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Conductors:
 - 1. Copper in accordance with ASTM B3.

2.04 MANUFACTURED UNITS

- A. General:
 - 1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
 - 2. Permanently mark each wire and cable with the following at 24-inch intervals:
 - a. AWG size.
 - b. Voltage rating.
 - c. Insulation type.
 - d. UL symbol.
 - e. Month and year of manufacture.
 - f. Manufacturer's name.
 - 3. Identify and mark wire and cable as specified in Section 16075 - Identification for Electrical Systems:
 - a. Use integral color insulation for #2 AWG and smaller wire.
 - b. Wrap colored tape around cable larger than #2 AWG.
- B. 600 volt class wire and cable:
 - 1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
 - a. When not indicated on the Drawings, size wire as follows:
 - 1) In accordance with the NEC:
 - a) Use 75 degree Celsius ampacity ratings.
 - b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
 - 2) Provide #12 AWG minimum for power conductors.
 - 3) Provide #14 AWG minimum for control conductors.
 - 2. Provide Class B stranding in accordance with ASTM B8:
 - a. Provide Class C stranding where extra flexibility is required.
 - 3. Insulation:
 - a. XHHW-2.
 - b. 90 degree Celsius rating.
 - 4. Multiconductor cables:
 - a. Number and size of conductors as indicated on the Drawings or in the Conduit Schedules.
 - b. Individual conductors with XHHW-2 insulation.
 - c. Overall PVC jacket.
 - d. Tray cable rated.
 - e. Color-coding for control wire in accordance with ICEA Method 1, E-2 in accordance with NEMA WC 57/ICEA S-73-532.
 - f. Ground conductor: Insulated, green:
 - 1) Sized in accordance with NEC.

- C. 600 volt VFD cables:
 - 1. Conductor:
 - a. Provide Class B stranding in accordance with ASTM B8.
 - 2. Insulation:
 - a. Cross-linked Polyethylene.
 - b. 90 degree Celsius rating.
 - c. UL 44 Type RHH/RHW-2 or XHHW-2.
 - 3. Ground:
 - a. Provide Class B stranding in accordance with ASTM B8.
 - b. 3 symmetrically placed bare copper conductors in direct contact with shield.
 - 4. Metallic shield:
 - a. Overall 5 mil bare copper tape shield with 50 percent overlap.
 - 5. Outer jacket:
 - a. UL 1277 Type PVC.
 - 6. Cable tray rated, UL Type TC-ER.
- D. Instrumentation class cable:
 - 1. Type TC.
 - 2. Suitable for use in wet locations.
 - 3. Voltage rating: 600 volts.
 - 4. Temperature rating:
 - a. 90 degree Celsius rating in dry locations.
 - b. 75 degree Celsius rating in wet locations.
 - 5. Conductors:
 - a. Insulation:
 - 1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
 - b. #16 AWG stranded and tinned.
 - c. Color code: ICEA Method 1:
 - 1) Pair: Black and white.
 - 2) Triad: Black, white and red.
 - 3) Multiple pairs or triads:
 - a) Color-coded and numbered.
 - 6. Drain wire:
 - a. #18 AWG.
 - b. Stranded, tinned.
 - 7. Jacket:
 - a. Flame retardant, moisture and sunlight resistant PVC.
 - b. Ripcord laid longitudinally under jacket to facilitate removal.
 - 8. Shielding:
 - a. Individual pair/triad:
 - 1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
 - b. Multiple pair or triad shielding:
 - 1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
 - 2) Completely isolate group shields from each other.
 - 3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
 - c. All shielding to be in contact with the drain wire.

- E. Network cables:
1. Category 6:
 - a. General:
 - 1) Provide all Cat 6 cables meeting the standards set by TIA/EIA-568-C.2.
 - b. Conductors:
 - 1) #24 AWG solid bare copper conductors.
 - c. Insulation:
 - 1) Polyolefin.
 - 2) 4 non-bonded twisted pair cables formed into a cable core.
 - d. Color code:
 - 1) Pair 1: White/blue stripe and blue.
 - 2) Pair 2: White/orange stripe and orange.
 - 3) Pair 3: White/green stripe and green.
 - 4) Pair 4: White/brown stripe and brown.
 - e. Outer jacket:
 - 1) PVC with ripcord.
 - f. Electrical characteristics:
 - 1) Frequency range: 0.772-100 MHz.
 - 2) Attenuation: 32.1 dB/100 m.
 - 3) Near-end crosstalk (NEXT): 39.3 dB.
 - 4) Power sum NEXT: 37.3 dB.
 - 5) Attenuation to crosstalk ratio (ACR): 7.2 dB.
 - 6) Power sum attenuation to crosstalk ratio (PSACR): 5.3 dB/100 m.
 - 7) Equal level far end crosstalk (ELFEXT): 22.8 dB.
 - 8) Power sum ELFEXT: 19.8 dB/100 m.
 - 9) Return loss: 17.3 dB.
 - 10) Propagation delay: 537 ns/100 m.
 - 11) Delay skew: 45 ns/100 m.
 - 12) Propagation delay (skew), max: 2.5 ns/100 m.
 2. Profibus cable:
 - a. Provide Profibus cables in the following cable types as indicated on the Drawings and in the Specifications:
 - 1) Profibus DP.
 - b. Profibus DP 1 pair:
 - 1) Tinned copper conductors with 7 by 30 stranding (minimum).
 - 2) Polyolefin insulation.
 - 3) Aluminum foil-polyester shield.
 - 4) 100 percent coverage of outer shield.
 - 5) 1 pair #22 AWG.
 - 6) Tinned copper drain wire.
 - 7) CPE outer jacket.
 - 8) 300-volt insulation level.
 - 9) Nominal OD 0.335 inch.
 - c. Meet NEC/UL specification for direct burial or wet locations.
 - d. Meet all Profibus specifications.
 3. Be certified by Profibus when applicable.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Wire ties:
 - 1. One of the following or equal:
 - a. T&B, "Ty-Rap" cable ties.
 - b. Panduit, cable ties.
- B. Wire markers:
 - 1. As specified in Section 16075 - Identification for Electrical Systems.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.
- B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Color-coding:
 - 1. Color-coding shall be consistent throughout the facility.
 - 2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Single phase system: Black for 1 hot leg, red for the other.
 - e. Neutral: White.
 - f. High phase or wild leg: Orange.
 - g. Equipment ground: Green.
 - 3. The following color code shall be followed for all 480/277 volt systems:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Gray.
 - e. Equipment ground: Green.
 - 4. The following color code shall be followed for all 120 VAC control wiring:
 - a. Power: Red.

- b. Neutral: White.
 - 5. The following color code shall be followed for all general purpose DC control circuits:
 - a. Grounded conductors: White with blue stripe.
 - b. Ungrounded conductors: Blue.
 - 6. Switch legs shall be violet. 3-way switch runners shall be pink.
 - 7. Wires in intrinsically safe circuits shall be light blue.
 - 8. Wire colors shall be implemented in the following methods:
 - a. Wires manufactured of the desired color.
 - b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
 - 1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.
- C. Install conductors only after the conduit installation is complete, and all enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
- 1. Install wires only in approved raceways.
 - 2. Do not install wire:
 - a. In incomplete conduit runs.
 - b. Until after the concrete work and plastering is completed.
- D. Properly coat wires and cables with pulling compound before pulling into conduits:
- 1. For all #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
 - a. Ideal Products.
 - b. Polywater Products.
 - c. 3M Products.
 - d. Greenlee Products.
 - e. Or equal as recommended by cable manufacturer.
 - f. Do not use oil, grease, or similar substances.
- E. Cable pulling:
- 1. Prevent mechanical damage to conductors during installation.
 - 2. For cables #1 AWG and smaller, install cables by hand.
 - 3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
 - 4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
 - 5. Ensure cable pulling crews have all calculations and cable pulling limitations while pulling cable.
 - 6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer's recommendation for the specified cable size:
 - a. Make splices in manholes or pull boxes only.
 - b. Leave sufficient slack to make proper connections.
- F. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer's recommendations.
- G. Install and terminate all wire in accordance with manufacturer's recommendations.

- H. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
 - 1. Do not lace wires in gutter or panel channel.
 - 2. Install all wire ties with a flush cutting wire tie installation tool:
 - a. Use a tool with an adjustable tension setting.
 - 3. Do not leave sharp edges on wire ties.
- I. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
 - 1. Use ring type lugs if box lugs are not available on the equipment.
- J. Lighting circuits:
 - 1. Each circuit shall have a dedicated neutral.
- K. Splices:
 - 1. Provide continuous circuits from origin to termination whenever possible:
 - a. Obtain Engineer's approval prior to making any splices.
 - 2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
 - 3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
 - a. Splice box NEMA rating requirements as specified in Section 16050 - Common Work Results for Electrical.
 - b. Make splices in labeled junction boxes for power conductors.
 - c. Make splices for control and instrument conductors in terminal boxes:
 - 1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
 - 4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
 - 5. Clearly label junction and terminal boxes containing splices with the word "SPICE LOCATED WITHIN".
 - 6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
 - 7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
 - a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
 - 8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
 - a. A heat shrink insulating system listed for submersible applications.
 - b. Or an epoxy resin splicing kit.
- L. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.
- M. Instrumentation class cable:
 - 1. Install instrumentation class cables in separate raceway systems from power cables:
 - a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
 - b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.

2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.
 3. Shield grounding requirements as specified in Section 16060 - Grounding and Bonding.
- N. Multi-conductor cable:
1. Where cable is not routed in conduit with a separate ground conductor, use 1 conductor in the cable as a ground conductor:
 - a) Use an internal ground conductor, if it is no smaller than as indicated on the Drawings and in accordance with NEC requirements for equipment ground conductor size.
 - b) Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with one of the full-sized conductors serving as ground.
- O. Signal cable:
1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.
- P. Submersible cable:
1. Provide Kellem's grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.
- Q. Wiring allowances:
1. Equipment locations may vary slightly from the drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
 2. Locations for pull boxes, manholes, and duct banks may vary slightly from the drawings. Include an allowance for necessary conductors and related materials to provide conductors to all pull boxes, manholes and duct banks within 20 linear feet of locations indicated on the Drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Grounding:
1. As specified in Section 16060 - Grounding and Bonding.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16125

FIBER OPTIC CABLE AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Fiber optic cable.
 - 2. Fiber splices and terminations.
 - 3. Accessories.
- B. Furnish a complete fiber optic network as indicated on the Drawings.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Bellcore Standards:
 - 1. GR-409, "Generic Requirements for Intrabuilding Fiber."
- C. Electronic Industry Association (EIA) 455B "Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components":
 - 1. FOTP-25 - Repeated Impact testing of Fiber Optic Cables and Cable Assemblies.
 - 2. FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test.
 - 3. FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables.
 - 4. FOTP-81 - Compound Flow (Drip) Test for Filled Fiber Optic Cable.
 - 5. FOTP-104 - Fiber Optic Cable Cyclic Flexing Test.
 - 6. FOTP-181 - Lightning Damage Susceptibility Test for Fiber Optic Cables with Metallic Components.
- D. Insulated Cable Engineer's Association (ICEA):
 - 1. S-83-596, "Optic Fiber Premises Distribution Cables."
 - 2. S-87-640, "Optic Fiber Outside Plant Communications Cable."
 - 3. S-104-696, "Fiber Optic Premises Distribution Cables."
- E. TIA/EIA Standards:
 - 1. 598, "Color Coding of Fiber Optic Cables."
- F. Underwriters Laboratories, Inc. (UL):
 - 1. 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
 - 2. 1685 - Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

1.03 DEFINITIONS

- A. As specified in Sections 16050 - Common Work Results for Electrical and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definition:
 - 1. N/Cm: Newtons per centimeter.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Complete manufacturer's brochures that identify materials and options.
 - 2. Completed data sheets, including catalog number and source for determining catalog number.
 - 3. Manufacturer's installation instructions.
 - 4. Include the following:
 - a. Manufacturer's data on testing equipment used on this project.
 - b. Manufacturer's specifications and data sheets for all fiber types.
 - c. Manufacturer's specifications and data sheets for all connectors, bulkheads, splicing kits, breakout devices, and appurtenances used connecting and terminating the fiber spans.
 - 5. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the NIST.
 - 6. Manufacturer's test procedures and quality assurance procedures:
 - a. After review, the Engineer may require that additional tests be performed before installation.
- C. Shop drawings:
 - 1. Interconnection cabling diagrams for the complete system including every fiber in each cable.
 - 2. Drawings indicating the locations of all pull boxes including pull box identifiers and lengths.
 - 3. Submit optical power budget calculations for all fiber segments. Include the following:
 - a. Minimum transmit power of active devices.
 - b. Minimum receive sensitivity.
 - c. Available power, in dBm.
 - d. Loss for each segment in dBm, including cable attenuation and connector losses. Use manufacturer's data for cable attenuation, at the wavelength to be used. Assume 0.5 dB per connector.
 - e. Demonstrate that remaining power budget at each receiver is equal to or greater than 3.0 dBm.
- D. Installation instructions:
 - 1. Submit a cable pulling and splicing work plan a minimum of 45 days before the planned initiation of cable pulling. The cable pulling and splicing work plan

must be approved a minimum of 15 days before pulling cable. Include the following:

- a. Pull tension calculations.
- b. Detailed description of pull operation methods for all conduit runs.
- c. Tools and equipment to be used for cable installation and testing.
- d. Physical location of equipment setup and type.
- e. Exact locations of splice points.
- f. Safety and manual assist cable-pulling operations.
- g. Detailed schedule for pulling and testing cables.
- h. The name and qualifications of the supervisory personnel directly responsible for the installation of the conduit system.
- i. Sample fiber optic cable test sheets.
- j. All signed test sheet results.

E. Operation and maintenance manuals:

1. Compile completed test reports, instruction manuals, and manufacturer's information into the operating manuals and submitted in accordance with Section 01782 - Operation and Maintenance Data.

F. Test reports:

1. Submit the results of all specified tests to the Engineer.
2. Submit 3 copies of all test reports showing the results of all tests specified herein or in Section 16950 - Field Electrical Acceptance Tests:
 - a. Test forms shall include the following information at a minimum:
 - 1) Test type.
 - 2) Test location.
 - 3) Test date.
 - 4) Wavelength.
 - 5) Index of refraction.
 - 6) Cable identification.
 - 7) Fiber type.
 - 8) Fiber number.
 - 9) Fiber color.
 - 10) Result of the value of the tested parameter.
3. Furnish hard copy and electronic copy for all OTDR traces.
4. Submit certification that the fiber optic cable has passed each testing stage:
 - a. Submit separate documentation for each testing stage result.

G. Record documents:

1. Furnish updated electrical drawings, network diagrams, and fiber cable block diagrams at the end of construction and submit as Record Drawings.

H. Calculations:

1. Cable pulling calculations for all conduit runs:
 - a. Indicate on the submittal any additional pull boxes that are required, including pull box identifiers and a written description of the location.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Furnish all cable and appurtenances manufactured within 1 year of installation.

- C. Proof test all optical fibers by the fiber manufacturer at a minimum load of 50 kpsi.
- D. Provide 100 percent attenuation testing for all optical fibers:
 - 1. Include with each cable reel the attenuation of each fiber.
- E. Provide information on at least 5 successful fiber optic cable installations of comparable size and complexity in the past 3 years with name, address, and telephone number of facility owner, name of project with completion date, and type of conduit system and length of cable pulled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Package the cable for shipment on wooden reels:
 - 1. Seal both ends of the cable to prevent the ingress of moisture.
 - 2. Place fiber cable assemblies on reels such that both cable ends are available for testing.
 - 3. Weatherproof cable reel markings shall include the following:
 - a. Manufacturer.
 - b. Date of manufacture.
 - c. Shipping date.
 - d. Cable identification.
 - e. Cable configuration/fiber count.
 - f. Cable length.
 - g. Gross weight.
 - h. Cable test date.
 - i. Handling instructions.
 - j. Direction to unreel.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. Testing:
 - 1. Perform testing of each fiber in each cable as follows:
 - a. At the factory before shipment.
 - b. At the project site upon delivery.
 - c. After installation, before breakout and terminations.
 - d. After installation is complete.
 - 2. Submit test reports following each set of tests as specified in this Section.
- B. Notify the Engineer and Owner a minimum of 15 days before post-installation testing.

1.10 SCHEDULING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable manufacturers are indicated with each component type as listed in the remainder of this specification.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. General fiber cable requirements:
 - 1. Suitable for the installed environment.
 - 2. Color-coded fibers according to EIA/TIA-598.
 - 3. Color-coded buffer tubes according to EIA/TIA-598.
 - 4. Furnish buffer tubes of a single layer nylon construction or of a material with similar mechanical performance.
 - 5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
 - 6. Utilize a glass reinforced plastic rod as the central anti-buckling member.
 - 7. Apply binders with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes:
 - a. Provide binders that are:
 - 1) Non-hygroscopic.
 - 2) Non-wicking (or rendered so by the flooding compound).
 - 3) Dielectric with low shrinkage.
 - 8. Provide a minimum of 1 ripcord under the cable sheath.
 - 9. Provide the high tensile strength Aramid yarns, Kevlar, and/or fiberglass helically stranded evenly around the cable core:
 - a. No metallic elements whatsoever are allowed in non-armored cable.
 - 10. The jacket or sheath shall be free of holes, splits, and blisters.
 - 11. Mark the jacket or sheath with:
 - a. Manufacturer's name.
 - b. The words "Optical Cable".
 - c. Year of manufacture.
 - d. Sequential meter marks.
 - e. Repeat markings every 1 meter.
 - f. The actual length of the cable to be within 1 percent of the length marking.
 - g. The marking must be in a contrasting color to the cable jacket.

- h. The height of the marking:
 - 1) Approximately 2.5 millimeters.
- 12. The shipping, storage, and operating temperature range of the cable shall be -40 degrees Celsius to +70 degrees Celsius.
- 13. General performance characteristics:
 - a. The rated tensile load of the cables:
 - 1) 2,670 N (600 lbf) for armored cables, 1,334 N (300 lbf) for non-armored cables.
 - 2) Maximum fiber strain within a cable no greater than 60 percent of the fiber proof test level.
 - b. Non-armored fiber optic cables: Compressive load withstand of 220 N/cm applied uniformly over the length of the cable.
 - c. Armored fiber optic cables: Compressive load withstand of 440 N/cm applied uniformly over the length of the cable.
 - d. The average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm for a cable subjected to this load:
 - 1) With no measurable increase in attenuation after load removal.
 - e. Test in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cable," except that the load must be applied at the rate of 3 millimeters to 20 millimeters per minute and maintained for 10 minutes.
 - f. Capable of withstanding 25 cycles of mechanical flexing at a rate of 30 within 1 cycles/minute.
 - g. The average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nanometers at the completion of the test.
 - h. For armored cables, any visible cracks causing separation of the armor and propagating more than 5 millimeters constitutes failure.
 - i. Outer cable jacket cracking or splitting observed under 10X times magnification, constitutes failure.
- B. Indoor/outdoor cable:
 - 1. General:
 - a. Application: Interior and exterior of buildings.
 - 2. Cable construction:
 - a. General:
 - 1) Cable type: Indoor/Outdoor - Flame retardant, low smoke, zero halogen, UV resistant.
 - 2) Fiber count: 24 strand or 12 strand, as noted on Drawings.
 - 3) Fiber type: Single mode.
 - 4) Buffer tube: Loose tube.
 - 5) Armoring: None.
 - 6) Waterproofing: Water blocking layer.
 - 7) Strength member: Central nonmetallic strength member with a coefficient of thermal expansion similar to the fibers.
 - 8) Approvals and listings: UL 1666 and UL 1685.
 - 9) Design and test criteria: In accordance with ICEA S-104-696.
 - b. Testing:
 - 1) All fibers in the cable:
 - a) Proof test of 100 kpsi.
 - b) Each optical fiber: Bellcore GR-409 strip force testing.
 - c) No gaps are allowed between the coating material and the buffer material visible under a 50-power microscope.

- c. Outer jacket material:
 - 1) Linear low-density polyethylene.
 - 2) Color: black.
 - 3) Meet all requirements of the NEC for use in all indoor/outdoor areas (excluding plenums) without being enclosed in conduit.
 - 4) Flame retardant OFNR riser rated conforming to UL 1666.
 - 5) Printed with all necessary UL marks and manufacturer identification.
 - 6) Sequential printing of footage in 2-foot increments.
 - 7) With a ripcord incorporated under the cable jacket.
- d. Manufacturers: One of the following or equal:
 - 1) Corning Cable Systems, Freedm[®] LST (OFNR Loose-Tube).
 - 2) Krone, LSZH Indoor/Outdoor (OFNR) distribution cables.

C. Single mode fibers:

- 1. All fibers in the cable must be usable fibers and meet required specifications.
- 2. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
- 3. Single mode fiber characteristics:
 - a. Fiber type: Single mode.
 - b. Core diameter: 8.2 within 2.5 micrometers.
 - c. Clad diameter: 125 within 0.7 micrometers.
 - d. Cladding non-circularity: Less than .7 percent.
 - e. Numerical aperture: 14 within 0.015.
 - f. Maximum attenuation: .4 dB/km at 1,310 nanometers, 3 dB/km at 1,550 nanometers.
 - g. Gigabit Ethernet distance: 5,000 m at 1,310 nanometers.
 - h. Coating diameter: 245 within 5 micrometers.
 - i. Cabled cutoff wavelength: Less than 1,260.
 - j. Mode-field diameter: 9.2 within 0.4 micrometers at 1,310 nanometers, 10.4 within 0.5 micrometers at 1,550 nanometers.
 - k. Zero dispersion wavelength: 1,313 nanometers.
 - l. Dispersion slope: 0.086 ps/(nm²*km).
- 4. Manufacturers: One of the following or equal:
 - a. ADC/KRONE Group.
 - b. Berk-Tek.
 - c. Corning Cable Systems.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Patch cords:

- 1. General:
 - a. Connector types to match supplied equipment and the patch panel terminations.
 - b. Maximum length of patch cords: 25 feet.
 - c. Provide 2 spare patch cords (or 1 duplex patch cord) of each type used at each PLC or network cabinet.
 - d. Factory assembled and optically tested.

2. Manufacturers: One of the following or equal:
 - a. Krone.
 - b. Corning Cable Systems.
- B. Fiber connectors:
 1. As specified in Section 17733 - Control Systems: Network Materials and Equipment.
- C. Fiber optic identification/warning tags:
 1. Black letters on orange or yellow background.
 2. UV resistant polyethylene or other suitable material.
 - a. Manufacturers: The following or equal.
 - 1) Almetek.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify the condition of the conduit system before installation of the fiber optic cable or inner duct.
- B. Pass a test mandrel through all fiber optic conduits prior to pulling fiber or installing inner duct.
 1. Run the mandrel in both directions.
- C. Examine all materials and equipment before installation and verify they are free from physical damage and defects.

3.02 PREPARATION

- A. Before fiber splicing terminating or testing activities, verify sufficient workspace is available to perform the activity without interferences from other trades.
- B. Pre-installation test:
 1. Conduct pre-installation tests on all fiber optic cable.
 2. Upon arrival at the site:
 - a. Inspect the cable and reel for damage.
 - b. Test all fibers with an optical time domain reflectometer (OTDR) for fiber integrity.
 - c. Verify that the fiber lengths are consistent with the cable manufacture.
 - d. Verify that all traces yield no point discontinuities.

3. Complete test sequence and obtain approval from the Engineer of submitted test results before cable installation:
 - a. Replace any cable failing to meet the requirements of the required tests and test before installation.
4. Submit copies of the test results to the Engineer within 5 days after the delivery to the site.

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install fiber optic patch cords in open network trays or in dedicated conduits no longer than 25 feet in length.
- C. Install all fiber optic system components in accordance with the recommendations of the manufacturer.
- D. Install fiber optic cable in continuous lengths without intermediate splices, except where approved by the Engineer.
- E. Installation:
 1. Utilize personnel certified by the manufacturer with specific knowledge of the cable manufacturer's recommended procedures:
 - a. Schedule Engineer, 5 days before installation, to witness all cable installations.
 2. Properly attach the fiber optic cable's strength elements to a 600-pound breakaway swivel containing tension or shear pins using Kellums pulling grips that are a minimum of 18 inches long.
 3. Certify that cable tensile limits do not exceed cable pull tension and bend limits using tension monitoring devices.
 4. Leave an extra loop of fiber optic cable in each pull box.
 5. Conform with the cable manufacturer's specifications, practices, and the following requirements:
 - a. When power equipment is used to install fiber optic cables, use low speeds and do not exceed a rate of 30 meters per minute.
 - b. Do not exceed the tensile and bending limitation for fiber optic cables under any circumstances.
 - c. Use large diameter wheels, pulling sheaves, and cable guides to maintain the specified bending radius.
 - d. Use commercial dynamometers or load cells to monitor pulling tension.
 - e. A nonfreezing type of swivel inserted between the pulling line and cable pulling grip to prevent twisting under strain.
 - f. All cable to be installed using a breakaway swivel.
 6. Apply to all conduits a lubricant at each conduit ingress and egress location during the pull operation:
 - a. Pour or pump lubricant into the end of the conduit at the feed location at a nominal application rate of 3 gallons per 1,000 feet of cable.
 - b. If the conduit is open at intermediate locations, then apply the appropriate proportion of lubricant at each opening.
 - c. Continuously lubricate the cable as it is being pulled by pouring or pumping the lubricant into the conduit at the feed location and at each intermediate location.

- d. Station workers at each intermediate location as required.
- e. Remove all excess lubricant that has collected.
- f. Remove and clean the surrounding area after cable installation.
- 7. Install using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions:
 - a. Use pulling equipment with "slip-load" capability to allow the winch to maintain a constant pulling force without taking up the winch line.
 - b. Use pulling equipment equipped with a hydraulic bypass set so that a maximum tension of 600 pounds is not exceeded.
 - c. Use only equipment designed to prevent a preset pulling tension from being exceeded.
 - d. Fiber optic cable manufacturer to provide the pulling tension setpoint.
 - e. If during the pulling operation excessive tension is detected, cease all operations and notify the Engineer.
- 8. Position the cable reel at the feed point in alignment with the raceway and in such a position that the cable can be passed from the top of the reel in a long, smooth bend into the raceway system:
 - a. The use of a cable feeder is required, unless the cable is hand-pulled.
- 9. Supply all bull wheels, blocks, split wheels, cable feeders, and necessary equipment required to provide a clean and safe operation:
 - a. The cable shall not be allowed to travel over any wheel or block that has a radius less than the minimum radius allowed by the cable manufacturer.
- 10. Minimize the use of snatch blocks and rollers to guide the cable into the conduit at the feed point:
 - a. Slack feed by hand the cable into the feed point and raceway without the use of rollers.
- 11. Tend the cable reel at all times and turn by hand to provide the required cable slack:
 - a. Under no circumstances shall the cable tension be allowed to turn the cable reel.
- 12. Use a rim roller, with a wheel radius greater than the minimum cable bending radius placed at the manhole or vault opening to prevent the cable from dragging on the manhole rim or steps.
- 13. Perform a continuous thorough visual inspection for flaws, breaks, and abrasions in the cable sheath as the cable leaves the reel, and maintain a slow pulling speed to permit this inspection.
- 14. Damage to the sheath or finish of the cable is cause for rejecting the cable:
 - a. Replace any cable damaged in any way during installation.
- 15. If the cable becomes damaged during installation, stop operations and notify the Engineer immediately:
 - a. Engineer to determine whether to replace the entire reel of cable or to install a termination panel to eliminate the damaged section.
- 16. Document all pulls by a graph which is annotated with the following information:
 - a. Reel number.
 - b. Pull point ID.
 - c. Date and time.
 - d. Explanations for abnormalities in readings or interruptions.
 - e. Sign-off by Contractor and Engineer.
- 17. Under no conditions shall the fiber optic cable be left exposed or unattended.

- F. After the cables are installed and spliced:
1. Rack the cables.
 - a. Loosely secure in racked position with wire ties.
 - b. Attach imprinted plastic coated cloth identification/warning tags to each cable in at least 2 locations in each handhole/manhole.
- G. Splices:
1. Submit all splice locations to the Engineer for approval before installation of the fiber cables.
 2. Provide field splices in a splice tray located in a waterproof splice enclosure:
 - a. Manufacturers: The following or equal:
 - 1) Tyco/Raychem, FOSC style splice enclosure.
 3. Loop the individual fibers a minimum of 1 full turn within the splice tray to avoid macro/micro bending.
 4. After completion of cable terminations, neatly dress all cables.
 5. Protect all splices with a thermal shrink sleeve.
 6. Provide fusion type fiber optic cable splicing meeting the following requirements:
 - a. Joins multimode or single mode fibers.
 - b. Establishes a permanent fusion splice.
 - c. Waterproof.
 - d. Re-enterable, rearrangeable, and reusable.
 - e. Splice loss less than 0.10 dB.
 - f. Protected by a splice enclosure.
 7. Requirement for outdoor fiber splice enclosures:
 - a. Seal.
 - b. Bond.
 - c. Anchor.
 - d. Protect fiber optic cable splices.
 - e. Stand-alone unit that does not require an outer enclosure.
 - f. Provide for a maximum of 6 cable entries in a butt-end configuration.
 - g. Used in aerial, underground, and direct buried applications.
 8. Requirement for indoor fiber splice enclosures:
 - a. Anchor.
 - b. Protect fiber optic cable splices.
 - c. Stand-alone unit that does not require an outer enclosure.
 - d. Suitable for the minimum number of splices at that location plus additional capacity for reconfigurations.
 9. Re-splice any splice that has a loss greater than 0.10 dB.
 10. Leave a minimum of 20 feet of fiber optic cable at each end of splice.
- H. Terminations:
1. Terminate all fiber inside a patch panel.
 - a. Direct landing to a switch, router hub, or PLC will not be allowed.
 2. Terminate outdoor cables using a breakout kit that seals the cable and provides physical protection for the fiber strands.
 3. Terminate indoor cables using breakout kits with field installed terminators.
 4. Labeling:
 - a. Permanently label all cable terminations. Use labels produced by a wire printer using pressure sensitive polyester labels. Label patch panels as specified in Section 16075 - Identification for Electrical Systems.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.
- B. Factory test:
 - 1. Before shipment and while on the shipping reel, test 100 percent of all fibers for attenuation:
 - a. Copies of the results shall be:
 - 1) Maintained on file.
 - 2) Attached to the cable reel in a waterproof pouch.
 - 3) Submitted before the delivery of the cable to the job site to Engineer for approval.
 - 2. Conduct the flex test in accordance with FOTP-104 test condition I and III with a maximum sheave diameter of 20 times the cable OD.
 - 3. Verify that the cable withstands 25 impact cycles with:
 - a. The average increase in attenuation for the fibers less than 0.20 dB at 1,550 nanometers.
 - b. No evidence of cracking or splitting.
 - c. Conduct the test in accordance with FOTP-25.
 - 4. Certify that the cable withstands a tensile load of 2,700 N (600 pounds):
 - a. Without exhibiting an average increase in attenuation of greater than 0.10 dB.
 - b. Test in accordance with FOTP-33 using a maximum mandrel and sheave diameter of 560 millimeters.
 - c. Apply the load for 1 hour in Test Condition II.
 - 5. Certify that the cable withstands a simulated lightning strike:
 - a. Peak value of the current pulse greater than 105kA.
 - b. Use a test current with a damped oscillatory maximum time-to-peak value of 15 microseconds (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz.
 - c. The time to half-value of the waveform envelope 40 to 70 microseconds.
 - d. Conduct the test in accordance with the FOTP-181.
 - e. In addition to the analysis criterion set forth in FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e. core tube) and strength members must be intact after removal of the cable specimens from the test box.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. General:
 - 1. All test results shall meet or exceed manufacturer specifications:
 - a. Test each fiber of each cable for breaks, abnormalities, and overall attenuation characteristics.
 - b. Replace any fiber that does not meet or exceed manufacturer specifications.

2. Conduct post-installation tests of the fiber optic system in accordance with Section 16950 - Field Electrical Acceptance Tests.
 3. Pre-installation tests and post-installation tests to be witnessed and signed off by Engineer and Owner.
 4. Perform attenuation tests with an optical loss test set capable and calibrated to show anomalies of 0.1 dB as a minimum:
 - a. Test multimode fibers at 850 nanometers and 1,300 nanometers.
 - b. Test single mode fibers at 1,310 and 1,550 nanometers.
 5. Perform OTDR tests on fiber cables less than 100 meters with the aid of a launch cable:
 - a. Adjust OTDR pulse width settings to a maximum setting of 1/1000th of the cable length or 10 nanoseconds.
- C. Manufacturer's field service:
1. Provide the services of a certified manufacturer's engineering representative for the equipment specified in this Section at the jobsite for the frequency and minimum duration (travel time excluded) as specified below to perform the following services:
 - a. Three 8-hour days for inspection, assistance during installation and alignment, and certification of proper installation:
 - 1) Submit a certificate of installation.
 - b. Three 8-hour days for assistance and witnessing of system testing and any required troubleshooting.
 - c. Three individual 8-hour sessions for operation and maintenance training of Owner's personnel:
 - 1) Conduct each individual training session on a separate workday.
 2. The manufacturer's engineering representative is required at the Engineer's direction to provide 5 separate trips to the jobsite to fulfill the above requirements.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. Clean all fiber optic connectors after termination and before testing. After cleaning, cover all un-terminated connectors with a protective boot.
- B. At the completion of construction, touch up the finish on all fiber patch panels and enclosures.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Protect the fiber system from physical damage and the encroachment of dust, before, during, and after installation.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16130

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Metallic conduits.
 - 2. Nonmetallic conduits.
 - 3. Conduit bodies.
 - 4. Conduit fittings and accessories.
 - 5. Conduit installation.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. American National Standards Institute (ANSI):
 - 1. C80.1 - Electrical Rigid Steel Conduit.
 - 2. C80.3 - Steel Electrical Metallic Tubing.
 - 3. C80.5 - Electrical Rigid Aluminum Conduit.
 - 4. C80.6 - Electrical Intermediate Metal Conduit.
- C. National Electrical Manufacturer's Association (NEMA):
 - 1. RN-1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit.
 - 2. TC2 - Electrical Polyvinyl Chloride (PVC) Conduit.
 - 3. TC3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - 4. TC7 - Smooth-Wall Coilable Electrical Polyethylene Conduit.
 - 5. TC13 - Electrical Nonmetallic Tubing.
 - 6. TC14 - Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
- D. Underwriters Laboratories (UL):
 - 1. 1 - Standard for Flexible Metal Conduit.
 - 2. 6 - Standard for Electrical Rigid Metal Conduit - Steel.
 - 3. 6A - Standard for Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel.
 - 4. 360 - Standard for Liquidtight Flexible Steel Conduit.
 - 5. 651 - Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
 - 6. 651B - Standard for Continuous Length HDPE Conduit.
 - 7. 797 - Standard for Electrical Metallic Tubing - Steel.
 - 8. 1242 - Standard for Electrical Intermediate Metal Conduit - Steel.
 - 9. 1653 - Standard for Electrical Nonmetallic Tubing.
 - 10. 1660 - Standard for Liquidtight Flexible Nonmetallic Conduit.
 - 11. 1684 - Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions and abbreviations:
 - 1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, Shapes C, E, LB, T, X, etc.
 - 2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.
 - 3. GRC: Galvanized rigid steel conduit.
 - 4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
 - 5. PVC: Polyvinyl chloride rigid nonmetallic conduit.
 - 6. SLT: Sealtight-liquidtight flexible conduit.
 - 7. EFLX: Explosion proof flexible conduit.
 - 8. NPT: National pipe thread.

1.04 SYSTEM DESCRIPTION

- A. Provide conduits, conduit bodies, fittings, junction boxes, and all necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
 - 2. Furnish complete manufacturer's recommended special tools to be used for installation if required.
 - 3. Certified test results for PVC-coated metallic conduit showing the adhesive bond is stronger than the tensile strength of the PVC.
- C. Shop drawings:
 - 1. Furnish conduit routing plans for all conduits before the installation of any conduit.
 - 2. Detail the intended routing of each conduit, conduit material and include supporting methods.
 - 3. Number conduits in accordance with the Contract Documents.
 - a. Provide conduit labels as specified in Section 16075 - Identification for Electrical Systems.
- D. Certifications:
 - 1. Furnish PVC-coated conduit manufacturer's certification for each installer.
- E. Record Documents:
 - 1. Incorporate all changes in conduit routing on electrical plan drawings.
 - 2. Dimension underground and concealed conduits from building lines.
 - 3. Furnish hard copy drawings.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All conduits, conduit bodies, and fittings shall be UL listed and labeled.
- C. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Do not expose non-metallic conduit to direct sunlight.
- C. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. Before installing any conduit or locating any device box:
 - 1. Examine the complete set of Drawings and Specifications, and all applicable shop drawings.
 - 2. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Galvanized rigid steel conduit:
 - 1. One of the following or equal:
 - a. Western Tube and Conduit.
 - b. Allied Tube and Conduit.

- c. Wheatland Tube Co.
- B. PVC-coated rigid steel conduit:
 - 1. One of the following or equal:
 - a. Robroy Ind.
 - b. Ocal, Inc.
 - c. Calbond.
- C. Sealtight-liquidtight flexible conduit:
 - 1. One of the following or equal:
 - a. Southwire.
 - b. AFC Cable Systems.
 - c. Electri-Flex Co.
 - d. Anaconda.
- D. Explosion proof flexible conduit:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. Hubbell Killark.
- E. Rigid nonmetallic PVC conduit:
 - 1. One of the following or equal:
 - a. Carlon.
 - b. Cantex.
 - c. Triangle Conduit and Cable.
- F. Conduit bodies:
 - 1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z/Gedney.
 - d. Ocal, Inc.
 - e. Robroy Ind.
 - f. Calbond.
 - g. Carlon.
- G. Joint compound:
 - 1. The following or equal:
 - a. Thomas and Betts.
- H. Galvanized rigid steel conduit expansion fittings:
 - 1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z/Gedney.
- I. PVC-coated rigid steel conduit expansion fittings:
 - 1. One of the following or equal:
 - a. Ocal, Inc.
 - b. Robroy Ind.

- J. Conduit sleeve:
 - 1. One of the following or equal:
 - a. Crouse-Hinds.
 - b. Appleton.
 - c. O-Z/Gedney.
- K. Conduit seals:
 - 1. One of the following or equal:
 - a. Appleton.
 - b. Crouse-Hinds.
 - c. O-Z/Gedney.
- L. Conduit hangers and supports:
 - 1. As specified in Section 16070 - Hangers and Supports.
- M. Conduit through wall and floor seals:
 - 1. The following or equal:
 - a. O-Z/Gedney:
 - 1) Type "WSK."
 - 2) Type "CSM."

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. GRC:
 - 1. All threads: NPT standard conduit threads with a 3/4-inch taper per foot:
 - a. Running conduit threads are not acceptable.
 - 2. Hot-dip galvanized inside and out:
 - a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
 - b. Electro-galvanizing is not acceptable.
 - 3. Manufactured in accordance with:
 - a. UL-6.
 - b. ANSI C80.1.
- B. PCS:
 - 1. The steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, conforming to the requirements for Type GRC.
 - 2. Coated conduit NEMA Standard RN-1:
 - a. The galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
 - 3. Factory-bonded PVC jacket:
 - a. The exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.

- b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictates otherwise.
 - c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
 - d. The PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
 - 1) Confirm bond with certified test results.
 - 4. A urethane coating shall be uniformly and consistently applied to the interior of all conduits and fittings:
 - a. Nominal thickness of 0.002 inch.
 - b. Conduits having areas with thin or no coating are not acceptable.
 - c. All threads shall be coated with urethane.
 - 5. The PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
 - 6. PCS conduit bodies and fittings:
 - a. Malleable iron.
 - b. The conduit body, before PVC coating, shall be new, unused material and shall conform to appropriate UL standards.
 - c. The PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of longitudinal ribs to protect the coating from tool damage during installation.
 - d. 0.002-inch interior urethane coating.
 - e. Utilize the PVC coating as an integral part of the gasket design.
 - f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.
 - g. A PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
 - 1) The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
 - 2) The sleeve shall provide a vapor- and moisture-tight seal at every connection.
- C. SLT:
- 1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
 - a. General purpose:
 - 1) Temperature range: -20 degrees Celsius to +80 degrees Celsius.
 - b. Oil-resistant:
 - 1) Temperature range: -20 degrees Celsius to +60 degrees Celsius.
 - 2. Sunlight-resistant, weatherproof, and watertight.
 - 3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
 - 4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
 - 5. Overall PVC jacket.
 - 6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

- D. EFLX:
 - 1. Suitable for the hazardous Class and Group where installed:
 - a. As specified in Section 16050 - Common Work Results for Electrical.
 - 2. Metallic braid shall provide continuous electrical path.
 - 3. Stainless steel construction.
 - 4. Provide fittings and unions as required for the installation.
- E. PVC:
 - 1. Extruded from virgin PVC compound:
 - a. Schedule 40 unless otherwise specified.
 - b. Schedule 80 extra-heavy wall where specified.
 - 2. Rated for 90 degrees Celsius conductors or cable.
 - 3. Rated for use in direct sunlight.
- F. Conduit bodies:
 - 1. Material consistent with conduit type:
 - a. Malleable iron bodies and covers when used with Type GRC.
 - b. PVC bodies and covers when used with Type PVC.
 - c. PVC-coated malleable iron bodies and covers when used with Type PCS.
 - 2. Conduit bodies to conform to Form 8, Mark 9, or Mogul design:
 - a. Mogul design conforming to NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
 - 3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.07 ACCESSORIES

- A. Connectors and fittings:
 - 1. Manufactured with compatible materials to the corresponding conduit.
- B. Insulated throat metallic bushings:
 - 1. Construction:
 - a. Malleable iron or zinc-plated steel when used with steel conduit.
 - b. Positive metallic conduit end stop.
 - c. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
 - d. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.
- C. Insulated grounding bushings:
 - 1. Construction:
 - a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
 - b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
 - c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.
- D. Electrical unions (Erickson Couplings):
 - 1. Construction:
 - a. Malleable iron for use with steel conduit.
 - b. Concrete tight, 3-piece construction.

- c. Rated for Class I Division 1 Group D in hazardous areas.
- E. SLT fittings:
 - 1. Construction:
 - a. Malleable iron.
 - b. Furnished with locknut and sealing ring.
 - c. Liquidtight, raintight, oiltight.
 - d. Insulated throat.
 - e. Furnish as straight, 45-degree elbows, and 90-degree elbows.
 - f. Designed to prevent sleeving:
 - 1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
 - g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.
 - h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
 - 2. Corrosion-resistant and outdoor SLT fittings:
 - a. Construction:
 - 1) PVC-coated liquidtight fittings with a bonded 0.040-inch thick PVC coating on the metal connector to form a seal around the SLT conduit.
 - 2) Insulated throat and an integral sealing ring.
- F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
 - 1. Construction:
 - a. Insulated throat.
 - b. PVC-coated when used in corrosive areas.
 - c. Bonding locknut.
 - d. Recessed neoprene o-ring to ensure watertight and dusttight connector.
 - e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
 - f. 1-1/2-inch through 6-inch malleable iron zinc plated.
 - 2. Usage:
 - a. All conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.
- G. Sealing fittings:
 - 1. Construction:
 - a. 40-percent wire fill capacity.
 - b. PVC-coated when used in corrosive areas.
 - c. Malleable ductile iron with steel conduit.
 - d. Aluminum with aluminum conduit.
 - e. Crouse-Hinds Type EYD where drains are required.
 - f. Crouse-Hinds Type EYS where drains are not required.
 - g. UL listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; and Class II, Divisions 1 and 2, Groups E, F, and G.

2. Sealing compound:
 - a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
 - b. Approved for the conditions and use.
 - 1) Not affected by surrounding atmosphere or liquids.
 - c. Melting point shall be 200 degrees Fahrenheit minimum.
- H. PVC fittings:
 1. Shall include the following:
 - a. Couplings.
 - b. Terminal adapters.
 - c. Female adapters.
 - d. Caps.
 - e. Reducer bushings.
 - f. Duct couplings.
 - g. End bells.
 - h. Expansion couplings.
 - i. Duct couplings: 5 degree.
 - j. C-Type pull fittings.
 - k. E-Type pull fittings.
 - l. LB-Type pull fittings.
 - m. LL-Type pull fittings.
 - n. LR-Type pull fittings.
 - o. T-Type pull fittings.
 - p. X-Type pull fittings.
 - q. Service entrance caps.
 2. Materials:
 - a. All devices shall be made of PVC, using the same materials as used for Type PVC conduit.
 - b. All metal hardware shall be stainless steel.
- I. Through wall and floor seals:
 1. Materials:
 - a. Body: Casting of malleable or ductile iron with a hot-dip galvanized finish.
 - b. Grommet: Neoprene.
 - c. Pressure rings: PVC-coated steel.
 - d. Disc material: PVC-coated steel.
- J. Expansion/deflection couplings:
 1. Use to compensate for movement in any directions between 2 conduit ends where they connect.
 2. Shall allow movement of 3/4 inch from the normal in all directions.
 3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
 4. Constructed to maintain electrical continuity of the conduit system.
 5. Materials:
 - a. End couplings: Bronze or galvanized ductile iron.
 - b. Sleeve: Neoprene.
 - c. Bands: Stainless steel.
 - d. Bonding jumper: Tinned copper braid.

- K. Expansion couplings:
 - 1. Shall allow for expansion and contraction of conduit:
 - a. Permitting 8-inch movement, 4 inches in either direction.
 - 2. Constructed to maintain electrical continuity of the conduit system.
 - 3. Materials:
 - a. Head: Malleable or ductile iron.
 - b. Sleeve: Steel.
 - c. Insulating bushing: Phenolic.
 - d. Finish: Hot-dip galvanized.
 - e. PVC-coated when used with Type PCS.
- L. Conduit markers:
 - 1. As specified in Section 16075 - Identification for Electrical Systems.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. General:
 - 1. Conduit routing:
 - a. The electrical drawings are diagrammatic in nature:
 - 1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
 - 2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
 - a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
 - b) Make changes in conduit routing due to the relocation of equipment.
 - 3) The electrical drawings do not indicate all required junction boxes and pull boxes:
 - a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
 - (1) To meet cable manufacturer's pulling tension requirements.
 - (2) To limit total conduit bends between pull locations.

- b) Install junction boxes and pull boxes at locations acceptable to the Engineer.
- b. The Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
 - 1) The Engineer is the sole source in determining whether the change is constituted as a deviation:
 - 2) Perform any changes resulting in additional conduits, or extra work from such deviations.
 - 3) Incorporate any deviations on the Record Documents.
- 2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
- 3. Provide adequate clearances from high-temperature surfaces for all conduit runs. Provide minimum clearances as follows:
 - a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
 - b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
 - c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
 - d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
- 4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
 - a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
- 5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
- 6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
 - a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
 - b. Make changes in direction with long radius bends or with conduit bodies.
- 7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
- 8. Route all exposed conduits to preserve headroom, access space and work space, and to prevent tripping hazards and clearance problems:
 - a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.
 - b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.
- 9. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
- 10. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
- 11. Install conduits through wall and floor seals where indicated on the Drawings.

12. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
 - a. Remove and replace conduits through which mandrel will not pass.
 13. Provide all sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
 14. Install complete conduit systems before conductors are installed.
 15. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
 16. Underground conduits:
 - a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
 - 1) As specified in Section 16133 - Duct Banks.
 - b. Make underground conduit size transitions at handholes and manholes.
 - c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
 - d. Seal around conduit penetrations of below grade walls with a mechanical seal.
- C. Lighting and receptacle conduits:
1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings:
 2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
 3. Minimum conduit size:
 - a. 3/4-inch for exposed conduits.
 - b. 1-inch for underground or in-slab conduits.
 4. Provide conduit materials for the installed location as specified in Section 16050 - Common Work Results for Electrical.
- D. Hazardous areas:
1. As specified in Section 16050 - Common Work Results for Electrical for hazardous areas and specific Class and Division.
 2. As specified in Section 16052 - Hazardous Classified Area Construction for hazardous area conduit installation requirements.
- E. Conduit usage:
1. Exposed conduits:
 - a. Rigid conduit:
 - 1) Install the rigid conduit type for each location as specified in Section 16050 - Common Work Results for Electrical.
 - 2) Minimum size: 3/4-inch.
 - b. Flexible conduit:
 - 1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
 - a) Use Type SLT with rigid metallic conduit.
 - b) Use Type EFLX in Class I Division 1 locations.

- 2) Minimum size: 3/4-inch:
 - a) 1/2 when required for connection to instruments.
- 3) Maximum length:
 - a) Fixed equipment:

Conduit Trade Size	Flexible Conduit Length (inch)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

- b) Removable instruments or hinged equipment:
 - (1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete-encased and embedded conduits:
 - a. Type PVC Schedule 40 and PVC-coated rigid metallic conduit as specified below:
 - 1) Use Type PCS in underground and embedded installation as follows:
 - a) Stub-up and risers to grade floor or equipment from nonmetallic conduits.
 - b) Entering and exiting underground or embedded conduit runs a minimum 12 inches above and below grade of finished floor.
 - c) For any and all bends where the total deflection is greater than 45 degrees.
 - b. Minimum size:
 - 1) 2-inch in duct banks unless otherwise indicated on the Drawings.
 - 2) 1-inch for in-slab conduits unless otherwise indicated on the Drawings.
3. Direct-buried and sand-bedded duct bank conduits:
 - a. Type PCS.
 - b. Minimum size: 1-inch.
4. PVC-coated rigid metallic conduit:
 - a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
5. GRC:
 - a. Conduit shall be cut square and reamed before threading.
6. PVC:
 - a. Conduit terminations shall be via threaded adapters into threaded hubs on the junction boxes or conduit bodies.
 - b. Conduit terminations into boxes without threaded hubs shall utilize a threaded adapter and a flat neoprene washer on the outside of the box.

- 1) Use a locknut on the inside of the box to tighten the adapter to the box.
- c. Route conduit to afford it the maximum physical protection.
 - 1) If necessary, cover conduit to afford additional protection when it cannot be shielded by the structure or machinery frames.
 - a) Use Schedule 80 where exposed runs may be subject to physical damage.

F. Conduit joints and bends:

- 1. General:
 - a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
 - b. Keep bends and offsets in conduit runs to an absolute minimum.
 - c. All bends shall be symmetrical.
 - d. The following conduit systems shall use large-radius sweep elbows:
 - 1) Underground conduits.
 - 2) Conduits containing fiber optic cables.
 - e. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.
 - f. Make field bends with a radius of not less than the requirements found in the NEC:
 - 1) The minimum bending radius of the cable must be less than the radius of the conduit bend.
 - 2) Make all field bends with power bending equipment or manual benders specifically intended for the purpose:
 - a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
 - b) For the serving utilities, make bends to meet their requirements.
 - g. Replace all deformed, flattened, or kinked conduit.
- 2. Threaded conduit:
 - a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that all bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that all joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
 - b. Thoroughly ream conduit after threads have been cut to remove burrs.
 - c. Use bushings or conduit fittings at conduit terminations.
 - d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar™," or CRC "Zinc It."
 - e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
 - 1) Apply to the male threads and tighten joints securely.
 - 2) Clean excess sealant from exposed threads after assembly.
 - f. Securely tighten all threaded connections.
 - g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that all exposed surfaces have a galvanized protective coating.

3. PVC:
 - a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
 - b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at all bends:
 - 1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

G. Conduit sealing and drainage:

1. Conduit drainage and sealing other than required for hazardous and classified areas:
 - a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
 - b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
 - c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
 - 1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.
 - d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on all conduits between corrosive and non-corrosive areas.
 - e. Seal one end only of all underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.
2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: control panels, junction boxes, pullboxes, or low points of the conduit.

H. Conduit supports:

1. General:
 - a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
 - 1) As specified in Section 16070 - Hangers and Supports.
 - 2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050 - Common Work Results for Electrical.
 - b. Support conduit at the intervals required by the NEC.
 - c. Perforated strap and plumbers tape are not acceptable for conduit supports.
2. Conduit on concrete or masonry:
 - a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
 - b. Use preset inserts in concrete when possible.
 - c. Use pipe spacers (clamp backs) in wet locations.
3. Suspended conduit:
 - a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.

- b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2-feet long, provide rigid sway bracing.
 - 4. Supports at structural steel members:
 - a. Use beam clamps.
 - b. Drilling or welding may be used only as specified or with approval of the Engineer.
 - 5. PVC conduit supports:
 - a. Mount all conduits with hangers specifically designed for use with PVC to minimize the problems of bowing resulting from the expansion and contraction of conduits caused by varying temperatures:
 - 1) Hangers to be constructed of PVC incorporating serrated teeth to grip the conduit securely and yet allow for conduit movement due to thermal considerations:
 - 2) Manufacturers: The following or equal:
 - a) Carlon; Models E978D, E, F, G, H, and J.
 - 6. PVC-coated rigid metal systems:
 - a. Provide right-angle beam clamps and "U" bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
 - b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.
 - I. Expansion or expansion/deflection fittings:
 - 1. General:
 - a. Align expansion coupling with the conduit run to prevent binding.
 - b. Follow manufacturer's instructions to set the piston opening.
 - c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
 - d. Furnish fittings of the same material as the conduit system.
 - 2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
 - a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.
 - 3. For PVC, provide expansion or expansion/deflection couplings, as appropriate, where length change due to temperature variation exceeds 2 inches:
 - a. Rigidly fix the outer barrel of the expansion coupling so it cannot move.
 - b. Mount the conduit connected to the piston loosely enough to allow the conduit to move as the temperature changes.
 - J. Empty conduits:
 - 1. Provide a polyethylene rope rated at 250 pounds tensile strength in each empty conduit more than 10 feet in length.
 - 2. Seal ends of all conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
 - a. Keep ends sealed until immediately before pulling conductors.

K. Miscellaneous:

1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
 - a. Running threads and threadless couplings are not allowed.
3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
4. Provide conduit housekeeping curb around all embedded or below-grade conduits exiting or entering the slab, per the Typical Details.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16133

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Electrical underground duct banks.
 - 2. Duct bank installation requirements.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Provide trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.
- B. Provide reinforced concrete duct banks for all conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. PVC conduit spacers.
 - 2. Detectable underground marking tape.
 - 3. Pull line.
- C. Provide applicable submittal documents as specified in:
 - 1. Section 02330 - Trenching and Backfilling.
 - 2. Section 03200 - Concrete Reinforcing.
 - 3. Section 03300 - Cast-In-Place Concrete.
- D. Shop drawings:
 - 1. Submit site plan drawings of duct banks including underground profiles indicating all underground utilities.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Conduit spacers:
 - 1. One of the following or equal:
 - a. Carlon Snap-Loc.
 - b. Cantex.
 - c. Osburn Associates, Inc.
- B. Detectable underground marking tape:
 - 1. One of the following or equal:
 - a. Blackburn Manufacturing Co.
 - b. Pro-Line Safety Products.
 - c. Panduit.
- C. Pull line:
 - 1. One of the following or equal:
 - a. Arnco.
 - b. Greenlee.
 - c. Osburn Associates, Inc.
- D. Duct seal:
 - 1. The following or equal:
 - a. OZ Gedney type DUX.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Provide conduit as specified in Section 16130 - Conduits:
 - 1. Use duct suitable for use with 90-degree Celsius rated conductors.
- B. Provide reinforcing steel as specified in Section 03200 - Concrete Reinforcing:
 - 1. Provide minimum Number 4 reinforcing steel.

2.04 MANUFACTURED UNITS

- A. Conduit spacers:
 - 1. Provide conduit spacers recommended by the conduit manufacturer or specified above.
 - 2. Saddle type.
 - 3. Non-metallic, non-corrosive, non-conductive.
 - 4. Interlocking type:
 - a. Vertical interlocking.
 - b. Horizontal interlocking.
 - 5. Suitable for concrete encasement.
 - 6. Molded-in rebar holder.
 - 7. Accommodates 2-inch through 6-inch conduit sizes.
 - 8. Relieves the conduit from both horizontal and vertical stresses.
- B. Pull line:
 - 1. Minimum 1/4-inch wide, flat design.
 - 2. Polyester.
 - 3. Minimum pulling strength 1,200 pounds.
- C. Detectable marking tape:
 - 1. Provide a detectable tape, locatable by a cable or metal detector from above the undisturbed grade.
 - 2. Aluminum core laminated between polyethylene film.
 - 3. 6-inch wide red tape imprinted with black lettering "CAUTION - BURIED ELECTRIC UTILITIES."
- D. Duct seal:
 - 1. Non-hardening sealing compound.
 - 2. Flexible, can be applied by hand.
 - 3. UL Listed for use with installed conductors.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES

- A. Concrete mix requirements as specified in Section 03300 - Cast-In-Place Concrete.

- B. Provide a red-oxide conduit encasement coloring agent as specified in Section 03300 - Cast-In-Place Concrete.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Duct banks:
 - 1. Install duct banks encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
 - 2. Damage minimization:
 - a. Conduit should not be left exposed in an open trench longer than is necessary.
 - b. Protect all underground duct banks against damage during pouring of concrete or backfilling.
 - 3. All plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
 - 4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank.
 - 5. Install underground ducts to be self-draining:
 - a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
 - b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
 - c. Slope a minimum of 1/4 inch per 10 feet.
 - 6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
 - 7. Install pull line in spare conduits:
 - a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
 - b. Cap above ground spare conduit risers at each end with screw-on conduit caps.
- C. Trenching:
 - 1. Perform trenching as specified in Section 02330 - Trenching and Backfilling.
 - 2. Trench must be uniformly graded with the bottom, rock free and covered with select material.

3. Whenever possible, use the walls of the trench as forms for concrete encasement:
 - a. Forms are required where the soil is not self-supporting.
 4. Avoid damaging existing ducts, conduits, cables, and other utilities.
- D. Duct spacing:
1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, unless otherwise indicated on the Drawings:
 - a. Separate medium voltage ducts a minimum of 7.5 inches on center.
 2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
 - a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
 - 1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
 - a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
 3. Spacers shall not be located at the center of a bend:
 - a. Locate spacer in the tangent, free of the coupling on fabricated bends.
 - b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.
- E. Terminating:
1. Use bell ends in duct at entrances into cable vaults.
 2. Make conduit entrances into cable vaults tangential to walls of cable vault.
 3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
 4. Install duct seal in all conduits including spare conduits, at both ends. Form by hand to conduit and around cables to develop moisture barrier.
 5. New manhole or handhole applications, provide a single opening or "window" per duct bank, sized to accommodate the duct bank envelope.
- F. Concrete:
1. Install concrete as specified in Section 03300 - Cast-In-Place Concrete.
 2. Provide nonferrous tie wires to prevent displacement of the conduits during pouring of concrete:
 - a. Tie wire shall not act as a substitute for spacers.
 3. Install minimum 3-inch cover around conduit and rebar.
 4. Consolidation of encasement concrete around duct banks shall be by hand puddling, with no mechanical vibration.
 5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.
- G. Marking tape:
1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

- H. For conduit installations beneath building slabs:
 - 1. Duct banks shall be continued under building slabs to the final destination of the conduits.
 - a. Construct separate duct banks as required.
 - b. Concrete for encasement under building slabs need not be colored red.
 - c. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 12 inches below the footer.
 - d. Where duct banks enter through building walls, foundation walls, stem walls, etc. make connections as indicated on the Drawings.
 - e. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.
- I. Restore all surfaces to their original condition as specified in Section 02952 - Pavement Restoration and Rehabilitation, unless otherwise specified.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide shoring and pumping to protect the excavation and safety of workers.
- C. Protect excavations with barricades as required by applicable safety regulations.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16134

BOXES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Device boxes.
 - 2. Raceway system boxes.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
 - 1. A47 - Standard Specification for Ferritic Malleable Iron Castings.
 - 2. D149 - Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
 - 3. D495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
 - 4. D570 - Standard Test Method for Water Absorption of Plastics.
 - 5. D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
 - 6. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - 7. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
- C. Joint Industry Conference (JIC).
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
 - 1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
 - 2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 SYSTEM DESCRIPTION

- A. Provide outlet boxes for devices such as switches, receptacles, telephone and computer jacks, security systems, junction, and pullboxes for use in the raceway systems, etc.
- B. Provide boxes as indicated on the Drawings or as needed to complete the raceway installation.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Manufacturer.
 - 2. Materials.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - e. NEMA rating.
 - 4. Conduit entry locations.
 - 5. Catalog cut sheets.
 - 6. Installation instructions.
- C. Shop drawings:
 - 1. Include identification and sizes of pullboxes.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Regulatory requirements:
 - 1. Outlet boxes shall comply with all applicable standards of:
 - a. JIC.
 - b. NEC.
 - c. NEMA.
 - d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Plastic coated boxes:
 - a. Rob Roy.
 - b. OCAL.
 - 2. Cast device boxes:
 - a. Appleton.
 - b. Crouse - Hinds.
 - c. OZ/Gedney.
 - 3. Formed steel enclosures:
 - a. Hoffman.
 - b. Thomas and Betts.
 - c. Stahlin.
 - d. Rittal.
 - 4. Stainless steel enclosures:
 - a. Hoffman.
 - b. Stahlin.
 - c. Rittal.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Cast device boxes:
 - 1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.
 - d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Tapered threaded hubs with integral bushing.
 - 2. Aluminum (copper free) boxes:
 - a. High strength copper free 4/10 of 1 percent maximum alloy for use with aluminum rigid conduit.

3. Malleable iron boxes:
 - a. Conforming to ASTM A47 Grade 32510.
- B. Plastic coated cast device boxes:
 1. Construction:
 - a. With internal green ground screw.
 - b. Furnished with a suitable gasketed cover.
 - c. With integral cast mounting lugs when surface mounted.
 - d. Conduit sizes range from 3/4 inch to 1 inch.
 - e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
 - f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
 - g. With pressure sealing sleeve to protect the connection with conduit.
- C. Class I Division 1 areas:
 1. Provide boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
 - a. The approval ratings must be permanently marked on each item.
- D. Class I, Division 2 areas:
 1. For boxes not containing arcing parts:
 - a. As specified in Section 16050 - Common Work Results for Electrical.
 - b. Pressed metal boxes are not allowed.
 2. For boxes containing arching parts provide:
 - a. Boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
 - 1) The approval ratings must be permanently marked on each item.
 3. Cast iron box and cover.
 4. Precision machined flame path between box and cover with neoprene O-ring.
 5. Cast-in-place mounting feet for horizontal or vertical mounting.
 6. For applications requiring hinged cover, provide flexible hinge mounting either left or right side.
 7. External flange.
 8. Provisions for mounting pan.
 9. Ground lug.

Physical Property	Value	ASTM Method
Flexural strength	12,000 psi	D790
Heat distortion	400° Fahrenheit	D648
Water absorption (24 hrs)	0.5 percent	D570
Tensile strength	5000 psi	D651
Specific gravity	1.8	D792
Flammability	94V-0	UL94
Dielectric strength	4000 V.P.M.	D149
Arc resistance	180 second	D495

- E. Formed steel enclosures:
 1. Steel:
 - a. NEMA Type 12.

- b. Fabricated from 14-gauge steel, minimum.
 - c. All seams continuously welded ground smooth.
 - d. Door:
 - 1) Rolled lip around 3 sides.
 - 2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
 - e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
 - 1) Attached with an adhesive.
 - 2) Retained by a retaining strip.
 - f. Fabricate all external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
 - 1) With a hasp and staple for padlocking.
 - g. Provide large enclosures with door and body stiffeners for extra rigidity.
 - h. No holes or knockouts.
 - i. Finish:
 - 1) ANSI-61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
 - 2) White electrostatically applied polyester powder mounting plate.
 - j. Heavy gauge steel external mounting brackets when surface mounted.
2. Stainless steel:
- a. NEMA Type 4X:
 - 1) Boxes in locations subject to flooding or temporary submersion:
 - a) NEMA Type 6.
 - b. Fabricated from 14-gauge Type 316 stainless steel.
 - c. All seams continuously welded.
 - d. Door:
 - 1) Rolled lip around 3 sides.
 - 2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
 - e. Neoprene door gasket to provide a watertight seal:
 - 1) Attached with an adhesive.
 - 2) Retained by a retaining strip.
 - f. Fabricate all external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
 - 1) With a hasp and staple for padlocking.
 - g. Provide large enclosures with door and body stiffeners for extra rigidity.
 - h. No holes or knockouts.
 - i. Finish:
 - 1) Brushed.
 - j. Stainless steel external mounting brackets when surface mounted.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Fasteners:
 - 1. Electroplated or stainless steel in boxes with wiring devices.
 - 2. Screws, nuts, bolts, and other threaded fasteners:
 - a. Stainless steel.

- B. Provide breather and drain fittings where appropriate.
- C. Internal panels:
 - 1. Provide internal panels where required for mounting of terminal strips or other equipment.
 - 2. With plated steel shoulder studs.
 - 3. Steel with white polyester powder finish.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. General:
 - 1. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050 - Common Work Results for Electrical.
 - 2. Provide outlet box materials to match the conduit system:
 - a. GRC - Cast ferrous boxes.
 - b. PCS - PVC coated cast ferrous boxes.
 - c. PVC - PVC boxes.
 - 3. Solid type gang boxes:
 - a. For more than 2 devices.
 - b. For barriered outlets.
 - 4. Support all wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
 - a. Use machined spacers to maintain air space; built-up washers are not acceptable.
 - b. Use stainless steel or nylon materials for spacers.
 - 5. Use cast malleable iron boxes when box must support other devices.
 - 6. Boxes serving luminaires or devices:
 - a. Use as pullboxes wherever possible.
 - 7. Fit all cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
 - 8. In terminal boxes, furnish terminals as indicated on the Drawings, with a minimum of 25 percent spare terminals:
 - a. Furnish wireways for discrete and analog/DC wiring.
 - b. Separate analog wiring from 120 V discrete or power wiring.

9. Size boxes in accordance with NEC requirements and to provide sufficient room for the future components and cables indicated on the Drawings.
10. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

C. Outlet boxes:

1. Locate outlet boxes as indicated on the Drawings:
 - a. Adjust locations so as not to conflict with structural requirements or other trades.
2. Use deep threaded-hub malleable iron or aluminum boxes:
 - a. In hazardous areas.
 - b. Where exposed to the weather.
 - c. In unheated areas.
 - d. Where subject to mechanical damage:
 - 1) Defined as exposed boxes less than 10 feet above the floor.
 - e. To act as a pullbox for conductors in a conduit system.
 - f. Accommodate wiring devices.
3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the conduit system is PVC coated steel.
4. Outlet boxes may be used as junction boxes wherever possible.

D. Pullboxes and junction boxes:

1. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits and cables as indicated on the Drawings.
2. Install pullboxes such that access to them is not restricted.

E. For boxes not indicated:

1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050 - Common Work Results for Electrical.
2. Outlet, switch, and junction boxes for flush-mounting in general purpose locations:
 - a. One-piece, galvanized, pressed steel.
3. Ceiling boxes for flush mounting in concrete:
 - a. Deep, galvanized, pressed steel.
4. Outlet, switch, and junction boxes where surface mounted in exposed locations:
 - a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
5. Outlet, control station, and junction boxes for installation in corrosive locations:
 - a. Fiberglass reinforced polyester, stainless steel, or plastic coated steel to match the conduit system.
 - b. Furnished with mounting lugs.
6. Fire rated construction: Use materials and methods to comply with the listing requirements for the classified construction.

F. Hazardous locations:

1. All metallic boxes, fittings, and joints shall utilize threaded connections to the conduit system.
2. All threaded connections shall be wrench tightened so that at least 5 threads are fully engaged.
3. Conduits entering and exiting metallic boxes in Class I Division 2 areas shall utilize approved grounding bushings to bond the conduits together.

4. Provide the following types of conduit bodies and boxes:
 - a. Malleable iron bodies and boxes with GRC or IMC conduit systems.
 - b. PVC coated conduit bodies and boxes with PCS conduit systems.
 - c. Aluminum conduit bodies and boxes with ARC conduit systems.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16136

WIREWAY

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Wireway systems as indicated on the Drawings.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. ICS-6 - Industrial Control and Systems: Enclosures.
- C. Underwriter's Laboratories (UL):
 - 1. Article 870 - Wireways, Auxiliary Gutters, and Associated Fittings.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. System includes horizontal and/or vertical straight runs of wireway, fittings, covers, splices, barriers, and related accessory and supports:
 - 1. Connected to form a complete system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Technical information:
 - a. Catalog cut sheets.
 - b. Wireway construction and materials.
 - c. Maximum loading and span.
 - d. NEMA enclosure type.
 - 2. Dimensions:
 - a. Width.
 - b. Depth.
 - 3. Weight of wireway sections and fittings.
 - 4. Complete bill of materials.
 - 5. Manufacturer's installation instructions.

- C. Shop drawings:
 - 1. Provide complete details and scaled drawings for the layout of the installed wireway system showing all components and proposed mounting details.
- D. Calculations:
 - 1. Provide cross sectional area and fill calculations.
 - a. Cross sectional area and fill shall be in accordance with the NEC.
 - 2. Provide structural calculations to ensure that the installed system meets all structural, seismic as specified in Section 16050 - Common Work Results for Electrical, wind as specified in Section 16050 - Common Work Results for Electrical requirements at the Project Site with respect to support and mounting:
 - a. Stamped by a professional engineer licensed in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Manufacturer qualifications:
 - 1. Member of NEMA for the manufacturer of wireway systems and fittings of types and capacities required.
- C. Wireway shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. The Drawings indicate the general route of the wireway systems. Data presented on those drawings are as accurate as preliminary surveys and planning can determine until final equipment selection is made.
- B. Specifications and Drawings are for assistance and guidance but exact routing, locations, distances, and levels will be governed by actual field conditions. Make field surveys as part of the work before ordering material.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Metallic wireway:
 - 1. One of the following or equal:
 - a. B-Line.
 - b. Hoffman.
 - c. Hammond.
 - d. Rittal Electromate.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. Provide wireways as indicated on the Drawings with respect to:
 - 1. Type (lay-in or feed-through or trough).
 - 2. Dimensions.
 - 3. NEMA enclosure rating.
 - 4. Wireway material.

2.06 COMPONENTS

- A. Fittings:
 - 1. Elbows, tees, and crossings:
 - a. Of the same materials and construction as the straight runs.
 - 2. Expansion fittings:
 - a. Provide flexible or sliding fittings.
- B. Covers:
 - 1. Hinged on one side.
 - 2. Held closed with latches or bolts.
- C. Gaskets:
 - 1. As required to meet NEMA enclosure requirements:
 - a. Provide gaskets at each flange and door opening to ensure complete seal between wireway components.
 - b. Held in place with adhesive or formed in place.

2.07 ACCESSORIES

- A. Barriers:
 - 1. To separate power, control and instrument wiring running within the same wireway as indicated on the Drawings.

2. Provide manufacturer's standard metallic barrier with metallic wireway and manufacturer's standard non-metallic barrier with non-metallic wireway.
- B. Mounting hardware:
1. As specified in Section 16050 - Common Work Results for Electrical.

2.08 MIXES (NOT USED)

2.09 FABRICATIONS (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Manufactured in accordance with NEMA ICS-6.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify all dimensions and route before ordering wireway:
1. Make all necessary field measurements.
 2. Coordinate with all subcontractors and suppliers to determine structural dimensions and equipment dimensions to avoid all potential conflicts with other systems.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the wireway per the manufacturer's guidelines and submitted installation instructions to meet the seismic and wind requirements at the project site.
- C. General:
1. Install in straight runs as much as possible, minimizing the number of turns.
 2. Expansion fittings:
 - a. Install as recommended by the manufacturer to accommodate thermal expansion.
 - b. Install where wireway crosses structural expansion joints.
 3. Fittings:
 - a. Not all fittings are indicated on the Drawings:
 - 1) Provide all fittings required to suit the installation.
 4. Wireway supports:
 - a. Support wireway in accordance with manufacturer's instructions and as required by the seismic conditions.
 - b. Support bracket spacing shall meet the requirements of the wireway manufacturer, and NEC.
 - c. Provide wireway supports with channels under the entire width of wireway.
 - d. Secure wireway to supports with manufacturer-approved fittings.

5. Mounting:
 - a. Oriented to allow hinged doors to be opened minimum 90 degrees.
 - b. Oriented to allow safe access to doors for maintenance and future installations.
6. Wiring installation:
 - a. In accordance the NEC.
 - b. Begin wiring installation only after the complete raceway system is installed.
 - c. Verify that all wireway surfaces and accessories are smooth, free from burrs or sharp edges.
 - d. Only install wiring that is UL listed for wireway use.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 PRE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Inspect entire wireway system for the following:
 1. Secure anchoring.
 2. Proper supports.
 3. Burrs or sharp edges.
 4. Sufficient clearance from ducts and piping, especially hot pipes.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Switches.
 - 2. Receptacles.
 - 3. Plates.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Federal Specifications (FS):
 - 1. W-C 596 - Connector, Electrical, Power, General Specification for.
 - 2. W-S 896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
- C. National Electrical Manufacturers Association (NEMA):
 - 1. WD1 - General Color Requirements for Wiring Devices.
 - 2. ICS 5 - Industrial Control and Systems, Control Circuit and Pilot Devices.
 - 3. OS1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
 - 4. WD6 - Wiring Devices Dimensional Specifications.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 20 - General Use Snap Switches.
 - 2. 498 - Standard for Attachment Plugs and Receptacles.
 - 3. 514D - Cover Plates for Flush-Mounted Wiring Devices.
 - 4. 943 - Ground-Fault Circuit-Interrupters.
 - 5. 1472 - Solid State Dimming Controls.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
 - 1. GFCI: Ground fault circuit interrupter.

1.04 SYSTEM DESCRIPTION

- A. Switches, receptacles, and plates as indicated on the Drawings wired and operable to form a complete system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

- B. Product data:
 - 1. Catalog cut sheets.
- C. Shop drawings:
 - 1. Engraving schedule:
 - a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Switches:
 - 1. One of the following or equal:
 - a. Hubbell.
 - b. Leviton.
 - c. Cooper Wiring Devices.
 - 2. Switches for hazardous areas:
 - a. One of the following or equal:
 - 1) Appleton.
 - 2) Crouse-Hinds.

- B. Receptacles:
 - 1. General purpose receptacles:
 - a. One of the following or equal:
 - 1) Hubbell.
 - 2) Leviton.
 - 3) Cooper Wiring Devices.
 - 2. Receptacles for hazardous areas:
 - a. One of the following or equal:
 - 1) Crouse-Hinds.
 - 2) Appleton.

- C. Plates:
 - 1. General location:
 - a. One of the following or equal:
 - 1) Pass and Seymour.
 - 2) Cooper Wiring Devices.
 - 2. Wet or corrosive areas:
 - a. One of the following or equal:
 - 1) Hubbell.
 - 2) Cooper Wiring Devices.
 - 3) Thomas and Betts.
 - 4) Pass and Seymour.
 - 3. In-use covers:
 - a. One of the following or equal:
 - 1) TayMac.
 - 2) Cooper Wiring Devices.
 - 3) Pass and Seymour.
 - 4) Thomas and Betts.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Switches:
 - 1. General:
 - a. 120-277 VAC.
 - b. 20 ampere.
 - c. Listed in accordance with UL 20.
 - d. Designed and constructed in accordance with FS W-S-896/2.
 - e. Back and side wired unless otherwise indicated.
 - f. Integral grounding terminal.
 - g. Totally enclosed:
 - 1) Color-coded body with color corresponding to ampere rating.
 - h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
 - i. Color:
 - 1) Ivory in finished areas.
 - 2) Brown in all other areas.
 - 2. General purpose switches:
 - a. Toggle type.

3. Switches for use with photocell:
 - a. Maintained contact.
 - b. 2 circuit.
 - c. 3 position:
 - 1) Center off.
 4. Switches for hazardous areas:
 - a. Suitable for use in Class I Division 1 and Class I Division 2 locations.
 - b. Factory sealed.
 - c. Through-feed or dead-end as required.
- B. Receptacles:
1. General purpose receptacles:
 - a. Single or duplex as indicated on the Drawings.
 - b. 125 VAC.
 - c. 20 ampere or as indicated on the Drawings.
 - d. NEMA Type 5-20R configuration for 20 ampere receptacles.
 - e. Other NEMA configurations as indicated on the Drawings.
 - f. Listed in accordance with UL 498.
 - g. Designed and constructed in accordance with FS W-C-596.
 - h. Back and side wired.
 - i. 1-piece, rivet-less mounting strap.
 - j. Color:
 - 1) Ivory in finished areas.
 - 2) Brown in all other areas.
 - 3) Orange when powered by a UPS.
 2. Ground fault interrupter receptacles (GFCI):
 - a. 125 VAC.
 - b. 20 ampere.
 - c. Trip level 4-6 milliamperes.
 - d. Individual and feed through protection.
 - e. UL 943 and UL 498 listed.
 - f. NEMA Type 5-20R configuration.
 - g. For damp or wet locations:
 - 1) Weather resistant, in accordance with UL 498.
 3. Receptacles for hazardous areas:
 - a. 125 VAC.
 - b. 20 ampere.
 - c. Factory sealed.
 - d. Single receptacle.
 - e. 2-wire, 3-pole.
 - f. Grounded through extra pole and shell.
 - g. Dead-front construction.
 - h. Interlocked to prevent plug from being withdrawn until circuit has been broken.
- C. Plates:
1. General location:
 - a. Type 302 or 304 stainless steel.
 - b. Brushed satin finish.
 - c. Minimum thickness: 0.032 inches.
 - d. Rectangular or square shape.

- e. Engraving:
 - 1) Engrave each switch plate with the following:
 - a) Area served.
 - b) Panelboard and Circuit.
 - 2) Engrave each receptacle plate with the following:
 - a) Panelboard and Circuit.
 - 3) Treat engraving to improve visibility.
 - 4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
 - f. Coordinate the number of gangs, number, and type of openings with the specific location.
- 2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
 - a. General:
 - 1) UL listed for wet locations.
 - 2) Gasketed.
 - 3) Die cast metal:
 - a) Match material to box material.
 - b. Switches:
 - 1) Lever operated:
 - a) Provide toggle switch.
 - c. Receptacles:
 - 1) Weather proof in-use cover:
 - a) Die cast metal construction with electrostatic powder coating for corrosion resistance.
 - b) Gasketed.
 - c) Lockable.
 - d) UL listed and in accordance with NEC.
 - 3. Corrosive areas:
 - a. Neoprene.
 - b. Gasketed.
 - c. Weatherproof.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Mounting heights:
 - 1. Process and production areas:
 - a. Switches and receptacles 48 inches from finished floor to top of plate.
 - 2. Offices and finished areas:
 - a. Switches: 48 inches from finished floor to top of plate.
 - b. Receptacles: 18 inches from finished floor to center of plate.
- C. Receptacles:
 - 1. Provide GFCI receptacles as indicated on the Drawings.
 - a. Provide weather resistant GFCI receptacles in all wet or damp areas.
 - 1) As specified in Section 16050 - Common Work Results for Electrical.
 - 2. Mount non-weatherproof receptacles vertically:
 - a. Ground slot down.
 - 3. Mount weatherproof receptacles horizontally:
 - a. Neutral slot up.
 - 4. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.
- D. Ensure all plates make a firm seal with wall for recessed mounted devices:
 - 1. Outside edges of plates parallel with building lines.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16150

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Wire connecting devices.
 - 2. Terminations.
 - 3. Splices.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. ASTM International (ASTM):
 - 1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- C. CSA International (CSA):
 - 1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Installation instructions.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. Control connections:

1. Use insulated ring type wire terminators for connections to all screw terminals:
 - a. With chamfered/funneled terminal barrel entry.
 - b. Deep internal serrations.
 - c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
 - d. Electroplated-tin copper conductor.
 - e. Manufacturers: The following or equal:
 - 1) Thomas and Betts, Stakon.
2. For process equipment connections work from manufacturer's drawings.

B. Joints, splices, taps, and connections:

1. 600-volt conductors:
 - a. Use solderless connectors.
 - b. Use only plated copper alloy connectors or lugs:
 - 1) Aluminum connectors or lugs are not acceptable for copper conductors.
 - c. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.
 - d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
 - 1) Manufacturers: The following or equal:
 - a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.
 - e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
 - 1) Manufacturers: One of the following or equal:
 - a) Burndy.
 - b) Thomas and Betts.
 - f. Heat shrink tubing:
 - 1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
 - 2) Minimum shrink ratio: 4 to 1.
 - 3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
 - 4) Internally applied adhesive sealant.
 - 5) Cross-linked polyolefin:
 - a) Manufacturers: One of the following or equal:
 - (1) 3M, ITCSN.
 - (2) Thomas & Betts, Shrink-Kon.
2. Instrumentation class cable splices:
 - a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
 - b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
 - c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
 - d. Two-part mold body with tongue and groove seams and built in spacer webbing.
 - e. Manufacturers: The following or equal:
 - 1) 3M, Scotchcast 72-N.

C. Insulating tape:

1. General purpose insulating tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
 - c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
 - d. Flame retardant, hot- and cold- weather resistant, UV resistant.
 - e. For use as a primary insulation for wire cable splices up to 600 VAC.
 - f. Meeting and complying with:
 - 1) ASTM D3005 Type I.
 - 2) UL 510.
 - 3) CSA C22.2.

- g. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number Super 33+.
- 2. General-purpose color-coding tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application on PVC and polyethylene jacketed cables.
 - c. For use indoors and outdoors in weather protected enclosures.
 - d. Available with the following colors:
 - 1) Red.
 - 2) Yellow.
 - 3) Blue.
 - 4) Brown.
 - 5) Gray.
 - 6) White.
 - 7) Green.
 - 8) Orange.
 - 9) Violet.
 - e. For use as phase identification, marking, insulating, and harnessing.
 - f. Meeting and complying with:
 - 1) UL 510.
 - 2) CSA C22.2.
 - g. Manufacturers: The following or equal:
 - 1) 3M, Scotch Number 35.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Load connections:
 - 1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.
- C. Zero to 600-volt systems:
 - 1. Make all connections with the proper tool and die as specified by the device manufacturer.

2. Use only tooling and dies manufactured by the device manufacturer.
 3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
 4. Number all power and control wires before termination.
- D. Motor connections (600 volts and below):
1. Terminate all leads and wires with compression type ring lugs.
 2. Terminations on all motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
 3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
 - a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
 - b. Shrink cap with low heat as recommended by manufacturer.
 4. Wire markers shall be readable after boot installation.
 5. Manufacturers: The following or equal:
 - a. Raychem, MCK.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16222

LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage motors up to 500 horsepower (hp).

1.02 REFERENCES

- A. American Bearing Manufacturers Association (ABMA):
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- B. American Petroleum Institute (API):
 - 1. 670 - Vibration, Axial Position, and Bearing Temperature Monitoring Systems.
- C. ASTM International (ASTM).
 - 1. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
- D. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - 2. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
 - 3. 841 - IEEE Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
- E. 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.
- F. Underwriters Laboratories Inc. (UL):
 - 1. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS (NOT USED)

1.04 SYSTEM DESCRIPTION

- A. Furnish electric motors and accessories as specified in this Section and the Sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

- A. Submit completed motor data sheets for each motor supplied:
 - 1. Conform to data sheet in the appendix of this Section.
 - 2. Manufacturer's or other data sheets are not acceptable.
- B. Product data:
 - 1. Descriptive bulletins.
 - 2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.
 - 3. Complete electrical data.
 - 4. Torque, current, and power factor versus speed curves:
 - a. At 100 percent rated voltage for all full voltage started and VFD-driven motors.
 - 5. Additional data for motors installed in classified areas:
 - a. Temperature code.
 - b. Hazardous area approval indicating Class, Division, and Group:
 - 1) For motors driven by variable frequency drives, provide manufacturer's certification that the motor is suitable for operation in the hazardous area when driven by a variable frequency drive.
 - 6. Accessories data:
 - a. Motor winding heaters:
 - 1) Voltage.
 - 2) Watts.
 - b. Winding temperature detectors:
 - 1) Type.
 - 2) Rating.
 - c. Moisture detectors.
 - 7. Mechanical data:
 - a. Bearing design and bearing life calculations.
 - b. Resonant frequencies for all VFD-driven motors 50 hp or greater.
- C. Shop drawings:
 - 1. Motor weight.
 - 2. Frame size.
 - 3. Conduit box(es), size(s), and location(s).
 - 4. Outline drawings with dimensions.
 - 5. Installation details for the project seismic criteria.
- D. Test reports:
 - 1. Factory test reports with test reference standard identified.
- E. Certification:
 - 1. When motors are driven by variable speed drive systems, submit certification that selected motor:
 - a. Is capable of satisfactory performance under the intended load.
 - b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.
- F. Calculations:
 - 1. Where site conditions exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Motors 200 hp and larger:
 - 1. Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTION (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. US Motors.
 - 2. General Electric.
 - 3. Reliance.
 - 4. Toshiba.
 - 5. Baldor.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. 3-phase induction motors - general:
 - 1. Voltage:
 - a. All motors 1/2 hp and larger shall be rated 460 V, 3-phase unless otherwise indicated on the Drawings.
 - b. Dual voltage motors rated 230/460 V, 3-phase are acceptable provided all leads are brought to the conduit box.
 - 2. Motors driving identical machines shall be identical.
 - 3. All motors greater than 1 hp and up to 500 hp shall meet the "NEMA Premium Efficiency" percent listed in NEMA MG-1.

4. Horsepower as indicated on the Drawings:
 - a. Horsepower ratings indicated on the Drawings are based on vendor's estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
5. Service factor:
 - a. 1.15 service factor on sine wave power.
 - b. 1.0 when driven by VFD.
6. Torque:
 - a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
 - b. When started using reduced voltage starters:
 - 1) Provide motors that develop sufficient torque for acceleration to full speed.
 - c. NEMA Design B except where driven load characteristics require other than normal starting torque:
 - 1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
7. Enclosures:
 - a. As specified in the individual equipment Specifications or in this Section.
 - b. Totally enclosed fan cooled:
 - 1) Cast iron conduit box.
 - 2) Tapped drain holes with Type 316 stainless steel plugs for frames 286 and smaller, and automatic breather and drain devices for frames 324 and larger.
 - c. Explosion-proof:
 - 1) Tapped drain holes with corrosion resistant plugs for frames 286 and smaller and automatic breather and drain devices for frames 324 and larger.
 - d. Lifting devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.
8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer's standard material for the specified rating.
9. Nameplates:
 - a. Provide all motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
 - 1) NEMA standard motor data.
 - a) Indicate compliance with NEMA MG-1 Part 31 for inverter duty motors.
 - 2) AFBMA bearing numbers and lubrication instructions.
10. Hardware:
 - a. Type 316 stainless steel.
11. Conduit boxes:
 - a. Cast iron or stamped steel.
 - b. Split from top to bottom.
 - c. Provide gaskets at the following interfaces:
 - 1) Frames and conduit boxes.
 - 2) Conduit boxes and box covers.
 - d. Rotatable through 360 degrees in 90-degree increments.
 - 1) Where available based on the size of the conduit box.
 - e. Exceeding the dimensions defined in NEMA MG-1.
 - f. Provide grounding lugs inside conduit boxes for motor frame grounding.

12. Motor bearings:
 - a. Antifriction.
 - b. Regreasable and initially filled with grease for horizontal motors and vertical motors per manufacturer's standard design.
 - c. Bearings and lubrication suitable for ambient temperature and temperature rise.
 - d. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.
 - e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
 - f. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.
13. Insulation systems:
 - a. Motors installed in ambient temperatures 40 degrees Celsius or less:
 - 1) Provide Class F insulation.
 - 2) Design temperature rise consistent with Class B insulation.
 - 3) Rated to operate at an ambient temperature of 40 degrees Celsius at the altitude where the motor will be installed.
 - b. Motors installed in ambient temperatures between 40 degrees Celsius.
14. Motor leads:
 - a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
15. Noise:
 - a. Maximum operating noise level in accordance with NEMA MG-1.

B. Motors installed in hazardous locations:

1. Class I, Division 1 or Class II, Division 1 areas:
 - a. Enclosures:
 - 1) Explosion proof for 3-phase motors.
 - 2) UL listed in conformance with UL-674.
 - 3) UL approval with nameplate and serial number.
2. Other hazardous areas:
 - a. Enclosures:
 - 1) TEFC for motors in Class I, Division 2 areas.
 - 2) Vertical motors as specified in this Section.
 - 3) Hazardous area and temperature code approval stamped on nameplate.

C. Motors installed in corrosive environments:

1. Nameplate indicating conformance to IEEE 841.
2. Stator double dipped in varnish and baked.
3. Stator and rotor coated with corrosion resistant epoxy.
4. Frame, brackets, fan guard and conduit box coated with minimum of 2 coats of epoxy paint.
5. Withstand salt spray tests in accordance with ASTM B117.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Motor winding heaters:
 - 1. Provide all 3-phase motors with belted or cartridge space heaters mounted within the motor enclosure.
 - 2. Space heater rating shall be 120 volts, single-phase, unless otherwise indicated on the Drawings.
 - 3. Power leads for heaters wired into conduit box.
 - 4. Installed within motor enclosure adjacent to core iron.
- B. Winding temperature detectors:
 - 1. Temperature switches with normally closed contacts as indicated on the Drawings.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install motors in accordance with manufacturer's instructions.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING AND PROCESS START-UP

- A. As specified in Section 01756 - Commissioning.
- B. Factory testing:
 - 1. Motors less than 250 hp:
 - a. Perform manufacturer's standard production tests including but not limited to:
 - 1) No load current.
 - 2) High potential test.
 - 3) Winding resistance.
 - b. Furnish copies of standard test reports on prototype or identical units.

3.08 FIELD QUALITY CONTROL

- A. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
 - 1. Windings energized to 1,000 volts DC for 1 minute.
 - 2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.
 - 3. Inform the Engineer of any unusual or unacceptable test results.
 - 4. This test is in addition to the acceptance tests in Section 16950 - Field Electrical Acceptance Tests.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

END OF SECTION

MOTOR DATA SHEET

MOTOR/ EQUIPMENT TAG _____ MOTOR NUMBER _____
SPECIFICATION NUMBER OF DRIVEN MACHINE _____

MOTOR NAMEPLATE DATA

MANUFACTURER _____ MODEL/SERIES _____ MODEL NO. _____
FRAME _____ ENCLOSURE _____ NEMA DESIGN _____
HP _____ SERVICE FACTOR _____ RPM _____
INSULATION CLASS _____ VOLTS _____ FULL LOAD AMPS _____
AMBIENT TEMP _____ PHASE _____ NO LOAD AMPS _____
DESIGN TEMP _____ HERTZ _____ LOCK ROTOR AMPS _____
INRUSH CODE LETTER _____

	100% LOAD	75% LOAD	50% LOAD
GUARANTEED MINIMUM EFFICIENCIES:	_____	_____	_____
GUARANTEED MINIMUM POWER FACTOR:	_____	_____	_____
MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR:	_____ KVAR		

ACCESSORIES

MOTOR WINDING HEATER _____ VOLTS _____ WATTS
WINDING THERMAL PROTECTION _____
WINDING TEMP SWITCHES (YES/NO) _____
RTD:
TYPE _____ QUANTITY PER PHASE _____ # OF WIRES _____
NOMINAL RESISTANCE _____ NOMINAL TEMP _____ COEFFICIENT _____
RECOMMENDED DEGREES RECOMMENDED DEGREES
ALARM _____ CELSIUS TRIP _____ CELSIUS

SPECIAL APPLICATIONS

INVERTER DUTY* (YES/NO) _____ PART WINDING (YES/NO) _____ WYE - DELTA (YES/NO) _____
2 SPEED, 1 WINDING (YES/NO) _____ 2 SPEED, 2 WINDING (YES/NO) _____
AREA CLASSIFICATION:
CLASS _____ DIVISION _____ GROUP _____ TEMP CODE _____

* Conforms to NEMA MG-1 Part 31.

SECTION 16262

VARIABLE FREQUENCY DRIVES 0.50 - 50 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Variable frequency drives (VFD) 0.5 to 50 horsepower for control of NEMA Design B squirrel cage induction motors.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. International Organization for Standardization (ISO):
 - 1. 9001 - Quality Management Systems - Requirements.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. MGI, Part 31 - Motors with higher peak voltage capability.
- D. Underwriters' Laboratories (UL):
 - 1. 508A - Standard for Safety for Industrial Control Panels.
 - 2. 508C - Standard for Power Conversion Equipment.
 - 3. 845 - Standard for Motor Control Centers.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
 - 1. Point of common coupling: the point of common coupling for all harmonic calculation and field measurements for both voltage and current distortions is defined as the closest directly connected bus supplying power to the VFD.

1.04 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Each VFD system consists of all components required to meet the performance, protection, safety, testing, and certification criteria of this Section.
 - 2. The VFD system:
 - a. Is a fully integrated package.
 - b. Includes all material necessary to interconnect all VFD system elements, even if shipped separately.
 - 3. Coordinate bearing protection methods with the supplier of the driven equipment.

- B. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer:
1. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete system by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
 2. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics based upon the installed conditions:
 - a. Provide equipment necessary to mitigate potential damage to motor insulation.
 - b. Motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

C. Performance:

1. Operating envelope:
 - a. Speed and torque requirements:
 - 1) Provide a variable torque or constant torque VFD as required by the driven load.
 - 2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 200 percent (25 to 120 hertz) speed range.
 - b. Current requirements:
 - 1) Full rated current output on a continuous basis.
 - 2) Variable torque VFD:
 - a) Minimum 110 percent current overload for 1 minute.
 - 3) Constant torque VFD:
 - a) Minimum 150 percent current overload for 1 minute.
2. Minimum VFD system efficiency:
 - a. 96 percent when operating at the rated kW output.
 - b. VFD system efficiency shall be calculated as follows:

$$\text{Efficiency (\%)} = \frac{\text{Power (Load)}}{\text{Power (Supply)}} \times 100$$

Power (Load) is the total power measured at the output terminals of the drive system, including VFD, output filters, or transformers. Power (Supply) is the total power measured at the input terminals of the VFD including input filters, line reactors, isolation transformers, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.

3. Total power factor:
 - a. Minimum of 0.96 lagging across the entire speed range.
 - b. At no speed shall the VFD have a leading power factor.
4. Frequency accuracy:
 - a. Minimum of within 0.01 percent.
5. Speed regulation:
 - a. Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical:
 - 1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.
- B. Product data:
 - 1. Manufacturer of the VFD.
 - 2. Manufacturer of all components of the VFD.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - 4. Nameplate schedule.
 - 5. Bill of material.
 - 6. Ratings:
 - a. Voltage.
 - b. Phase.
 - c. Input current.
 - d. Output current.
 - e. Interrupting rating.
 - f. Momentary current rating.
 - 7. List of recommended spare parts.
 - 8. Catalog cut sheets for major components.
 - 9. Design data:
 - a. Efficiency and power factor values.
 - b. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude and ambient temperature.
 - c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
 - d. Certification that all electronic circuits and printed circuit boards are conformally coated.
 - 10. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
 - 1. Complete plan and elevation drawings showing:
 - a. All dimensions.
 - b. Panel, sub-panel, and component layout indexed to the bill of material.
 - c. Conduit connections.
 - 2. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.

3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
 - a. Include terminal number and wire numbers.
 4. Complete single-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
 - a. Clearly indicate device electrical ratings on the drawings.
- D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- E. Operation and maintenance manuals:
1. Spare parts list with supplier names and part numbers.
 2. Startup and commissioning instructions and data.
 3. Operating manuals:
 - a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
 4. Operating instructions:
 - a. Written descriptions detailing the operational functions of all controls on the front panel.
 5. Maintenance manual:
 - a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.
 - b. Manuals shall include, but are not limited to the following:
 - 1) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
 - 2) Detailed control instructions which outline the purpose and operation of every control device used in normal operation.
 - 3) All schematic wiring and external diagrams:
 - a) Furnish drawings in a reduced 11-inch by 17-inch format that are fully legible at that size.
- F. Test forms and reports.
1. Submit complete factory acceptance test procedures and all forms used during the test.

- G. Manufacturer's Certificate of Installation and Functionality Compliance.
- H. Manufacturer's field reports:
 - 1. Report listing the setting of all VFD adjustable parameters and their values after start-up.
- I. Record Documents:
 - 1. Certified Record Documents of equipment with information listed above.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Qualifications:
 - 1. Any third-party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
 - 2. VFDs shall be UL 508C listed and labeled:
 - a. UL 508C for individual units.
 - b. UL 508A for VFD systems in control panels.
 - c. UL 845 for VFD systems in motor control centers.
 - 3. Variable frequency drives shall be manufactured by the VFD manufacturer at its own facility which shall have a quality assurance program that is certified in conformance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Ship the VFDs and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on site offloading equipment:
 - 1. VFDs shall be delivered to the site preassembled and wired.
- C. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. Conduct factory acceptance test and submit certified test results for Engineer's review.
- B. Ship equipment to project site after successful completion of factory acceptance test.
- C. Assemble equipment in the field.
- D. Conduct field acceptance test and submit results for Engineer's review.
- E. Submit Manufacturers Certificate of Installation and Functionality Compliance.

- F. Conduct Owner's training sessions.
- G. Commissioning and process start-up as specified in Section 01756 - Commissioning.

1.10 SCHEDULING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. The VFD manufacturer shall be responsible for start-up of the VFDs in the presence of the equipment suppliers, Contractor, Engineer, and Owner.

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

- A. Spare parts:
 - 1. The following spare parts shall be furnished:
 - a. 1 complete VFD of each size furnished.
 - b. Any special dedicated tools for emergency service and troubleshooting.
 - c. All hardware and software required for configuration, maintenance, troubleshooting, and inquiry of all drive parameters.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. General Electric.
 - 2. Eaton.
 - 3. Allen-Bradley.
 - 4. Siemens-Robicon.
 - 5. Schneider Electric.
 - 6. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. General:
 - 1. Sinusoidal pulse width modulated (PWM) type drive.
 - a. 6-pulse insulated gate bipolar transistor (IGBT) power section.
 - b. Microprocessor based controls.
 - c. Line and load reactors.
- B. Ratings:
 - 1. Voltage:
 - a. Input voltage as indicated on the Drawings.
- C. Operational features:
 - 1. Protective features:
 - a. Provide the following minimum protective features:
 - 1) Motor overload protection.
 - 2) Instantaneous overcurrent.
 - 3) Instantaneous overvoltage.
 - 4) Undervoltage.
 - 5) Power unit overtemperature.
 - 6) Phase loss.
 - 7) VFD output short circuit.
 - 2. Control mode:
 - a. Operation in either a constant volts/hertz or sensorless vector mode:
 - 1) The control mode selectable using the programming keypad.
 - 3. Frequency control:
 - a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
 - b. Programmable minimum frequency.
 - c. Programmable maximum frequency.
 - 4. Acceleration/deceleration:
 - a. Separately adjustable acceleration and deceleration rates:
 - 1) Each rate adjustable from 0.01 to 1,800 seconds.
 - 5. Spinning load:
 - a. The VFD shall be capable of determining the speed and direction of a spinning load, "catch" the load and accelerate or decelerate it without damage to the load.
 - 6. Programmable loss of signal:
 - a. Upon loss of speed reference the VFD shall be programmable to either:
 - 1) Stop.
 - 2) Maintain current speed.
 - 3) Default to pre-selected speed.
 - 7. Power interrupt ride-through:
 - a. The VFD shall be capable of continuous operation in the event of a power loss of 5 cycles or less.
 - 8. Inputs/Outputs:
 - a. Manufacturer's standard number the following:
 - 1) Analog inputs:
 - a) Configurable as either 0 to 10 volts or 4 to 20 milliamperes.
 - 2) Analog outputs:
 - a) Programmable 4 to 20 milliamperes isolated.
 - 3) Discrete inputs:
 - a) Programmable.

- 4) Discrete outputs:
 - a) Programmable.
 - b) Form C relay contacts.
 - 5) Potentiometer 3-wire input.
 - b. Provide additional inputs/outputs as required to meet the control functions indicated on the Drawings.
- 9. Communications:
 - a. Provide each VFD with a Modbus TCP communications interface module.
 - b. Provide each VFD with an end-of-line termination resistor for the network specified above.
- 10. Diagnostics:
 - a. Store a minimum of 4 fault conditions in non-volatile memory on a first in-first out basis.
 - b. Operational parameters stored at the time of the fault:
 - 1) Operating frequency.
 - 2) Drive status.
 - 3) Power mode.
 - c. Fault memory accessible via RS-232, RS-422, or RS-485.
- 11. Automatic restart:
 - a. User selectable automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
 - 1) Programmable for up to 9 restart attempts.
 - 2) Adjustable time delay between restart attempts.

2.06 COMPONENTS

- A. Enclosure:
 - 1. Motor control center.
 - 2. Provide cooling devices required to maintain the VFD within the manufacturer's specified temperature limits for the Project conditions:
 - a. Provide cooling device failure alarm.
- B. Power disconnect:
 - 1. Flange-mounted motor circuit protector (MCP).
 - 2. Lockable in the OFF position.
- C. Input Reactor:
 - 1. 3 percent input line reactor.
- D. Output Device:
 - 1. 3 percent output load reactor.
- E. Keypad:
 - 1. Provide each VFD with a keypad for programming and control.
 - 2. Keypad requirements:
 - a. Password security to protect drive parameters.
 - b. Mounted on the door of the motor control center.
 - c. Back-lit LCD:
 - 1) Minimum of 2 lines with a minimum of 16 characters per line.
 - d. Programming and display features language: English.
 - e. Capable of displaying the following parameters:
 - 1) Speed (percent).

- 2) Output current (amperes).
 - 3) Output frequency (hertz).
 - 4) Input voltage.
 - 5) Output voltage.
 - 6) Total 3-phase kilowatt.
 - 7) Kilowatt-hour meter.
 - 8) Elapsed run time meter.
 - 9) Revolutions per minute.
 - 10) Direct current bus voltage.
 3. In addition to all keys required for programming, provide the following controls on the keypad:
 - a. Auto/manual selector.
 - b. Start pushbutton.
 - c. Stop pushbutton.
 - d. Jog pushbutton.
 - e. Speed increment.
 - f. Speed decrement.
 - g. Forward/reverse selector.
 - h. Run LED indicator.
 - i. Program LED indicator.
 - j. Fault LED indicator.
 4. Provide the VFD with the hardwired controls as indicated on the Drawings.
- F. Control power transformer:
1. Furnish a control power transformer mounted and wired inside the VFD enclosure.
 2. With primary and secondary fusing.
 3. Sized to power all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.

2.07 ACCESSORIES

- A. Metal oxide varistors:
1. Provide protection for the VFD against:
 - a. Line transients: 5,000 volt peak minimum.
 - b. Line to ground transients: 7,000 peak minimum.
- B. Conformal coating:
1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as a protection against moisture, dust, temperature extremes, and chemicals such as H₂S and chlorine.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Enclosure finish shall be manufacturer's standard gray.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
 - 1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories needed to complete the installation of the VFD (free-standing or within motor control center).
 - 2. Assemble and install the VFD in the locations and with the layouts indicated on the Drawings.
 - 3. Perform work in accordance with manufacturer's instructions and shop drawings.
 - 4. Furnish components and equipment as required to complete the installation.
 - 5. Replace any hardware lost or damaged during the installation or handling to provide a complete installation.
 - 6. Install free-standing enclosures on 3-1/2 inch raised concrete housekeeping pad:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - b. Weld and/or bolt the VFD frame to the leveling channels.
 - 7. Provide openings in top or bottom of the VFD (free-standing or within motor control center) enclosure for conduit only, no additional openings will be allowed:
 - a. Improperly cut holes will require that the entire panel be replaced:
 - 1) No hole closers or patches will be allowed.
 - 8. Bundle circuits together and terminate in each unit:
 - a. Tie with nylon wire ties.
 - b. Label all wires at each end with wire numbers shown on the approved control drawings.
 - c. All connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

- B. Source testing (Factory Acceptance Tests):
 - 1. Owner and Engineer will witness the Factory Acceptance Test as specified in Section 16050 - Common Work Results for Electrical.
 - 2. General:
 - a. Incoming inspection of components and raw materials based on strategic supplier base and experience.
 - b. All VFDs furnished under this Section shall be tested and inspected as specified below. Testing of VFDs based on sampling plans is not allowed.
 - c. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.
 - 3. Failure of any component during testing requires repair of the faulted component and complete retest.
 - 4. Tests:
 - a. Perform manufacturer's standard factory acceptance tests.
- C. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.
- D. Owner training:
 - 1. As specified in Sections 01756 - Commissioning and 16050 - Common Work Results for Electrical.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide the services of a VFD manufacturer representative for startup assistance and training:
 - 1. Inspection and field adjustment:
 - a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
 - 2. Startup field testing:
 - a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
 - b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.

3.09 ADJUSTING

- A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.
- B. Provide the services of a VFD manufacturer factory technician to make all drive parameters and protective device settings:
 - 1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
 - 2. Provide documentation of VFD settings included but not limited to:
 - a. Minimum speed.
 - b. Maximum speed.
 - c. Skip speeds.
 - d. Current limit.

- e. Acceleration time.
- f. Deceleration time.

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16272

DRY-TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Enclosed dry-type transformers:
 - a. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
 - b. Primary voltage 600 volts and below.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.
 - 2. C57.12.01 - IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings.
 - 3. C57.12.91 - IEEE Standard Test Code for Dry-Type Distribution and Power Transformers.
 - 4. C57.96 - IEEE Guide for Loading Dry-Type Distribution and Power Transformers.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- D. Underwriters Laboratory (UL):
 - 1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.
- E. U.S. Department of Energy (DOE):
 - 1. 10 CFR Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. NEMA:
 - 1. Type 2 enclosure in accordance with NEMA 250.
 - 2. Type 3R enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTIONS

- A. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as indicated on the Drawings:
 - 1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in Section 16050 - Common Work Results for Electrical after all derating factors have been applied.
 - 2. Suitable for continuous operation at full rating with normal life expectancy in accordance with IEEE C57.96.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Nameplate data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - 4. Inrush current.
 - 5. Insulation system and temperature constraints.
 - 6. Number and rating of taps.
 - 7. Sound levels.
 - 8. Connection diagrams:
 - a. Primary.
 - b. Secondary.
 - 9. BIL rating.
 - 10. Required clearances.
 - 11. Percent impedance.
 - 12. Efficiency.
 - 13. Certification of full capacity capability at the Project elevation and ambient conditions.
 - 14. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Installation instructions:
 - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 - 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.

3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 1. General Electric.
 2. Jefferson.
 3. Schneider Electric.
 4. Eaton.
 5. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Cores:
 - 1. Non-aging, grain-oriented silicon steel.
 - 2. Magnetic flux densities below the saturation point.
- B. Windings:
 - 1. High-grade magnet wire.
 - 2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
 - a. Cured to reduce hot-spots and seal out moisture.
 - 3. Material electrical grade:
 - a. Copper.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. General:
 - 1. 10 kilovolts BIL for 600-volt class windings.
 - 2. Sound levels, in accordance with IEEE 389 test conditions, not to exceed:

Kilovolt-Amperes Range	Audible Sound Level (db)
1-9	40
10-50	45
51-150	50
151-300	55
301-500	60
501-700	62
701-1000	64

- 3. Taps:
 - a. 15 kilovolt-amperes and less:
 - 1) Two 5 percent full capacity primary taps below rated voltage.
 - b. 25 kilovolt-amperes and larger:
 - 1) Four 2.5 percent full capacity primary taps below rated voltage.
 - 2) Two 2.5 percent full capacity primary taps above rated voltage.
 - c. Operated by a tap changer handle or tap jumpers accessible through a panel.
 - 4. Terminals:
 - a. UL listed for either copper or aluminum conductors.
 - b. Rated for 75 degrees Celsius.
 - 5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with IEEE C57.96.
- B. Transformers less than 15 kilovolt-amperes:
 - 1. Insulation class: 185 degrees Celsius.
 - 2. Temperature rise: 115 degrees Celsius.
- C. Energy efficient transformers 15 kilovolt-amperes and larger:
 - 1. Insulation class: 220 degrees Celsius.

2. Temperature rise: 80 degrees Celsius, except as noted below:
 - a. 150-degree Celsius rise for dry-type transformers located in motor control centers.
3. Efficiency:
 - a. In accordance with DOE 10 CFR Part 431.

D. Enclosures:

1. Heavy gauge steel:
 - a. Outdoor: Moisture and water resistant with rodent screens over all openings and in a weather-protected enclosure, NEMA Type 3R.
 - b. Indoor: NEMA Type 2.
2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.
3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
 - a. Neoprene vibration pads and sleeves.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. Nameplates:

1. Non-corrosive metal or UL listed non-metallic:
 - a. Stamped, engraved or printed with the following information:
 - 1) Phases.
 - 2) Frequency.
 - 3) Kilovolt-ampere rating.
 - 4) Voltage ratings.
 - 5) Temperature rise.
 - 6) Impedance.
 - 7) Insulation class.
 - 8) BIL rating.
 - 9) Connection diagram.
 - 10) Weight.
 - 11) Manufacturer.
 - 12) The identification "transformer".
 - 13) Classes of cooling.
 - 14) Tap voltage(s).
 - 15) Vector diagram.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited manufacturer's standard gray enamel rust-inhibiting paint.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
 - 1. Floor, wall, platform, motor control center, packaged power supply, or roof mounted, as indicated on the Drawings.
 - 2. Install where not in direct contact with building structure.
 - 3. Install on single layer vibration pad under the entire mounting surface.
 - a. Manufacturers: The following or equal:
 - 1) Korfund.
 - 4. Make any necessary connections to the enclosure with liquidtight flexible conduit having neoprene gaskets and insulated ground bushings.
 - 5. Ground the enclosure:
 - a. To an equipment ground conductor in the conduit.
 - b. To the facility grounding electrode system.
 - 6. Floor mounted transformers:
 - a. Install transformers on 3-1/2-inch housekeeping pads.
 - b. Install transformers with adequate space from walls or other enclosures for proper ventilation in accordance with the manufacturer's recommendations.

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.
- B. Factory tests:
 - 1. Applied voltage test to each winding and from each winding to the core:
 - a. 600-volt class winding 4.5 kilovolt.
 - 2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
 - 3. Voltage ratio and polarity.
 - 4. Sound level, performed in a test room with ambient sound level not exceeding 24 db.
 - 5. Perform all tests in accordance with UL 1561.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING

- A. Set the transformer taps as required to obtain nominal output voltage on the secondary terminals.

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16285

SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. High-energy surge protective devices.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
 - 2. C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
 - 3. C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
 - 4. C62.62- Standard Test Specifications for Surge Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000 V and less) AC Power Circuits.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- D. Underwriters Laboratory:
 - 1. 1449, 4th Edition, Standard for Surge Protective Devices.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. NEMA:
 - 1. Type 1 enclosure in accordance with NEMA 250.
 - 2. Type 4 enclosure in accordance with NEMA 250.
 - 3. Type 4X enclosure in accordance with NEMA 250.
 - 4. Type 12 enclosure in accordance with NEMA 250.
- C. Specific definitions:
 - 1. SPD: Surge protective device.
 - 2. SAD: Silicon avalanche diode.
 - 3. MOV: Metal oxide varistor.
 - 4. MCOV: Maximum continuous operating voltage.
 - 5. I_n : Nominal discharge current.
 - 6. VPR: Voltage protection rating.
 - 7. SCCR: Short circuit current rating.

1.04 SYSTEM DESCRIPTION

- A. Surge protective devices as an integral component of the electrical equipment or externally mounted as indicated on the Drawings.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Furnish complete product data confirming detailed compliance or exception statements to all provisions of this Section.
 - 2. Manufacturer's catalog cut sheets indicating:
 - a. Manufacturer and model numbers.
 - b. Ratings of each SPD including but not limited to:
 - 1) Short circuit current rating.
 - 2) Nominal discharge current.
 - 3) Maximum continuous operating voltage.
 - 4) Voltage protection rating.
 - 5) System voltage.
 - 6) System frequency.
 - 7) Surge current capacity.
 - 3. Submit independent test data from a nationally recognized testing laboratory verifying the following:
 - a. Overcurrent protection.
 - b. UL 1449.
- C. Shop drawings:
 - 1. Provide electrical and mechanical drawings by the manufacturer that detail:
 - a. Unit dimensions.
 - b. Weights.
 - c. Components.
 - d. Field connection locations.
 - e. Mounting provisions.
 - f. Connection details.
 - g. Wiring diagram.
- D. Operation and maintenance manuals:
 - 1. Provide the manufacturer's manual with installation, start-up, spare parts lists, and operating instructions for the specified system.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
 - 1. Institute of Electrical and Electronics Engineers (IEEE C62.41.1, C62.41.2, C62.45, C62.62).
 - 2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
 - 3. National Electrical Manufacturer Association.
 - 4. National Fire Protection Association (NFPA 20, 75 and 780).

5. National Electric Code (NFPA 70).
6. Underwriters Laboratories (UL 1449 4th Edition and UL 1283).
7. International Electrotechnical Commission (IEC 801).

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. Coordinate with and provide SPD equipment to the electrical equipment manufacturer before final assembly and factory testing.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Extended warranty:
 1. Furnish a manufacturer's full 5-year parts and labor warranty from date of shipment against any part failure when installed in compliance with manufacturer's written instructions, UL listing requirements, and any applicable national, state, or local electrical codes.
 2. Warranty shall include:
 - a. Direct, factory trained employees must be available within 48 hours for assessment of the problem.
 - b. A 24-hour toll-free 800-number for warranty support.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 1. Liebert.
 2. Eaton.
 3. Schneider Electric.
 4. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Provide Type 1 or Type 2 SPD units as required for the locations indicated on the Drawings.
- B. Electrical requirements:
- SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
 - MCOV:
 - For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
 - Operating frequency:
 - 47 to 63 hertz.
 - SCCR:
 - 65 kAIC minimum, but not less than the equipment it is connected to as indicated on the Drawings.
 - The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
 - Nominal discharge current I_n :
 - 20 kA.
 - Maximum VPR:

Modes	<u>240/120</u>	<u>208Y/120</u>	480Y/277
L-N, L-G, N-G	900	900	1,500
L-L	1,200	1,200	2000

- Peak surge current:
 - Service entrance locations:
 - 240 kA per phase minimum.
 - 120 kA per mode minimum.
 - Branch locations:
 - 120 kA per phase, minimum.
 - 60 kA per mode minimum.
- C. Protection modes:
- Provide SPD protection modes as follows:
 - Line to Neutral (L-N) where applicable.
 - Line to Ground (L-G).
 - Neutral to Ground (N-G), where applicable.
- D. Environmental requirements:
- Storage temperature:
 - 40 degrees to +50 degrees Celsius.
 - Operating temperature:
 - 0 degrees to +60 Celsius.
 - Relative humidity:
 - 5 percent to 95 percent.
 - Audible noise:
 - Less than 45 dBa at 5 feet (1.5 m).

- 5. Operating altitude:
 - a. Zero to 12,000 feet above sea level.

- E. Provide surge protective devices that are suitable for application in IEEE C62.41.1, C62.41.2 Category A, B and C3 environments, as tested to IEEE C62.45.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Enclosure:
 - 1. Located in electrical equipment as indicated on the Drawings.
- B. Internal connections:
 - 1. Provide low impedance copper plates for intra-unit connections:
 - a. Attach surge modules using bolted connections to the plates for low impedance connections.
 - 2. Size all connections, conductors, and terminals for the specified surge current capacity.
- C. Surge diversion modules:
 - 1. MOV:
 - a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.
- D. Overcurrent protection:
 - 1. Individually fuse all components, including suppression, filtering, and monitoring components:
 - a. Rated to allow maximum specified nominal discharge current capacity.
 - b. Overcurrent protection that limits specified surge currents is not acceptable.
- E. Connections:
 - 1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.07 ACCESSORIES

- A. Unit status indicators:
 - 1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
 - a. The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
 - b. Indicates the status of protection on each mode or phase.
- B. Dry contacts for remote monitoring:
 - 1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.
- C. Provide an audible alarm which activates under any fault condition.
 - 1. Provide an alarm On/Off switch to silence the alarm.
 - 2. A visible LED will confirm whether alarm is On or Disabled.
 - 3. Locate both switches and the audible alarm on the unit's front cover.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Permanently affix surge rating to the SPD.
- B. Perform manufacturer's standard factory test:
 - 1. Perform testing in accordance with UL 1449.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Follow the manufacturer's recommended installation practices and comply with all applicable codes.
- C. Special techniques:
 - 1. Install the SPD with as short and straight conductors including ground conductor as practically possible:
 - a. Twist the input conductors together to reduce input conductor inductance.
 - 2. Do not subject SPD to insulation resistance testing.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16950 - Field Electrical Acceptance Tests.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16305

ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Short-circuit fault analysis study.
 - 2. Protective device coordination study.
 - 3. Arc-flash hazard study.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 1584 - IEEE Guide for Performing Arc Flash Hazard Calculations.
- C. National Fire Protection Association (NFPA).

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. General study requirements:
 - 1. Scope:
 - a. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall include all new and existing equipment in the power distribution system including, but not limited to:
 - 1) Utility equipment.
 - 2) Switchgear.
 - 3) Switchboards.
 - 4) Generators.
 - 5) Transformers:
 - a) Including all dry-type transformers.
 - 6) Motor control centers.
 - 7) Freestanding variable frequency drives and starters.
 - 8) Disconnect switches.
 - 9) Motors.
 - 10) Panelboards:
 - a) Including all 240- and 208-volt systems.
 - 11) Vendor control panels.
 - 12) HVAC equipment.
 - b. Study scenarios:
 - 1) The studies shall include all possible electrical system configurations, for example:
 - a) Operation on normal (utility) source.

- b) Operation on generator source.
 - c) Main-breakers closed, tie-breaker open.
 - d) Either main-breaker open, tie-breaker closed.
- 2. Obtain, for all equipment, the required data for preparation of the study including, but not limited to:
 - a. Transformer kilovolt-ampere (kVA) and impedances.
 - b. Generator impedances.
 - c. Generator decrement curves.
 - d. Bus withstand ratings.
 - e. Cable and bus data.
 - f. Protective device taps, time dials, instantaneous pickups, and time-delay settings.
- 3. Obtain the Electric Utility information on the minimum and maximum available fault current, minimum and maximum utility impedances, utility protective device settings including manufacturer and model number, interrupting ratings, X/R ratios, and model information one level above the point of connection:
 - a. Utility tolerances and voltage variations.
- 4. The individual performing the studies shall visit the site and collect all necessary field data in order to perform and complete comprehensive electrical system studies.
- 5. Obtain equipment layouts and configurations from the manufacturer's final submittal requirements and project layout drawings as required.
- 6. Bus and conductor data:
 - a. Use impedances of the actual installed or specified conductors, unless otherwise indicated.
 - b. Use cable and bus impedances calculated at 25 degrees Celsius, unless otherwise indicated.
 - c. Use 600-volt cable reactance based on typical dimensions of actual installed or specified conductors, unless otherwise indicated.
 - d. Use bus withstand values for all equipment having buses.
 - e. Use medium-voltage cable reactances based on typical dimensions of shielded cables with 133-percent insulation levels, unless otherwise indicated.
- 7. Motors:
 - a. Each motor shall be individually modeled:
 - 1) Grouping of motors for fault contribution current is not acceptable.
 - b. Motors with variable frequency drives may be assumed to have no contribution to fault current.
- 8. Use the equipment, bus, and device designations as indicated on the Drawings for all studies.
- B. Short-circuit fault analysis study additional requirements:
 - 1. The short-circuit fault analysis shall be performed and submitted in 2 phases:
 - a. Initial short-circuit fault analysis:
 - 1) Based on the Contract Documents and Electric Utility information.
 - 2) The initial short-circuit fault analysis study shall indicate the estimated available short-circuit current at the line side terminals of each piece of equipment covered by the scope of the study.
 - 3) Provide a list of assumptions used in the initial study.

- b. Final short-circuit fault analysis:
 - 1) The final short-circuit fault analysis shall modify the initial analysis as follows:
 - a) Utilize the actual equipment provided on the project.
 - b) Utilize conductor lengths based on installation.
 - 2. Calculate 3-phase bolted fault, line-to-line fault, line-to-ground fault, double line-to-ground fault, short-circuit 1/2 cycle momentary symmetrical and asymmetrical RMS, 1-1/2 to 4 cycle interrupting symmetrical RMS, and 30-cycle steady-state short-circuit current values at each piece of equipment in the distribution system.
 - 3. Evaluate bus bracing, short-circuit ratings, fuse interrupting capacity and circuit-breaker-adjusted interrupting capacities against the fault currents, and calculate X/R values:
 - a. Identify and document all devices and equipment as either inadequate or acceptable.
 - 4. Calculate line-to-ground and double line-to-ground momentary short-circuit values at all buses having ground-fault devices.
 - 5. Provide calculation methods, assumptions, one-line diagrams, and source impedance data, including utility X/R ratios, typical values, recommendations, and areas of concern.
- C. Protective device coordination study additional requirements:
 - 1. Furnish protective device settings for all functions indicated on the Drawings including, but not limited to:
 - a. Current.
 - b. Voltage:
 - 1) Provide settings for all voltage relays based upon actual utility and generator tolerances and specifications.
 - c. Frequency:
 - 1) Provide settings for all frequency relays based upon actual utility and generator tolerances and specifications.
 - d. Negative sequence.
 - e. Reverse power.
 - f. Machine protection functions:
 - 1) Provide settings for all motor and generator protective relays based on the manufacturer's recommended protection requirements.
 - 2. Provide log-log form time-current curves (TCCs) graphically indicating the coordination proposed for the system:
 - a. Include with each TCC a complete title and one-line diagram with legend identifying the specific portion of the system covered by the particular TCC:
 - 1) Typical TCCs for identical portions of the system, such as motor circuits, are acceptable as allowed by the Engineer.
 - b. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics:
 - 1) These details can be included on the TCC.
 - c. Include a detailed description of each protective device tap, time dial, pickup, instantaneous, and time delay settings:
 - 1) These details can be included on the TCC.
 - 3. TCCs shall include all equipment in the power distribution system where required to demonstrate coordination. Include utility relay and fuse characteristics, medium-voltage equipment protective relay and fuse

- characteristics, low-voltage equipment circuit breaker trip device characteristics, transformer characteristics, motor and generator characteristics, and characteristics of other system load protective devices:
- a. Include all devices down to the largest branch circuit and largest feeder circuit breaker in each motor control center, main breaker in branch panelboards, and fused disconnect switches.
 - b. Provide ground fault TCCs with all adjustable settings for ground fault protective devices.
 - c. Include manufacturing tolerances and damage bands in plotted fuse and circuit breaker characteristics.
 - d. On the TCCs, show transformer full load currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and transformer damage curves.
 - e. Cable damage curves.
 - f. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed based on the short-circuit fault analysis study.
 - g. Coordinate time interval medium-voltage relay characteristics with upstream and downstream devices to avoid nuisance tripping.
4. Site generation: When site generation (including cogeneration, standby, and emergency generators) is part of the electrical system, include phase and ground coordination of the generator protective devices:
 - a. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices.
 5. Suggest modifications or additions to equipment rating or settings in a tabulated form.
- D. Arc-flash hazard study additional requirements:
1. Include the calculated arc-flash boundary and incident energy (calories/square centimeter) at each piece of equipment in the distribution system:
 - a. Perform study with 15 percent arcing fault variation as defined by IEEE 1584.
 - b. Perform arc-flash calculations at minimum and maximum utility and generator fault contributions.
 - c. Perform arc-flash calculations for both the line side and load side of the switchgear, switchboard, motor control center, and panelboard main breakers.
 - d. Perform arc-flash calculations for all short-circuit scenarios with all motors on for 3 to 5 cycles and with all motors off.
 - e. Protective device clearing time shall be limited to 2 seconds, maximum.
 2. Provide executive summary of the study results:
 - a. Provide summary based upon worst case results.
 3. Provide a detailed written discussion and explanation of the tabulated outputs:
 - a. Include all scenarios.
 4. Provide alternative device settings to allow the Owner to select the desired functionality of the system:
 - a. Minimize the arc-flash energy by selective trip and time settings for equipment maintenance purposes.
 - b. Identify the arc-flash energy based upon the criteria of maintaining coordination and selectivity of the protective devices.

- E. Electrical system study meetings:
1. The individual conducting the short-circuit fault analysis, protective device coordination, and the arc-flash hazard studies shall meet with the Owner and Engineer 3 times.
 2. The purpose of the 3 meetings is as follows:
 - a. Initial meeting:
 - 1) Meet with the Owner and Engineer to discuss the scope of the studies.
 - 2) Discuss the Owner's operational requirements for both normal operation and maintenance.
 - b. Preliminary results meeting:
 - 1) This meeting will be held after the studies have been completed, reviewed, and accepted by the Engineer.
 - 2) The purpose of this meeting is to inform the Owner of the results of the study and impacts on normal operation and maintenance including:
 - a) Protective device coordination problems and recommended solutions.
 - b) Explanation of the arc-flash hazard study results and its potential impact on operations.
 - c) Recommendations for reduction of arc-flash category levels including reduction of protective device settings or changes in operational practices.
 - c. Final meeting:
 - 1) Discuss changes to the studies based on the previous meeting.
 - 2) Discuss with the Owner how changes to the electrical system may change the arc-flash hazard category.
 - 3) Deliver the final electrical system studies report.
 3. The meetings will be at the Owner's facility:
 - a. Provide a minimum of 3 weeks' notice to the Owner and Engineer in advance of the projected meeting date.
 - b. Submit a draft of the meeting agenda when each meeting is requested.
 4. Meeting materials:
 - a. Prepare and provide the following materials:
 - 1) Meeting agenda. Include, at a minimum, the scope of the meeting, estimated time length for the meeting, and meeting goals.
 - 2) 6 copies of the project one-line diagrams for the initial meeting.
 - 3) 6 copies of the submitted studies.
- F. By virtue of the fact that this is a professional study, the Owner reserves the right to modify the requirements of the study to comply with its operational requirements. The protective device coordination study and the arc-flash hazard study shall be modified based on the results of the meetings with the Owner.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Initial studies and reports:
1. Include the following in the initial short-circuit current report:
 - a. List of all devices included in the studies.

- b. A description of all operating scenarios.
 - c. Form and format of arc-flash labels.
- C. Final studies and reports:
 - 1. Format and quantity:
 - a. Provide 3 bound copies of all final reports.
 - b. Provide 3 complete sets of electronic files on CD or DVD media, including the electrical system model(s), configuration files, custom libraries, and any other files used to perform the studies and produce the reports. Also provide an electronic version of the bound reports in PDF format.
 - c. Provide the number of copies specified in Section 01330 - Submittal Procedures.
 - 2. Include the sections below in the final report:
 - a. Copies of correspondence and data obtained from the electric utility company.
 - b. Letter certifying the inspection and verification of existing equipment.
 - c. One-line diagrams:
 - 1) The following information shall be included at a minimum:
 - a) Motor horsepower.
 - b) Transformer data:
 - (1) kVA.
 - (2) Configuration.
 - c) Cable data:
 - (1) Insulation.
 - (2) Size.
 - (3) Length.
 - 2) One-line diagrams shall be fully legible at 11-inch by 17-inch size.
 - d. Include in the short-circuit fault analysis study:
 - 1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
 - 2) Normal system connections and those that result in maximum fault conditions.
 - 3) Tabulation of circuit breaker, fuse, and other protective device ratings compared to maximum calculated short-circuit duties.
 - 4) Fault current calculations for the cases run including a definition of terms and guide for interpretation of computer software printouts.
 - e. Protective device coordination study shall include:
 - 1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
 - 2) List all requirements used in the selection and setting criteria for any protective devices.
 - 3) TCCs graphically indicating the coordination proposed for the system on log-log graphs.
 - 4) Tabulation of relay, fuse, circuit breaker, and other protective devices in graphical form with a one-line diagram to display area coordination.
 - 5) Where coordination could not be achieved, an explanation shall be included in the report to support the statement along with recommendations to improve coordination. Recommended equipment modifications or settings shall be in a tabulated form.

- f. Include in the arc-flash hazard study:
 - 1) Descriptions, purpose, basis, assumptions, recommendations, and scope of the study.
 - 2) Normal system connections and those that result in maximum arc-flash conditions.
 - 3) Arc-flash raw data, calculations, and assumptions.
 - 4) Arc-flash label data:
 - a) Identifying the content of each label.
 - b) Identifying the location of each label.
- D. Certification:
 - 1. Submit written certification, sealed and signed by the professional engineer conducting the study, equipment supplier, and electrical subcontractor stating that the data used in the study is correct.
- E. Submit the credentials of the individual(s) performing the study and the individual in responsible charge of the study.
- F. The Engineer will review all studies and reports. After review, the Engineer will make recommendations and/or require changes to be made to the short-circuit fault analysis, protective device coordination, or arc-flash hazard studies. These changes shall be provided as part of the scope of work.
- G. Submit course outline for Owner's training.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Qualifications of the entity responsible for electrical system studies:
 - 1. The studies shall be performed, stamped, and signed by a professional engineer registered in the state where the project is located.
 - 2. A minimum of 5 years of experience in power system analysis is required for the individual in responsible charge of the studies.
 - 3. The short-circuit fault analysis, protective device coordination, and arc-flash hazard studies shall be performed with the aid of a digital computer program:
 - a. Point-to-point calculations are not acceptable.
- C. The study shall be performed by an independent firm.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT/SITE CONDITIONS (NOT USED)

1.09 SEQUENCING

- A. Site visit to gather data on the existing facility systems for all studies:
 - 1. Make multiple trips as required to obtain all data for the short-circuit fault analysis, protection device coordination, and arc flash hazard studies.
- B. Submit the initial short-circuit fault analysis study before submittal of any electrical equipment.

- C. Initial electrical system study meeting.
- D. Submit the preliminary short-circuit fault analysis, protective device coordination, and arc-flash hazard studies.
- E. Second electrical system study meeting for preliminary results.
- F. Final arc-flash meeting and final short-circuit fault analysis, protective device coordination, and arc-flash hazard studies.
- G. Label equipment with approved arc-flash labels.
- H. Owner's training.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Electrical system study software:
 - 1. Operation Technology, Inc., ETAP, no equal.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Arc-flash hazard labels:
 - 1. Dimensions:
 - a. Minimum 5 inches by 3.5 inches.
 - 2. Materials:
 - a. Polyester with polyvinyl polymer over-laminate.
 - b. Self-adhesive.
 - c. Resistant to:
 - 1) UV.
 - 2) Chemicals and common cleaning solvents.
 - 3) Scuffing.
 - 4) Wide temperature changes.

3. Contents:
 - a. Short-circuit bus identification.
 - b. Calculated incident energy (calories/square centimeter) range:
 - 1) Based on worst-case study results.
 - c. Personnel protective equipment level number.
 - d. Arc-flash protection boundary.
 - e. Shock hazard boundary:
 - 1) The Contractor may provide separate labels for indication of the shock hazard boundary.
 - f. Description of the combined level of personnel protective equipment.
4. Color scheme:
 - a. For locations above 40 calories/square centimeter:
 - 1) White label with red "DANGER" strip across the top.
 - 2) Black lettering.
 - b. For locations below 40 calories/square centimeter:
 - 1) White label with orange "WARNING" strip across the top.
 - 2) Black lettering.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. After review and acceptance of the arc-flash hazard study by the Engineer, install all arc-flash hazard labels:
 1. Install labels at all locations required by NFPA, ANSI, or IEEE standards.
 2. At a minimum, install labels in the following locations:
 - a. The front of each main or incoming service compartment.
 - b. The front of each low-voltage switchgear section.
 - c. The front of each medium-voltage circuit breaker door.
 - d. The front of each accessible auxiliary or conductor compartment.
 - e. Each accessible rear or side vertical section.
 - f. Each motor control center vertical section.
 - g. Each panelboard covered by the study.
 - h. Each control panel, individual starter or VFD, or other equipment covered by the scope of the study.
 3. Install labels prior to equipment energization.

- C. After review and acceptance of the arc-flash hazard study and protective device coordination study by the Engineer, adjust protective device settings per final study prior to equipment energization.
 - 1. Devices that require power for configuration may be set during energization, but before any subfed loads are energized.
 - 2. Ensure that settings for upstream equipment are set prior to energizing downstream devices.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. The individual performing the arc-flash hazard study shall direct the installation of the arc-flash hazard labels:
 - 1. Remove and replace any improperly applied labels.
 - 2. Repair the equipment finish damaged by removal of any label.
 - 3. Install labels level or plumb across the entire dimension of the label.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16411
DISCONNECT SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Non-fusible disconnect switches.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. National Electric Manufacturer's Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment.
 - 2. KS 1-2001 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- C. Underwriters Laboratories Inc. (UL):
 - 1. 20 - General-Use Snap Switches.
 - 2. 98 - Enclosed and Dead-Front Switches.
 - 3. 508 - Standard for Industrial Control Equipment.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
 - 1. Safety switches and disconnect switches are to be considered synonymous.

1.04 SYSTEM DESCRIPTION

- A. Provide heavy-duty type disconnect switches as indicated on the Drawings and specified in the Contract Documents.
- B. Provide disconnect switches with the number of poles, voltage, current, short circuit, and horsepower ratings as required by the load and the power system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Manufacturer.
 - 2. Manufacturer's specifications and description.
 - 3. Ratings:
 - a. Voltage.
 - b. Current.

- c. Horsepower.
 - d. Short circuit rating.
 - 4. Fused or non-fused.
 - 5. NEMA enclosure type.
 - 6. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - 7. Weight.
 - 8. Cross-referenced to the disconnect schedule indicated on the Drawings.
- C. Shop drawings:
 - 1. Manufacturer's installation instructions:
 - a. Indicate application conditions and limitations of use stipulated by product testing agency specified under Quality Assurance, Regulatory Requirements below.
 - b. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
 - 2. Identify motor or equipment served by each switch; indicate nameplate inscription.
- D. Installation instructions:
 - 1. Provide anchorage instructions and requirement based on the seismic requirements at the Project Site as specified in Section 16050 - Common Work Results for Electrical and calculations:
 - a. Stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Regulatory requirements:
 - 1. NEMA KS1- Enclosed and Miscellaneous Distribution Switches (600 V Maximum).
 - 2. UL 98 - Enclosed and Dead-Front Switches.
- C. Disconnect switches shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. Conduct the initial fault current study as specified in Section 16305 - Electrical System Studies and submit results for Engineer's review.

- B. After successful review of the initial fault current study, submit complete equipment submittal.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Schneider Electric.
 - 2. Eaton.
 - 3. General Electric.
 - 4. Siemens.
 - 5. Appleton.
 - 6. Crouse-Hinds.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. Switch mechanism:
 - 1. Quick-make, quick-break heavy-duty operating mechanisms:
 - a. Provisions for padlocking the switch in the Off position.
 - b. A minimum of 90-degree handle travel position between Off and On positions:
 - 1) Provide handle position indicators to identify the handle position.
 - c. Full cover interlock to prevent opening of the switch door in the On position and to prevent closing the switch mechanism with the door open:
 - 1) With an externally operated override.
- B. Switch interior:
 - 1. Switch blades visible when the switch is Off and the cover is open.
 - 2. Lugs:
 - a. Front accessible.
 - b. Removable.

- c. UL listed for 60/75-degree Celsius copper conductors.
 - 3. Current carrying parts completely plated to resist corrosion.
 - 4. Removable arc suppressors to facilitate easy access to line side lugs.
 - 5. Furnish equipment ground kits for every switch.
- C. Ratings:
- 1. UL horsepower rated for AC or DC with the rating not less than the load served.
 - 2. Current:
 - a. 30 to 1,200 amperes.
 - 3. Voltage:
 - a. 250 volts AC, DC.
 - b. 600 volts (30 A to 200 A, 600 volts DC).
 - 4. Poles:
 - a. 2, 3, 4, and 6 poles.
 - 5. UL listed short circuit ratings:
 - a. 10,000 RMS symmetrical amperes when used with or protected by Class H or K fuses (30-600 amperes).
 - b. 200,000 RMS symmetrical amperes when used with or protected by Class R or J fuses (30-600 amperes employing appropriate fuse rejection).
 - c. 200,000 RMS symmetrical amperes when used with or protected by Class L fuses (800-1,200 amperes).
 - 6. Where not indicated on the Drawings, provide switches with the NEMA ratings specified in Section 16050 - Common Work Results for Electrical for the installed location.
- D. Size, fusing and number poles as indicated on the Drawings or as required:
- 1. Provide solid neutral where indicated on the Drawings.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Disconnect switches to have provisions for a field installable "B" type electrical interlock for position indication as indicated on the Drawings.
- B. Disconnect switches to have provisions for a field installed insulated groundable neutral kit as indicated on the Drawings.
- C. Disconnect switches to be provided with auxiliary contacts as indicated on the Drawings.
- D. NEMA Type 7 and 9 enclosures furnished with drain and breather kit when used in outdoor applications.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
 - 1. Use Myers hubs or bolt-on hubs for all conduit penetrations on NEMA Type 12, Type 4, and Type 4X enclosures.
 - 2. Provide all mounting brackets, stands, supports and hardware as required:
 - a. Match finish and materials for all brackets, stands, and hardware with the switch installed.
 - b. Provide adequate supporting pillar(s) for disconnect switches in accordance with the approved seismic calculations, and locate aboveground or above decks, where there is no structural wall or surface for box.
 - 3. When possible, mount switches rigidly to exposed building structure or equipment structural members:
 - a. For NEMA Type 4 and Type 4X locations, maintain a minimum of 7/8 inch air space between the enclosure and supporting surface.
 - b. When mounting on preformed channel, position channel vertically so that water may freely run behind the enclosure.
 - 4. Provide a nameplate for each disconnect switch:
 - a. Provide per requirements specified in Section 16075 - Identification for Electrical Systems.
 - b. Identify voltage, circuit, fuse size, and equipment served on the nameplate.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage molded case circuit breakers.

1.02 REFERENCES

- A. National Electrical Manufacturers Association (NEMA):
 - 1. AB 3 - Molded Case Circuit Breakers and Their Application.
- B. Underwriter's Laboratories (UL):
 - 1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
 - 2. 943 - Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

- A. In accordance with UL 489.

1.04 SYSTEM DESCRIPTION

- A. Molded case thermal magnetic or motor circuit protector type circuit breakers as indicated on the Drawings and connected to form a completed system.

1.05 SUBMITTALS

- A. Product data:
 - 1. Catalog cut sheets.
 - 2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

1.06 QUALITY ASSURANCE

- A. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.07 DELIVERY, STORAGE AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. General Electric Co.
 - 2. Eaton.
 - 3. Schneider Electric.
 - 4. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. General:
 - 1. Conforming to UL 489.
 - 2. Operating mechanism:
 - a. Quick-make, quick-break, non-welding silver alloy contacts.
 - b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
 - c. Mechanically trip free from the handle.
 - d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
 - e. Lockable in the "OFF" position.
 - 3. Arc extinction:
 - a. In arc chutes.
 - 4. Voltage and current ratings:
 - a. Minimum ratings as indicated on the Drawings.
 - b. Minimum frame size 100A.
 - 5. Interrupting ratings:
 - a. Minimum ratings as indicated on the Drawings.
 - b. Not less than the rating of the assembly (control panel).
- B. Motor circuit protectors:
 - 1. Instantaneous only circuit breaker as part of a listed combination motor controller.
 - 2. Each pole continuously adjustable in a linear scale with 'LO' and 'HI' settings factory calibrated.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Terminals:
 - 1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.
- B. Case:
 - 1. Molded polyester glass reinforced.
 - 2. Ratings clearly marked.
- C. Trip units:
 - 1. Provide thermal magnetic or solid-state trip units as indicated on the Drawings.
 - 2. Thermal magnetic:
 - a. Instantaneous short circuit protection.
 - b. Inverse time delay overload.
 - c. Ambient or enclosure compensated by means of a bimetallic element.
 - 3. Solid state:
 - a. With the following settings as indicated on the Drawings.
 - 1) Adjustable long time current setting.
 - 2) Adjustable long time delay.
 - 3) Adjustable short time pickup.
 - 4) Adjustable short time delay.
 - 5) Adjustable instantaneous pickup.
 - 6) Adjustable ground fault pickup as indicated on the Drawings.
 - 7) Adjustable ground fault delay as indicated on the Drawings.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Test breakers in accordance with:
 - 1. UL 489.
 - 2. Manufacturer's standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install breakers to correspond to the accepted shop drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16422

MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Motor starters and contactors.

1.02 REFERENCES

- A. International Electrotechnical Commission (IEC):
 - 1. 60 947-4 - Low-Voltage Switchgear and Control Gear.
 - 2. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.
- B. National Electrical Manufacturer's Association (NEMA):
 - 1. ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.
- C. Underwriters Laboratories (UL):
 - 1. 508 - Standard for Industrial Control Equipment.
 - 2. 508A - Standard for Industrial Control Panels.

1.03 DEFINITIONS

- A. Specific definitions and abbreviations:
 - 1. FVNR: Full voltage non-reversing.
 - 2. FVR: Full voltage reversing.
 - 3. TS1W: 2 speed 1 winding (consequent pole).
 - 4. TS2W: 2 speed 2 winding.
 - 5. PWS: Part winding start.
 - 6. RVAT: Reduced voltage auto transformer.
 - 7. RVSS: Reduced voltage solid state.
 - 8. Overload relay class: A classification of an overload relay time current characteristic by means of a number which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 SYSTEM DESCRIPTION

- A. General requirements:
 - 1. Starters for motor control centers, individual enclosed starters, or control panels.

1.05 SUBMITTALS

- A. Product data:
 - 1. Manufacturer.
 - 2. Catalog cut sheets.
 - 3. Technical information.
 - 4. Complete nameplate schedule.
 - 5. Complete bill of material.
 - 6. List of recommended spare parts.
 - 7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
 - 8. Electrical ratings:
 - a. Phase.
 - b. Wire.
 - c. Voltage.
 - d. Ampacity.
 - e. Horsepower.
 - 9. Furnish circuit breaker submittals as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
- B. Operation and maintenance manuals:
 - 1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section. Including but not limited to:
 - a. Electrical ratings:
 - 1) Phase.
 - 2) Wire.
 - 3) Voltage.
 - 4) Ampacity.
 - b. Complete bill of material.
 - c. Manufacturer's operating and maintenance instructions starter and/or contactor component parts, including:
 - 1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
 - 2) Pilot devices.
 - d. Complete renewal parts list.

1.06 QUALITY ASSURANCE

- A. Regulatory requirements:
 - 1. All starters and components shall be UL listed and labeled:
 - a. UL 508 - Industrial Control Equipment.
 - b. UL 508A - Industrial Control Panels.
 - 2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
 - 3. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

A. Spare parts:

1. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
 - a. 1 spare fuse of each size and type per starter.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

1. NEMA starters and contactors:
 - a. General Electric
 - b. Allen-Bradley.
 - c. Schneider Electric.
 - d. Eaton.
2. Manual motor starters:
 - a. Schneider Electric.
 - b. General Electric.
 - c. Cutler-Hammer.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:

1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as indicated on the Drawings.
2. NEMA size, design, and rated:
 - a. NEMA Size 1 minimum.
3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor:
 - a. If motors provided are different in horsepower rating than those specified or indicated on the Drawings, provide starters coordinated to the actual motors furnished.
4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking contacts.

5. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.
- B. Full voltage starters (FVNR, FVR, TS1W, TS2W):
1. Across-the-line full voltage magnetic starters.
 2. Rated for 600 volts.
 3. Electrical characteristics as indicated on the Drawings.
 4. Provide positive, quick-make, quick-break mechanisms, pad lockable enclosure doors.
 5. Furnish starter with solid state electronic overload relays.
 6. Double-break silver alloy contacts.
 7. Reversing starters provided with both mechanical and electrical interlocks to prevent line shorts and energizing both contactors simultaneously.
 8. Provide 2-speed, 2-winding motor starters consisting of two 3-pole contactors and 2 sets of overload relays assembled together:
 - a. Provided with contactors that are both mechanically and electrically interlocked to prevent energizing both contactors simultaneously.
- C. Manual motor starters:
1. General:
 - a. Provide with number of poles as indicated on the Drawings or as required by the connected load.
 - b. Provide handles that clearly indicate the On and Off (with lockout), positions.
 - c. Switch shall have positive, quick-make, quick-break mechanisms.
 2. Thermal overload switches:
 - a. Provide thermal overloads in manual motor starters where integral overloads are not furnished with the motor.
 - b. Size heater elements for approximately 115 percent of the nameplate full load current, for motors with a 1.15 service factor.
 - c. Thermal overload units in all phase legs.
 - d. Overload conditions interrupts all ungrounded conductors.
 3. Enclosure:
 - a. Provide the NEMA enclosure type specified in Section 16050 - Common Work Results for Electrical for the starter location.
 4. Manufacturer:
 - a. Square D 2510 or equal.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Molded case circuit breakers:
1. Circuit breaker type and ratings as indicated on the Drawings.
 2. Provide as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
- B. Contactors:
1. NEMA size as indicated on the Drawings.
 2. Electrically held:
 - a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.

3. Factory adjusted and chatter free.
4. Auxiliary contacts:
 - a. Contact ratings as per NEMA A 600 rating:
 - 1) Auxiliary contacts rated 10 amps at 600 volts.
 - b. Provide all contacts indicated on the Drawings, and any additional contacts required for proper operation.
 - c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.
5. Constructed in accordance with the following standards:
 - a. UL 508.
 - b. IEC 947-4:
 - 1) Type 1 coordination when protected by a circuit breaker.
 - 2) Type 2 coordination when protected by a suitable UL listed fuse.
 - c. IEC 801-1 parts 2 through 6.

C. Overloads:

1. Solid state electronic with communications:
 - a. Selectable Class 5, 10, 20, 30 protection.
 - b. Motor current range:
 - 1) As required by the equipment:
 - a) Provide current transformers external to the overload where required.
 - c. Protective functions:
 - 1) Load protection:
 - a) Under current: adjustable from 50 to 90 percent of motor full load amps with an adjustable 1 to 60 second delay.
 - b) Low power: adjustable from 20 to 80 percent of rated kW with an adjustable 1 to 60 second delay.
 - c) High power: adjustable from 50 to 110 percent of rated kW with an adjustable 1 to 60 second delay.
 - 2) Supply protection:
 - a) Over voltage: adjustable from 323 to 528 VAC with an adjustable 1-20 second delay.
 - b) Under voltage: adjustable from 323 to 528 VAC with an adjustable 1-20 second delay.
 - c) Voltage imbalance: adjustable from 1 to 20 percent with an adjustable 1 to 20 second delay.
 - 3) Motor protection:
 - a) Jam: adjustable from 150 to 400 percent of motor full load amps with an adjustable 1 to 20 second delay.
 - b) Current imbalance: adjustable from 1 to 30 percent with an adjustable 1 to 20 second delay.
 - c) Current phase loss: set at 60 percent an adjustable 1 to 20 second delay.
 - d) Ground fault:
 - (1) Adjustable from 0.3 to 2 amps for motor currents up to 5 amps.
 - (2) Adjustable from 3 to 20 amps for motor currents from 5 to 90 amps.

- (3) Time delay based on the percentage of ground fault current:
 - (a) Less than 150 percent: adjustable from 1 to 60 seconds.
 - (b) Greater than 150 percent: 2 seconds.
 - (c) Greater than 25 percent: 1 second.
 - e) Phase reversal.
 - d. Manual or automatic reset:
 - 1) Automatic reset shall have an adjustable time delay and from 2 to 500 minutes and an adjustable fault reset attempts from 0 to 4 for motor protection and load protection faults.
 - 2) Supply faults shall have an adjustable 1 to 500 second reset delay.
 - e. Monitoring functions:
 - 1) Current:
 - a) Per phase RMS with 2 percent accuracy.
 - b) Average RMS with 2 percent accuracy.
 - c) Imbalance percent.
 - 2) Voltage:
 - a) Per phase RMS with 2 percent accuracy.
 - b) Average RMS with 2 percent accuracy.
 - c) Imbalance percent.
 - 3) Power:
 - a) Motor kW with 5 percent accuracy.
 - b) Power factor with 1 percent accuracy.
 - 4) Thermal capacity.
 - 5) Motor run hours.
 - 6) Frequency: 47 to 63 hertz with 1 percent accuracy.
 - f. User interface:
 - 1) Provide the ability to set typically used parameters.
 - 2) Trip pushbutton.
 - 3) Reset pushbutton.
 - a) Shall have ability to be manually reset external to the overload.
 - 4) LED status indicators.
 - 5) Power, voltage, and current display LED display.
 - g. 120 VAC powered.
 - h. Output contacts:
 - 1) B300 pilot duty.
 - 2) Form C fault relay.
 - 3) Form A ground fault relay.
 - i. Communications module:
 - 1) Mounts to the side of the overload.
 - 2) Provides network connection for programming and monitoring of the overload.
 - 3) Four discrete inputs:
 - a) 120 VAC.
 - 4) Two discrete outputs:
 - a) One form C, one form A.
 - b) Rated for 3A at 120 VAC.
 - j. Network communications: Modbus TCP.

2. Control power transformer:
 - a. Furnish integral control power transformer capacity to power:
 - 1) All motor controls; Motor and starter accessories indicated on the Drawings or specified.
 - b. Primary and secondary fusing as indicated on the Drawings:
 - 1) Fusing sized by the manufacturer for the rating of the transformer furnished.

2.07 ACCESSORIES

- A. Lugs and terminals:
 1. For all external connections of No. 6 AWG and larger.
 2. UL listed for either copper or aluminum conductors.
- B. Surge protective devices:
 1. Furnish surge protection devices across the coil of each starter, contactor, and relay.
- C. Conformal coating:
 1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H₂S and chlorine.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Starters in control panels:
 1. Install as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.
- B. Manual motor starters:
 1. Provide complete mounting brackets and hardware as necessary for complete support of manual motor starter at locations indicated on the Drawings.
 2. Mount manual motor starter rigidly to exposed building or equipment structural members.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING

A. Set all overloads and motor circuit protectors based on the nameplate values of the installed motor.

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16444

LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage motor control centers.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. National Electrical Manufacturer's Association (NEMA):
 - 1. ICS 18-2001 - Motor Control Centers.
- C. Underwriters Laboratories (UL):
 - 1. 845 - Motor Control Centers.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Factory assembled, factory wired and factory tested motor control centers:
 - 1. Motor control centers and major components to be products of a single manufacturer.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Manufacturer of motor control center.
 - 2. Manufacturer of motor control center parts.
 - 3. Nameplate schedule.
 - 4. Bill of material.
 - 5. Enclosure:
 - a. NEMA rating.
 - b. Finish color.
 - 6. Ratings:
 - a. Voltage.
 - b. Phase.
 - c. Current:
 - 1) Horizontal bus ampacity.
 - 2) Vertical bus ampacity.
 - 3) Ground bus ampacity.

- d. Short circuit withstand rating.
 - e. Protective device interrupting rating.
 - 7. List of recommended spare parts.
 - 8. Catalog cut sheets:
 - a. Submit complete manufacturer's catalog information:
 - 1) Clearly indicate the features of the equipment including any options necessary to meet the required functionality.
 - 9. Furnish component submittals as specified in the appropriate Section.
 - 10. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
- 1. Layout drawings:
 - a. Provide fully dimensioned and to scale layout drawings which include:
 - 1) Dimensions:
 - a) Overall length.
 - b) Overall width.
 - c) Overall height.
 - d) Overall weight and weight of individual shipping splits.
 - 2. Interfaces to other equipment.
 - 3. Shipping splits.
 - 4. Allowable top and bottom conduit windows.
 - 5. Complete component and unit layout drawings.
 - 6. Indicate lug sizes, type, and manufacturer based on the cable size specified in the Contract Documents and as indicated on the Drawings.
 - 7. Elementary schematics:
 - a. Provide one custom schematic diagram for each compartment:
 - 1) Include all remote devices.
 - 2) Show wire numbers on the schematics:
 - a) Provide wire numbering as specified in Section 16075 - Identification for Electrical Systems.
 - 8. External connection diagram showing the wiring to the external controls and devices associated with the motor control center.
 - 9. One-line diagrams:
 - a. Provide complete one-line diagrams for each motor control center, including but not limited to: protective devices, starters, drives, metering, and other equipment.
 - b. Indicate electrical ratings of the equipment shown on the one-line diagrams.
- D. Installation instructions:
- 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 - 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.

3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- E. Operation and maintenance manuals:
 1. Provide complete operating and maintenance instructions presenting full details for care and maintenance of all types of equipment furnished and/or installed under this Section. Include the following:
 - a. Electrical ratings:
 - 1) Phase.
 - 2) Wire.
 - 3) Voltage.
 - 4) Ampacity.
 - 5) Bus bracing and protective device interrupting ratings.
 - b. Manufacturer's operating and maintenance instructions for the motor control center and all component parts, including:
 - 1) Starters.
 - 2) Overload relays and heater elements.
 - 3) Variable frequency drives.
 - 4) Protective devices including, but not limited to, fuses, circuit breakers and protective relays.
 - 5) Pilot devices.
 - c. Complete renewal parts list.
- F. Test forms and reports:
 1. Submit complete factory acceptance test procedures and all forms used during the test.
- G. Manufacturer's Certificate of Installation and Functionality Compliance.
- H. Record Documents:
 1. Elementary schematics:
 - a. Furnish as-built elementary schematics indicating final:
 - 1) Wire numbers.
 - 2) Interfaces with other equipment.
 - b. Provide one custom schematic diagram for each compartment:
 - 1) Include all remote devices.
 - 2) Show wire numbers on the schematics.
 - c. Layout drawings: Provide complete dimensioned component and unit layout drawings.
 2. The Record Documents shall reflect all modifications made during the submittal review process and during construction.

- I. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the motor control center to prove the motor control center is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. All portions of the motor control center, vertical bays, and components shall be UL listed and labeled.
 - 1. Where indicated as service entrance equipment, the motor control center shall be UL labeled and listed "Suitable for Service Entrance."

1.07 DELIVERY, STORAGE AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Ship the motor control center and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize onsite off-loading equipment.
- C. Furnish temporary equipment heaters within the motor control center to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. Conduct the initial fault current study as specified in Section 16305 - Electrical System Studies and submit results for Engineer's review.
- B. After successful review of the initial fault current study, as specified in Section 16305 - Electrical System Studies, submit complete equipment submittal.
- C. Conduct factory acceptance test.
- D. Submit Manufacturer's Certificate of Installation and Functionality Compliance.
- E. Ship equipment to the Project Site after successful completion of factory acceptance test.
- F. Assemble equipment in the field.
- G. Conduct field acceptance test and submit results for Engineer's review.
- H. Submit manufacturer's certification that the equipment has been properly installed and is fully functional for Engineer's review.
- I. Conduct Owner's training sessions.

- J. Commissioning and process start-up as specified in Section 01756 - Commissioning.

1.10 SCHEDULING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTION (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following, or equal:
 - 1. General Electric.
 - 2. Eaton.
 - 3. Schneider Electric.
 - 4. Allen Bradley.

2.02 EXISTING PRODUCTS

- A. Existing motor control centers:
 - 1. Install new motor starters in the existing motor control centers as shown on the Drawings.
 - 2. Install Ethernet switches and Ethernet cable in motor control centers BR-MCC-2, BR-MCC-3 and BR-MCC-4 as indicated on the Drawings.
 - 3. Provide additions that are of the same manufacturer, type, and electrical ratings as the existing motor control centers.

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. General:
 - 1. Furnish motor control centers as specified in the Contract Documents and indicated on the Drawings.
 - 2. Arrange the equipped sections to form continuous motor control center lineups as indicated on the Drawings:
 - a. Identify any deviations from the Drawings in writing and submit for approval.

3. Provide wire markers at each end of every wire as specified in Section 16075 - Identification for Electrical Systems.
 4. Provide complete and functional motor control centers.
 5. Provide devices or accessories not specified in this Section but necessary for the proper installation and operation of the equipment.
- B. Design and construct motor control center to operate at the voltage level and configuration indicated on the Drawings.
- C. Bus system:
1. Material:
 - a. Tin-plated copper.
 - b. Short-circuit rating:
 - 1) As indicated on the Drawings.
 - c. Bus bar supports:
 - 1) High impact strength, non-tracking glass-polyester material that is impervious to moisture and gases.
 2. Horizontal power bus:
 - a. Current-carrying capacity as indicated on the Drawings.
 - b. Mounting:
 - 1) Mount horizontal bus bars edgewise, one above the other, and fully isolated from all wireways and units.
 - c. Temperature rise:
 - 1) In accordance with UL 845.
 - 2) De-rate the temperature rating of the bus for the specified conditions of ambient temperature and altitude as specified in Section 16050 - Common Work Results for Electrical.
 3. Vertical power bus:
 - a. Current-carrying capacity of not less than 600 amps.
 - b. Mounting:
 - 1) Enclose the vertical bus in a polyester-glass cover with small openings to permit unit stabs to mate with the bus:
 - a) Provide a shutter mechanism to cover the stab openings when plug-in units are removed.
 - 2) Provide top and bottom bus covers for insulation and isolation of the ends of the bus.
 - c. Isolated from the unit compartments by a full height barrier.
 4. Ground bus:
 - a. Horizontal ground bus:
 - 1) Current-carrying capacity:
 - a) 300 amps when the horizontal bus is 2,000 amps or less.
 - b) 600 amps when the horizontal bus is greater than 2,000 amps.
 - 2) Mounting:
 - a) Full-width, firmly secured to each vertical section structure:
 - (1) Located in the top or bottom wireway.
 - b) Pre-drilled and furnished with lugs for connection to equipment ground wires:
 - (1) Furnish a minimum of 10 lugs per vertical section of MCC.
 - b. Vertical ground bus:
 - 1) Mounting:
 - a) Furnish in each vertical section.
 - b) Bolted to the horizontal ground bus.

- c) Install parallel to the vertical power bus.
 - d) Mount vertical ground bus such that plug-in units engage the ground bus before any connection to the power bus is made. Upon removal of plug-in units, ground stabs are disconnected from the ground bus after the power stabs have been disconnected.
 - 5. Bus splice bars:
 - a. Provided to join the bus at the splits.
 - b. Connected to each horizontal bus bar with a minimum of two bolts.
 - c. Employ conical or spring washers at connections, designed to maintain constant pressure against the splice joint.
 - d. Same ampacity rating as the horizontal bus.
 - 6. Provide bus system configured for back-to-back MCCs, where required.
- D. Enclosures:
- 1. Each motor control center shall consist of 1 or more vertical sections bolted together:
 - a. Freestanding.
 - b. Totally enclosed.
 - c. Dead-front assembly.
 - d. Designed for modification and/or addition of future vertical sections.
 - e. Form each vertical section of heavy gauge steel.
 - f. Designed for back-to-back arrangement installation, where required and/or as indicated on the Drawings.
 - 2. Enclosure rating:
 - a. Indoor:
 - 1) NEMA Type 1 gasketed.
 - 3. Standard section dimensions:
 - a. Nominal height: 90 inches.
 - b. Nominal depth: 20 inches.
 - c. Vertical section width as indicated on the Drawings.
 - 4. Wireways:
 - a. Provide each vertical section with a horizontal wireway at the top and bottom of the section:
 - 1) Arranged to provide a full-width metal enclosed wiring trough across the entire motor control center assembly.
 - b. Provide each vertical section with a full-height vertical wireway.
 - c. Completely isolated from the vertical and horizontal bus bars.
 - d. Provide a removable, hinged door.
 - 5. Shipping splits:
 - a. No more than 3 vertical sections and not more than 60 inches in width.
 - b. Solid bussing between vertical sections in a shipping split is not acceptable.
 - 6. Lifting angles:
 - a. Furnish each vertical section and/or shipping split with a removable lifting angle mounted to the top of the enclosure:
 - 1) Extending the entire width of the shipping split.
 - 7. Mounting channels:
 - a. Mount each vertical section and/or shipping split on an external 1.5-inch by 3-inch mounting channel.

E. Units:

1. A plug-in unit consists of:
 - a. Unit assembly.
 - b. Unit support pan.
 - c. Unit door assembly.
2. Completely enclosed and isolated from adjacent units, buses, and wireways, except for conductor entries into the unit, by a metal enclosure.
3. Constructed so that any fault will be contained in the unit compartment.
4. Supported and guided by a removable unit support pan:
 - a. Re-arrangement of units and the removal of a unit so that a new and possibly larger unit can be added without the removal of an in-service unit to gain access to the unit support pan.
5. Held in place by screws or other positive locking means after insertion.
6. Provide a test position with the unit supported in the structure but disengaged from the bus.
7. Integral plug-in ground stab.
8. Stabs:
 - a. Free floating.
 - b. Self-aligning.
 - c. Backed by spring steel clips to ensure high pressure contacts:
 - d. Electrolytically tin-plated copper.
9. Handle:
 - a. Provide a flange mounted handle mechanism to operate each disconnect switch or circuit breaker.
 - b. Door mounted operators or operator handles are not acceptable.
 - c. Engaged with the disconnect device at all times as an integral part of the unit independent of the door position.
 - d. Lockable in the "OFF" position with up to 3 padlocks.
 - e. Mechanically interlocked so that the door cannot be opened with the handle in the "ON" position.
 - 1) Provide a means for qualified personnel to defeat this interlock.
 - f. Interlocked so the unit cannot be inserted or withdrawn with the handle in the "ON" position.
 - g. Lockable in the "ON" position:
 - 1) This shall not prevent the circuit breaker from operating and opening the contacts in the event of a fault condition.
 - h. Color-coded to indicate position.
 - i. Located so the center of the grip when it is in its highest position is not more than 6 feet 7 inches above the finished floor, including the height of the housekeeping pad and mounting channels.
10. Where indicated on the Drawings, provide units for spaces and future equipment:
 - a. Equip these units to accept a future plug-in unit without modification to the vertical sections.

A. Motor control center networks:

1. General:
 - a. Furnish each MCC with a factory installed Ethernet network.
 - b. The network shall include a complete and tested cabling system compliant with applicable standards.

2. Ethernet networks:
 - a. Network architecture:
 - 1) Connect each device directly to an Ethernet switch.
 - a) Ring or daisy-chained networks between the MCC devices are not allowed.
 - b) Disconnecting or removing multiple devices shall not affect communications with the remaining devices.
 - 2) Connect the Ethernet switches to each other and to the PCIS in a linear topology.
 - b. Ethernet switches:
 - 1) Provide managed Ethernet switches
 - a) Provide switches as shown on the Drawings.
 - 2) Provide the number of switches required to connect each smart device in the MCC and one port for a customer connection.
 - a) Provide an empty port for each future device and each space.
 - 3) Provide an electronic circuit protector for Ethernet switches requiring a Class 2 power source.
 - 4) The switches will be powered from an external power source.
 - 5) As specified in Section 17733 - Control Systems: Network Materials and Equipment and as indicated on the Drawings.
 - c. Ethernet cable:
 - 1) Shielded.
 - 2) 600 Volt insulation.
 - 3) Cat 6A.

2.06 COMPONENTS

- A. Provide components contained within the motor control center as specified in:
 1. Section 16075 - Identification for Electrical Systems.
 2. Section 16123 - 600-Volt or Less Wires and Cables.
 3. Section 16150 - Low Voltage Wire Connections.
 4. Section 16262 - Variable Frequency Drives 0.50 - 50 Horsepower.
 5. Section 16285 - Surge Protective Devices.
 6. Section 16412 - Low Voltage Molded Case Circuit Breakers.
 7. Section 16422 - Motor Starters.
 8. Section 16445 - Panelboards.
 9. Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

2.07 ACCESSORIES

- A. Wiring:
 1. Wire the motor control center in accordance with the following NEMA Class and Type as defined by NEMA ICS 18-2001:
 - a. NEMA Class II-S:
 - 1) Furnish wiring diagrams for individual units consisting of drawings that identify electrical devices, electrical connections, and indicate terminal numbering designations.
 - 2) Furnish individual unit diagrams with each unit and include inter-wiring between units, i.e. electrical interlocking, etc., as specifically specified in the Contract Documents.

- 3) Provide custom drawings with unique terminal numbering designations in lieu of standard manufacturer drawings.
- b. NEMA Type B wiring:
 - 1) Control wiring:
 - a) Type B-T pull-apart terminal blocks.
 - 2) Power wiring:
 - a) Type B-T for Size 1 starters.
 - b) Type B-T or B-D for Size 2 and 3 starters.
 - c) Type B for Size 4 and larger starters and feeder units.
- B. Lugs and terminals:
 1. For all external connections of No. 6 AWG wire or larger:
 - a. UL listed for copper or aluminum conductors.
 2. Compression type, requiring a hydraulic press and die for installation.
 3. Provide 20 percent spare control block terminals.
- C. Nameplates:
 1. Provide nameplates as specified in Section 16075 - Identification for Electrical Systems:
 - a. Identifying the motor control center designation as indicated on the Drawings.
 2. Identifying each vertical section:
 - a. Mounted and centered on the top horizontal wireway of the vertical section.
 3. Furnish individual nameplates for each unit indicated on the Drawings:
 - a. 1 nameplate to identify the unit designation.
 - b. 1 nameplate to identify the load served.
 - c. Furnish space units with blank nameplates.
 4. Manufacturer's labels:
 - a. Furnish each vertical section with a label identifying:
 - 1) Serial number.
 - 2) Bus rating.
 - 3) Vertical section reference number.
 - 4) Date of manufacture.
 - 5) Catalog number of section.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Finish metal surfaces and structural parts with phosphatizing, or equal, treatment before painting.
- B. Finish interior surfaces including bus support angles, control unit back plates, and top and bottom barrier plates with baked white enamel.
- C. Finish exterior of enclosure with manufacturer's standard gray.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
 - 1. Furnish all cables, conduit, lugs, bolts, expansion anchors, sealants, and other accessories necessary to completely install the motor control center for the line, load, and control connections.
 - 2. Assemble and install the motor control center in the locations and with the layouts as indicated on the Drawings.
 - 3. Make bus splice connections.
 - 4. Perform work in accordance with manufacturer's instruction and shop drawings.
 - 5. Furnish all components, and equipment necessary to complete the installation.
 - 6. Replace hardware, lost or damaged during installation or handling, in order to provide a complete installation.
 - 7. Install the MCC on a 3-1/2-inch raised concrete housekeeping pad where indicated on the Drawings:
 - a. Provide structural leveling channels in accordance with the manufacturer's recommendations to provide proper alignment of the units.
 - 1) Remove the manufacturer's supplied mounting channels as required by the manufacturer's installation instructions.
 - b. Weld and/or bolt the motor control center frame to leveling channels.
- D. Provide openings in the top or bottom of the motor control center for conduit only.
 - 1. No additional openings will be accepted:
 - a. Miscut holes will require that the entire vertical section or removable panel be replaced.
 - b. No hole closers or patches will be accepted.
- E. Bundle circuits together and terminate in each unit:
 - 1. Tie with nylon wire ties as specified in Section 16123 - 600-Volt or Less Wires and Cables.
 - 2. Label all wires at each end with wire markers as specified in Section 16075 - Identification for Electrical Systems as shown on the approved elementary schematics.

3.04 ERECTION, INSTALLATION, APPLICATION CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 REINSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.
- B. Source testing (Factory Acceptance Tests):
 - 1. Owner and Engineer will witness the factory acceptance test as specified in Section 16050 - Common Work Results for Electrical.
 - 2. Test the complete motor control center at the manufacturer's establishment. Completely assemble, wire and test the motor control center:
 - a. Detailed inspections before and after assembly to ensure correctness of design and workmanship.
 - b. Provide groups of wires leaving the shipping-assembled equipment with terminal blocks with suitable numbering strips.
 - 3. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Provide the services of a manufacturer's representative to:
 - 1. Inspect, verify, and certify that the motor control center installation meets the manufacturer's requirements.

3.09 ADJUSTING

- A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16445

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Panelboards serving feeder circuits and branch circuits.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Underwriter's Laboratories, Inc. (UL):
 - 1. 67 - Standard for Panelboards.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Circuit breaker panelboards as indicated in the panelboard schedules, one-lines, and where indicated on the Drawings:
 - 1. Service voltage and configuration as indicated on the panel schedules.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Manufacturer of panelboard.
 - 2. Bill of material.
 - 3. Assembly ratings including:
 - a. Voltage.
 - b. Phase.
 - c. Continuous current.
 - d. Short circuit interrupting rating.
 - 4. NEMA enclosure type.
 - 5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
 - 6. Furnish circuit breaker submittals as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
 - 7. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050 - Common Work Results for Electrical:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.

- b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
 - 1. Drawings to contain:
 - a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
 - 1) Height.
 - 2) Length.
 - 3) Width.
 - b. Weight.
 - c. Anchoring locations.
 - d. Breaker layout drawing with dimensions:
 - 1) Location of the main, branches, solid neutral, and ground.
 - e. Conduit entry/exit locations:
 - 1) Identify all conduit entry/exit locations and restrictions.
 - f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.
- D. Installation instructions:
 - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 - 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 - 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050 - Common Work Results for Electrical.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- E. Operations and maintenance manual:
 - 1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
 - a. Including but not limited to:
 - 1) Instruction narratives and bulletins.
 - 2) Renewal parts lists.
 - 3) Time-current curves for all devices.
- F. Calculations:
 - 1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Panelboards shall be UL listed and labeled.

1. Where indicated as service entrance equipment, panelboards shall be UL labeled and listed "Suitable for Service Entrance."

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 1. General Electric Co.
 2. Eaton.
 3. Schneider Electric.
- B. Circuit breakers:
 1. Same manufacturer as the panelboard.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. Provide panelboards with:
 1. Molded-case circuit breakers with trip ratings as shown on the panel schedules.
 2. Spares and spaces for future circuit breakers in panels as shown on the panel schedules.

- B. Short circuit rating:
 - 1. Provide panelboards with short-circuit ratings as indicated on the Drawings:
 - 2. Testing method in accordance with UL 67.
 - 3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
 - 4. Panelboards shall be fully rated.

2.06 COMPONENTS

- A. Enclosure:
 - 1. NEMA enclosure type as indicated on the Drawings.
 - a. Where not indicated on the Drawings, as specified in Section 16050 - Common Work Results for Electrical for the installed location.
 - 2. Minimum width: 20 inches.
 - 3. Gutter space in accordance with the NEC:
 - a. Minimum of 4 inches of gutter space.
 - 4. Dead-front, no live parts when the panelboard is in service.
 - 5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
 - 6. 4-piece front to provide ease of wiring access.
 - 7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
 - a. Minimum 2 keys per panelboard.
 - b. Key all panelboard locks alike.
 - 1) Match locks on existing panelboards to the extent possible.
 - 8. Circuit directory frame and card on the inside of the door.
 - 9. Door-in-door construction consists of a one-piece front with 2 doors:
 - a. The smaller door provides access to all device handles and rating labels and shall be lockable.
 - b. The larger door provides access to all conductors and wiring terminals.
 - 10. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.
 - 11. Outdoor locations: Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard, unless otherwise indicated.
- B. Bus:
 - 1. General:
 - a. Tin-plated copper.
 - 2. Phase bus:
 - a. Full size and height without reduction.
 - b. Sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees Celsius:
 - 1) Limit current density to less than 1,000 amps per square inch.
 - c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
 - 3. Ground bus:
 - a. Copper, solidly bonded.
 - 4. Neutral bus:
 - a. Provide where indicated on the Drawings.
 - b. 100 percent rated.
 - c. Provide lugs for each outgoing feeder requiring a neutral connection.

5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.
- C. Lugs:
 1. UL listed for copper and aluminum wire:
 - a. Provide lugs rated for 75-degree Celsius terminations.
 - b. Provide bolted or compression main lug terminations as required for the incoming cable size.
- D. Circuit breakers: As specified in Section 16412 - Low Voltage Molded Case Circuit Breakers and as indicated on the Drawings:
 1. Provide all circuit breakers with bolt-on connections:
 - a. Plug-in circuit breakers are not allowed.

2.07 ACCESSORIES

- A. Surge protective devices:
 1. Furnish panelboards with surge protective devices as indicated on the Drawings.
 2. As specified in Section 16285 - Surge Protective Devices.
- B. Nameplates:
 1. As specified in Section 16075 - Identification for Electrical Systems.
 2. Install on outside of door.
 3. Indicating:
 - a. Panel designation.
 - b. Voltage.
 - c. Number of phases and configuration.
- C. Circuit identification labels:
 1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
 2. Type all information on the cards using designations in the panel schedules.
 3. Laminated on both sides.
- D. Pad locking mechanism:
 1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
 2. At a minimum, provide 1 mechanism per panelboard:
 - a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer's standard gray.
- B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
 - 1. Surface, flush or MCC mounted as indicated on the Drawings.
 - 2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
 - 3. Perform work in accordance with the manufacturer's instructions and shop drawings.
 - 4. Provide all brackets, hangers, supports, and hardware for mounting as required.
 - 5. In all NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
 - a. Use only stainless steel mounting hardware.
 - 6. Mount panelboard so that top operating handle is not more than 6 feet and 7 inches above the operating floor.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.
- B. Factory testing:
 - 1. Perform standard factory tests on the panelboards:
 - 2. Test in accordance with the latest version of NEMA and UL standards.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES

- A. Circuiting within the panelboard shall match the panel schedules as indicated on the Drawings.
- B. Provide typewritten schedule in each panelboard.

END OF SECTION

SECTION 16491
TRANSFER SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Transfer switches.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Underwriters Laboratories (UL):
 - 1. UL 1008 Transfer Switch Equipment.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions:
 - 1. ATS: Automatic transfer switch.
 - 2. MTS: Manually initiated, electrically operated transfer switch.

1.04 SYSTEM DESCRIPTION

- A. Provide transfer switches capable of transferring load circuits from utility power to standby power and back.
- B. ATS sequence of operation:
 - 1. When the voltage of any normal source phase drops below 80 percent and after an adjustable time delay (0 to 6 seconds minimum), the transfer switch shall start the standby generator.
 - 2. When standby voltage reaches 90 percent of nominal, and frequency is within 2 hertz of nominal, following an adjustable time delay (0 to 10 seconds), the switch shall transfer to standby power.
 - 3. When normal power has been restored to 90 percent of nominal on all phases, following an adjustable time delay (0 to 30 minutes), the switch shall retransfer to normal power.
 - a. If the standby source fails during this time delay, the switch shall automatically retransfer to normal power.
 - 1) The switch shall have an adjustable delay transition timer (0 to 5 minutes) for the load disconnect position.
 - 2) An alarm shall be initiated if the switch fails to retransfer in a
 - 4. Following an adjustable generator cool-down timer (0 to 60 minutes), the switch shall stop the generator.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Manufacturer of transfer switch.
 - 2. Manufacturer of all component parts of the ATS.
 - 3. Dimensions:
 - a. Width.
 - b. Length.
 - c. Height.
 - d. Weight.
 - 4. Bill of material.
 - 5. Description of operation.
 - 6. Ratings:
 - a. Voltage.
 - b. Phase.
 - c. Current.
 - d. Number of poles.
 - 7. List of recommended spare parts.
 - 8. For equipment installed in structures designated as Seismic Design Category C, D, E, or F, submit the following as specified in Section 16050 - Common Work Results for Electrical:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
 - 1. Layout drawings:
 - a. Furnish full-dimension and to-scale equipment layout drawings which include:
 - 1) Plan, front, and side views.
 - 2) Sub-panels.
 - 3) Interior panels.
 - 4) Top and bottom conduit windows.
 - 2. Complete electrical wiring diagrams:
 - a. Point-to-point connections.
 - b. Indicate wire numbers.
 - 3. Complete interface and connection diagrams.
- D. Installation instructions:
 - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 - 2. For equipment installed in structures designated as Seismic Design Category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 - 3. For equipment installed in structures designated as Seismic Design Category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind

loads as specified in Section 16050 - Common Work Results for Electrical.

- b. Submit anchoring drawings with supporting calculations.
- c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

E. Operation and maintenance manuals:

- 1. Operating instructions:
 - a. Printed and framed instruction chart suitable for wall hanging.
 - b. Detail the operational functions of all transfer switch controls.
- 2. Maintenance manual:
 - a. Furnish maintenance manuals with instructions covering maintenance of all equipment and data identifying all parts.
 - b. Furnish all information needed to maintain the transfer switch including, but not limited to, the following:
 - 1) Instructions for testing, adjustment, and start-up.
 - 2) Detailed control instructions that outline the purpose and operation of every control device used in normal operation.
 - 3) Description of the sequence of operation that outlines the steps that follow normal power failure, transfer to standby power, return to normal power, and fault conditions.
 - 4) Schematics and wiring:
 - a) Furnished in a reduced 11-inch-by-17-inch fully legible format.
 - 5) Report listing the installed setting of all adjustable parameters for the automatic transfer system.

F. Test forms and reports:

- 1. Submit complete factory acceptance test procedures and all forms used during the test.
- 2. Manufacturer to furnish certified report after the factory tests.
- 3. Manufacturer to furnish written report after start-up:
 - a. Report must state that the installation is complete and satisfactory, or list items requiring additional attention and a proposal for the corrective actions.
 - b. If the items require attention after the initial start-up, a final report is required stating that the installation is complete and satisfactory.

G. Calculations:

- 1. Detailed calculations or details of the actual physical testing performed on the transfer switch to prove the transfer switch is suitable for the seismic requirements at the Project Site.

H. Warranty.

1.06 QUALITY ASSURANCE

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Transfer switches shall be UL listed and labeled.

- 1. Where indicated on the Drawings the transfer switch shall be UL labeled and listed "Suitable for Service Entrance."

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Ship the transfer switch to the job site on a dedicated air-ride vehicle that will allow the Contractor to utilize on-site off-loading equipment.
- C. Furnish temporary equipment heaters within the transfer switch to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Transfer switch: One of the following or equal:
 - 1. GE Zenith Controls, Inc.
 - 2. Russelectric, Inc.
 - 3. Eaton.
 - 4. ASCO.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. General:
 - 1. Capable of switching all classes of load.
 - 2. Rated for continuous duty when installed in a non-ventilated enclosure.
 - 3. Provide circuit breakers or contactors rated for continuous duty.

4. Minimum transfer time for delayed transition ATS: 1 second.
 5. Capable of transferring successfully in either direction with 70 percent of rated voltage applied to the terminals.
 6. Provide automatic transfer switches with provisions for manual operation under no load.
- B. Electrical ratings:
1. Voltage, configuration, and amp ratings as indicated on the Drawings.
 2. Withstand and close into fault ratings in accordance with UL 1008.
- C. Contacts:
1. Mechanically held.
 2. Mechanically interlocked to prevent normal and standby sources from being closed at the same time.
 3. Silver alloy construction.
 4. Neutral contact, when indicated on the Drawings:
 - a. Same ratings as the phase contacts.
 - b. Break last and make first operation.
- D. Controls:
1. ATS shall have 3-phase over-voltage, under-voltage, over-frequency, and under-frequency on both normal and standby sources.
 2. ATS shall have a synch check relay for closed transfer:
 - a. Allows re-transfer when normal and standby sources are within 5 electrical degrees and within 5 percent of voltage.
 3. Control panel:
 - a. Microprocessor based.
 - b. 4-line, 20-character LCD display. Displayed data shall include:
 - 1) Normal and standby source parameters.
 - 2) Diagnostic information.
 - 3) Switch and timer status.
 - c. Keypad for making all ATS settings and operating parameters.
 - 1) All settings shall be password protected.
 - d. LED display of the following:
 - 1) Normal source available.
 - 2) Connected to normal source.
 - 3) Standby source available.
 - 4) Connected to standby source.
 - e. Communications: Modbus TCP.
 - f. Provisions for testing ATS operation by simulating a normal source failure.
 - g. Generator exerciser:
 - 1) Programmable to start the generator on a daily, weekly, monthly, or yearly basis for an adjustable period of time.
 - 2) Load or no load selectable.
 - a) When load is selected, ATS will transfer to the generator for the duration of the exercise period. Re-transfer back and cool down the generator.
 - b) When no load is selected, the ATS will run the generator for the duration of the exercise period and then stop the generator.
 4. Status and control contacts:
 - a. Generator start/stop contact:
 - 1) Single-pole, double-throw.

- 2) Rated for 5 amps at 30 VDC.
- b. Status contacts:
 - 1) Single-pole, double-throw.
 - 2) Rated for 10 amps at 250 VAC.
 - 3) Provide contacts for the following:
 - a) Normal source available.
 - b) Normal source failure.
 - c) Connected to normal source.
 - d) Standby source available.
 - e) Standby source failure.
 - f) Connected to standby source.

E. Enclosure:

- 1. Open type for mounting in electrical equipment as indicated on the Drawings.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

- B. Factory testing:
 - 1. Complete factory test to verify proper operation of all timers, settings, and operation.
 - 2. In accordance with UL-1008.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16510

LIGHTING: LED LUMINAIRES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: LED luminaires, drivers, poles, and accessories.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Illuminating Engineering Society of North America (IESNA):
 - 1. LM-79 - IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.
 - 2. LM-80 - IES Approved Method: Measuring Lumen Maintenance of LED Light Sources.
 - 3. TM-21 - Projecting Long Term Lumen Maintenance of LED Light Sources.
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
- D. National Electrical Manufacturers Association (NEMA):
 - 1. 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts.
- E. Underwriters Laboratories (UL):
 - 1. 1598 - Luminaires.
 - 2. 8750 - Light Emitting Diode (LED) Equipment For Use In Lighting Products.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Specific definitions and abbreviations:
 - 1. CCT: Correlated color temperature - Scientific scale to describe how "warm" or how "cool" the light source is, measured in Kelvin. The lower the Kelvin temperature, the warmer the light feels, or appears.
 - 2. CRI: Color Rendering Index - A quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source.
 - 3. Driver - Device that manages power and controls the current flow from AC to DC for an LED lighting product.
 - 4. Efficacy - Lumen output of a light source per unit of power supplied to that source (lumens per watt).
 - 5. EMI: Electromagnetic Interference - Electrical interference (noise) generated by electrical and electronic devices.
 - 6. FC: Foot Candles - Measure of light level on a surface being illuminated.

7. L70 - The extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
8. LED: Light emitting diode - A solid-state semiconductor device that produces light when electrical current flows through it.
9. LED light source - See LED luminaire.
10. LED luminaire - A complete lighting unit consisting of LED-based light emitting elements and a matched driver together with parts to distribute light, to position and protect the light emitting elements, and to connect the unit to a branch circuit.
11. Lumen - The international (SI) unit of luminous flux or quantity of light. The amount of light that is spread over a square foot of surface by one candle power when all parts of the surface are exactly one foot from the light source.
12. Lumen ambient temperature multiplier - LED light source relative lumen output when compared to a standard ambient temperature.
13. Lumen maintenance factor - How well an LED light source is able to retain its intensity when compared to new.
14. Luminaire - Lighting unit.
15. THD: Total harmonic distortion - The combined effect of harmonic Distortion on the AC waveform produced by a driver or other device.

1.04 SYSTEM DESCRIPTION

- A. Provide luminaires, and accessories for all lighting systems, complete and operable, in accordance with the requirements of the Contract Documents.
- B. Individual luminaire types are indicated on the Drawings and on the Luminaire Schedule.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 1. LED Luminaires:
 - a. Catalog literature for each luminaire specified, cross-referenced to the luminaire type on the Luminaire Schedule in the Drawings.
 - b. Provide for each luminaire type:
 - 1) Materials.
 - 2) Type of diffuser.
 - 3) Hardware.
 - 4) Gasketing.
 - 5) Reflector.
 - 6) Chassis.
 - 7) Finish and color.
 - 8) Driver type and protection.
 - 9) LED luminaire:
 - a) Initial lumen output at 40 degrees Celsius ambient.
 - b) Correlated color temperature.
 - c) Lumen maintenance factors.
 - d) Lumen ambient temperature multipliers.
 - e) Drive current.

- f) Efficacy.
- 10) Picture of luminaire.
- 11) Dimensioned drawings:
 - a) Effective projected area rating for pole mounted luminaires.
- 12) Weight.
- 13) Photometric data:
 - a) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
 - b) Luminaire dirt depreciation factor.
 - c) Candlepower distribution curves.
 - d) Average luminaire brightness.
 - e) Lumen output charts.
- 14) Furnish support method for interior luminaires weighing more than 30 pounds and all wall-mounted luminaires:
 - a) Support methods shall be based on seismic requirements at the project site as specified in Section 16050 - Common Work Results for Electrical.
- c. Luminaire substitutions:
 - 1) Provide complete literature for each luminaire substitution:
 - 2) Submittals for substituted luminaires shall be sufficient for competent comparison of the proposed luminaire to the originally specified luminaire:
 - a) Photometric data:
 - (1) IES file in standard IES format.
 - (2) Coefficient of utilization tables based on the IES zonal cavity system by an approved testing laboratory.
 - (3) Candlepower distribution curves.
 - (4) Average luminaire brightness.
 - (5) Lumen output charts.
 - (6) Power requirements in watts and volt-amperes.
 - b) Calculations:
 - (1) Provide software generated calculations showing illuminance levels in footcandles and power usage in watts per square foot for each of the areas in which substitutions are proposed:
 - (a) Use surface reflectance values and luminaire light loss factors approved by the Engineer to perform all calculations.
 - c) Specification sheets:
 - (1) If lacking sufficient detail to indicate compliance with contract documents, standard specification sheets will not be accepted. This includes, but is not limited to, luminaire type designation, manufacturer's complete catalog number, voltage, LED type, CCT, CRI, specific driver information, system efficacy, L70 life rating, and any modifications necessary to meet the requirements of the contract documents.
 - 3) Substitutions for specified luminaires will be evaluated upon quality of construction, light distribution, energy use, appearance, and maintenance.
 - 4) Substitutions shall comply with all applicable building and energy codes.

2. Driver: Provide for each driver type:
 - a. Catalog number.
 - b. Type of driver.
 - c. Output wattage.
 - d. Input voltage.
 - e. Operating voltage range.
 - f. Maximum input power.
 - g. Efficiency.
 - h. Operating line current.
 - i. Power factor.
 - j. Operating temperature range.
 - k. Current output range in ambient temperatures of 30 to 55 degrees Celsius.
 - l. Surge suppression data.
3. Photocell:
 - a. Provide for each photocell type:
 - 1) Switching capacity.
 - 2) Life expectancy when used on LED sources.
 - 3) The means of adjusting the lighting pickup level.
 - 4) Enclosure type.
 - 5) Mounting method.
4. Luminaire poles:
 - a. Submit complete data for each pole type including but not limited to:
 - 1) Material.
 - 2) Finish and color.
 - 3) Handholes.
 - 4) Anchoring.
 - 5) Luminaire attachment methods and fittings.
 - 6) Pole height.
 - 7) Pole dimensions.
 - 8) Bolt hole circle layout and hardware.
 - 9) Accessories.
 - 10) Provide the EPA wind load rating.

C. Calculations:

1. Provide complete design calculations and installation documents for pole mounting piers and poles mounted from structures:
 - a. Include in the calculations the wind and seismic requirements at the project site.
 - b. Calculations and design shall be performed by and signed by a Professional Engineer registered in the state where the project is being constructed:
 - 1) Because this design is being provided by a Professional Engineer, the submittal will be reviewed for form and content but not reviewed for technical completeness, methods, or calculations.

D. Record documents:

1. Update the Luminaire Schedule in the Drawings to reflect the acceptable substitutions, after the substitution has been reviewed and accepted by the Engineer.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

- A. Exterior and outdoor lighting system operation shall be demonstrated during the hours of darkness.
- B. Lighting demonstration shall occur within 2 weeks before substantial completion.

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. LED luminaire:
 - 1. 5 year warranty from the date of installation including material, workmanship, photometrics, driver, and LED modules.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

- A. Furnish 1 complete spare LED luminaire, with driver, of each type used.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Luminaires:
 - 1. The following or equal:
 - a. As noted on the Luminaire Schedule.
- B. Drivers:
 - 1. One of the following or equal:
 - a. Philips Advance.
 - b. Thomas Research.
 - c. eldoLED.

- C. Photo-electric cells:
 - 1. One of the following or equal:
 - a. Cooper.
 - b. Tork.
 - c. Intermatic.
- D. Substitutions:
 - 1. The lighting design and luminaire selection has been based upon the photometric data of the identified luminaire. It is the Contractor's responsibility to ensure and prove to the Engineer at time of submittal the substitutions meet the quality and photometric requirements of the original design.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. LED Luminaires:
 - 1. General:
 - a. Pre-wired with leads of 18-AWG, minimum, for connection to building circuits.
 - b. Provide the luminaires furnished per the Luminaire Schedule in the Drawings:
 - 1) The Specifications noted in this Section are an addition or supplement to the Luminaire Schedule.
 - c. Individual LEDs connected such that a catastrophic loss or the failure of 1 LED will not result in the loss of the entire luminaire.
 - 2. Minimum ambient temperature range of 0 degrees Celsius to 40 degrees Celsius.
 - 3. Minimum rated life:
 - a. Office Areas: 70,000 hours when operated at 25 degrees Celsius.
 - b. Process Areas: 60,000 hours when operated at 40 degrees Celsius.
 - c. Hazardous Areas: 50,000 hours when operated at 40 degrees Celsius.
 - 4. Minimum efficacy of 70 lumens/watt.
 - a. Hazardous Areas: Minimum 60 lumens/watt.
 - 5. Minimum Color Rendering Index of 70.
 - 6. Tested according to IESNA LM-79 and LM-80.
 - 7. Lumen maintenance projection in accordance with IESNA TM-21.
 - 8. RoHS compliant.
 - 9. Integral driver.
 - 10. Suitable for dry, damp, or wet locations as indicated on the Drawings or on the Luminaire Schedule.
 - a. Wet or damp locations: UL 1598 listed.
 - 11. Designed as a complete LED assembly. Retrofit LED lamps in luminaires not designed specifically for LED light sources shall not be used.
 - 12. Exterior/outdoor luminaires:
 - a. Luminaires in combination with their mounting pole and bracket shall be capable of withstanding:
 - 1) Wind levels at the project site without damage.

- 2) Seismic levels at the project site.
 - b. Corrosion-resistant hardware and hinged doors or lens retainer.
 - c. Luminaires furnished with integral photoelectrical control shall be of the luminaire manufacturer's standard design.
- 13. Luminaires in hazardous areas:
 - a. In accordance with NEC Section 500 requirements.
 - b. UL labeled and identified for hazardous area.
 - c. Marking on Class I and II Division 1 and 2 areas shall identify the applicable material classification group.
 - d. Marking shall include the temperature class (T code).
- B. Photo-electric cells:
 - 1. Photoelectric cells for control of multiple luminaires:
 - a. Self-contained.
 - b. Weatherproof.
 - c. Provided with time-delay features.
 - d. Sized to meet switching capacity of the circuit:
 - 1) Based on luminaire VA as indicated on the Drawings.
 - 2. Photoelectric cell for control of a single luminaire:
 - a. Integral to the luminaire.
- C. Luminaire control:
 - 1. Lighting control relays or contactors as specified in Section 16422 - Motor Starters.
- D. Drivers:
 - 1. Dimmable, with dimming signal protocol of 0-10 VDC or DALI.
 - 2. Input power source:
 - a. As indicated on the Drawings.
 - 3. Drive current:
 - a. As indicated in the Luminaire Schedule.
 - 4. Power factor: greater than 0.90.
 - 5. Efficiency: greater than 80 percent.
 - 6. Total harmonic distortion (THD) of the input current less than 20 percent.
 - 7. Rated life of 60,000 hours in an LED luminaire operated at an ambient temperature of 40 degrees Celsius.
 - 8. Minimum operating temperature of -40 degrees Celsius.
 - 9. Sound rating: Class A+ or quieter.
 - 10. UL listed Class 2 Outdoor in accordance with UL 8750.
 - 11. In accordance with IEEE C62.41 Category A for transient protection.
 - 12. Driver must limit inrush current:
 - a. Meet or exceed NEMA 410 driver inrush standard:
 - 1) 230 Amps per 10 Amp load with a maximum of 106 Amps squared-seconds at 120V.
 - 2) 430 Amps per 10 Amp load with a maximum of 370 Amps squared-seconds at 277V.

2.06 COMPONENTS

- A. Luminaire poles:
 - 1. As indicated on the Luminaire Schedule.

2. Anchor bolts:
 - a. Use anchor bolts, bolts, or welded studs for anchors for resisting seismic and wind forces.
 - 1) Standard hex bolt head.
 - 2) Do not use anchor bolts fabricated from rod stock with an L or J-shape.
 - b. Complete with leveling shims.
3. Anchor base:
 - a. Fabricated from the same type of material as the pole shaft.
 - b. Base plate to telescope the pole shaft.
 - c. Welded top and bottom along the entire perimeter.
 - d. With slotted bolt holes on the bolt circles as submitted.
4. Pole shaft:
 - a. As indicated on the Luminaire Schedule.
5. Handhole:
 - a. Reinforced handhole located approximately 18 inches above the base.
 - b. Complete with cover fabricated from the same material as the pole shaft and stainless steel attachment screws.
 - c. With an integral ground connection nut, 1/2 inch by 13 inch UNC welded to the pole for connection to the grounding system.
6. Shroud:
 - a. Fabricated from the same type of material as the pole shaft.
 - b. 1-piece formed channel section that shall conform to the pole shaft taper.
 - c. Secured by a locking device with provisions for a padlock to prevent accidental lowering.
7. Fastening hardware:
 - a. All fasteners shall be stainless steel.
8. Finish:
 - a. As indicated on the Luminaire Schedule.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install luminaires per the manufacturer's guidelines and submitted installation calculations to meet seismic and wind requirements at the project site.

- C. Special techniques:
 - 1. Support luminaires from structural elements capable of carrying the total weight.
 - 2. Install luminaires plumb and square with building and wall intersections:
 - a. Suspend pendant-mounted luminaires that are mounted from sloping ceilings with ball hangers, unless otherwise indicated on the Drawings.
 - b. Install luminaires in machinery rooms after machines have been installed, so as to ensure no conflict with machinery, piping, or ductwork.
 - 3. In all cases, coordinate luminaire locations with work of other trades to prevent obstruction of light from the fixtures:
 - a. Locate bottom of luminaire approximately at the bottom of ductwork, unless otherwise specified or indicated on the Drawings.
 - 4. Support luminaires weighing more than 25 pounds independently of the outlet box and the conduit.
 - 5. Provide ceiling or pendent mounted luminaires with a safety chain connecting the lens, driver, and other components to the building structure.
 - 6. Provide recessed luminaires with auxiliary safety supports attached directly to the building structure:
 - a. The safety supports shall consist of number 12 AWG soft drawn galvanized wires.
 - 7. Install luminaires in accordance with the architectural reflected ceiling Drawings:
 - a. Center luminaires on ceiling tiles unless otherwise indicated.
 - 8. Support luminaires installed in suspended grid ceilings, independently of the grid:
 - a. Provide seismic restraint clips for all luminaires installed in suspended grid ceilings.
- D. Luminaire poles:
 - 1. Set poles on anchor bolts and secured with double nuts on each bolt.
 - 2. Dry-pack the pole base, after the luminaire and pole has been leveled and plumbed.
 - 3. Bond metal poles to the plant grounding system, utilizing a ground lug connection within the pole:
 - a. Route ground conductor through pier and pole base sleeve using Schedule 40 PVC conduit.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING

- A. Aim and verify all exterior and outdoor luminaires alignment, during dark evening hours, as directed by Owner or the Engineer.

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Clean all lenses, diffusers, and reflectors.
- C. Refinish all luminaires' trim, poles, and support brackets, where finish has been damaged.
- D. Clean all LED luminaires (new and old), used during construction for construction lighting, before substantial completion.
- E. Clean and re-lamp all existing fluorescent and HID luminaires used during construction for construction lighting, before substantial completion.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES

- A. Refer to the Luminaire Schedule in the Drawings.

END OF SECTION

SECTION 16710

FIRE ALARM AND SMOKE DETECTION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Fire alarm systems, including:
 - a. Initiating devices.
 - b. Notification appliances.
 - c. Controls.
 - d. Supervisory devices.
 - e. Software.
- B. Utilize a single Fire Alarm System Supplier (FASS) to design, furnish, and install all materials, equipment, labor, and services required to achieve a fully integrated and operational fire alarm system, in complete compliance with the NFPA Class and Style specified.
- C. Coordinate the fire alarm system with related equipment and materials furnished under other sections of these Specifications.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. FM Global (FM).
- C. Factory Mutual (FM).
- D. National Electric Code (NEC).
- E. National Fire Protection Association (NFPA):
 - 1. 72 - National Fire Alarm Code.
- F. Underwriters Laboratories, Inc. (UL):
 - 1. 268 - Standard for Smoke Detectors for Fire Alarm Systems.
 - 2. 268A - Standard for Smoke Detectors for Duct Application.
 - 3. 464 - Standard for Audible Signal Appliances.
 - 4. 1971 - Standard for Signaling Devices for the Hearing Impaired.

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Provide a complete, non-coded, addressable, microprocessor-based fire alarm system with initiating devices, notification appliances, and controls and supervisory devices for the Grit Removal Building (GRB) as specified in this Section.
 - 1. System connections for initiating (signaling) circuits and notification appliance circuits shall be Class B Style 4.
 - 2. Circuit supervision: Circuit faults shall be indicated by a trouble signal at the FACP. Provide a distinctive audible tone and alphanumeric annunciation.
- B. HVAC systems:
 - 1. The following groups of HVAC equipment shall be shut down by the FACP in the event a duct smoke detector on any equipment in the group senses smoke:
 - a. MAU-21.810, EF-21.830, EF-21.840.
 - b. MAU-21.820, EF-21.850, EF-21.860.
 - c. FAB-21.500.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Product data:
 - 1. Data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification including electrical characteristics such as voltage and current ratings, connection requirements, software and firmware versions and operational details of all equipment.
 - 2. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds, or does not comply with this Specification.
- C. Shop drawings:
 - 1. Fire detection system block diagram.
 - a. Fire detection functions and control interconnections for each building as described in this Section.
 - b. FACP layout, schematic, and wiring diagrams, panel displays, and LED arrangement.
 - c. Detection device type, features, and setpoints.
 - d. Number and size of wires, type of wire insulation required for devices specified, and conduit size for proposed circuits.
 - 2. System power and battery charts with performance graphs and voltage drop calculations to ensure that system will operate per the specified backup time periods and under all voltage conditions per UL and NFPA standards.
 - 3. Test reports indicating satisfactory completion of required tests and inspections.
 - 4. System layout on floor plan drawings, drawn to scale.
 - 5. Location diagrams for all ventilation duct mounted smoke detectors and corresponding ventilation system shutdown interlock.
 - 6. Fire alarm system input-output point list.
 - 7. Spare parts list for extra materials being furnished.

- 8. Operating and Maintenance data as specified in Section 01782 - Operation and Maintenance Data.
- D. Manufacturer's installation instructions.
- E. Designer, manufacturer and installer qualifications.
- F. Submit the equipment layout drawings and product data to the local authority having jurisdiction (AHJ), for review and approval of the proposed system.
 - 1. Contractor is responsible for paying plan check, permit and inspection fees as necessary.
 - 2. Submit AHJ's approval to Engineer.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Designer qualifications:
 - 1. Designer of similar installations for a minimum of 5 years with a satisfactory performance record.
- C. Manufacturer qualifications: Manufacturer of proposed system for a minimum of 10 years with satisfactory performance record.
- D. Installer qualifications: Manufacturer approved installer of products similar to specified products on a minimum of 3 projects of similar scope as this project with a satisfactory performance record.
- E. Installation to be supervised by NICET Level II Technician.
- F. Fire alarm systems shall be UL approved.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. Submit plans to AHJ for approval.
- B. Make submittals, including AHJ's approval to the Engineer.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

- A. Furnish service and maintenance of fire alarm system for 1 year from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Fire alarm and smoke detection systems:
 - 1. One of the following or equal:
 - a. Mircom
 - b. Siemens.
 - c. Simplex Grinnell.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. Provide the fire alarm system with all necessary hardware and software to perform the following functions:
 - 1. Fire alarm and detection operations.
 - a. Provide all required network interface modules, fiber optic communication modules, relay modules, and zone modules for interconnections as required and specified in this Section.
 - 2. Control and monitoring of duct mounted smoke detectors, heat detectors, smoke detectors, and other equipment as indicated in the Specifications or as indicated on the Drawings.
 - 3. Annunciation:
 - a. Operation of alarm and supervisory initiating devices shall be annunciated at the FACP indicating the location and type of device.
 - b. Signal transmission:
 - 1) Alarms from the FACP shall be routed to
 - a) PLC.
 - 4. System general alarm sequence:
 - a. Indication of alarm condition at the FACP.
 - b. Identification of the device that is the source of the alarm at the FACP.
 - c. Operation of audible and visible notification devices throughout the building until silenced at FACP.
 - d. Shutting down make-up air units and exhaust fans serving zone where alarm is initiated.

- e. Activate alarm contacts to the PLC.
- 5. Alarm silencing:
 - a. When the "Alarm Silence" button is pressed, all audible alarm signals turn off.
- 6. System reset:
 - a. Provide a system reset button that returns the system to its normal state.
 - b. Display messages providing operator assurance of the sequential steps as they occur.
 - c. The system shall verify all circuits or devices are restored before resetting the system to avoid the potential for re-arming the system.
 - d. Should an alarm condition continue, the system remains in an alarmed state.

2.06 COMPONENTS

- A. Fire alarm control panel (FACP):
 - 1. Power requirements:
 - a. 120 VAC input power via a dedicated circuit.
 - b. Battery system:
 - 1) Provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of 48 hours with 5 minutes of alarm operation at the end of this period.
 - 2) The system shall automatically transfer to battery standby upon power failure.
 - 3) Provide automatic battery charging and recharging operations.
 - 4) Supervise the system batteries so that a low battery condition or disconnection of the batteries indicates a trouble at the FACP.
 - c. All circuits requiring system operating power shall be 24 VDC with individual fuses at the FACP.
 - d. Supervise the incoming power to the system so that any power failure will be indicated at the control unit.
 - 1) A green "power on" LED shall be displayed continuously while incoming power is present.
 - 2) FACP shall sound a trouble signal at loss of primary power and to indicate when the system is operating on battery power.
 - 2. Alphanumeric display and system controls:
 - a. Include an LCD display to indicate alarm, supervisory, and component status messages and include a keypad for use in entering and executing control commands.
 - b. Display battery voltage and amperage readouts on LCD display.
 - 3. System supervision: Component or power supply failure places system in trouble mode.
 - 4. Distributed module operation: Capable of allowing remote location of the following modules; through a Style 4 (Class B) supervised serial communications channel:
 - a. Addressable signaling line circuits.
 - b. Initiating device circuits.
 - c. Notification appliance circuits.
 - d. Auxiliary control circuits.
 - e. Graphic annunciator LED/switch control modules.

5. Group actuating devices together in zones represented by zone light emitting diodes, LED.
 - a. Provide provisions for supervised zone remote annunciator outputs.
 - b. Actuation of a UL approved alarm-initiating device shall cause the respective red alarm LED to flash.
 - 1) This LED should continue to flash until the alarm acknowledge switch is actuated.
 - 2) Once acknowledged, the LED or zone LED will be constantly illuminated until the actuating device is restored to normal and the system is reset.
 6. FACP shall scan each addressable detector for its type identification to prevent inadvertent substitution of another sensor.
 - a. Upon detection of a "wrong device", the FACP shall operate with the installed device at the default alarm settings for that sensor; 2.5 percent obscuration.
 7. Supply with an alarm silence/acknowledge switch to silence the audible alarms.
 - a. Should a subsequent alarm actuation of a different zone occur, the alarm devices shall sound until silenced.
 8. Cabinet:
 - a. UL listed, lockable steel enclosure.
 - b. Front access only.
 - c. If more than a single unit is required to form a complete control unit, provide matching modular unit enclosures.
- B. Software:
1. Allows for loading and editing instructions and operating sequences as necessary.
 2. Capable of on-site programming to accommodate system expansion and facilitate changes in operation.
 3. Stored in a non-volatile programmable memory within the fire alarm control unit.
 4. Loss of primary and secondary power shall not erase the instructions stored in memory.
 5. Capable of full system operation during a new configuration download.
- C. Manual pull stations:
1. Description:
 - a. Double action type.
 - b. Red Lexan™ or metal enclosure.
 - c. Molded, raised-letter operating instructions of contrasting color.
 - d. Mechanically latches upon operation and remain so until manually reset by opening with a key common with the FACPs.
 2. Protective shield: Provide a tamperproof, clear Lexan™ shield and red frame that easily fits over manual pull stations.
- D. Smoke detectors:
1. In accordance with UL 268.
 2. Provide with the following features:
 - a. Factory nameplate: Serial number and type identification.
 - b. Operating voltage: 24 VDC, nominal.

- c. Plug-in arrangement: Detector and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection.
 - 1) Base to provide break-off plastic tab that can be removed to engage the head/base locking mechanism.
 - 2) No special tools required to remove head once it has been locked.
 - 3) Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit.
 - d. LED that will flash each time it is scanned by the FACP (once every 4 seconds). In alarm condition, the detector head LED shall be on steady.
 - e. Magnetically actuated test switch to provide for easy alarm testing at the detector location.
 - f. EMI and RFI shielded.
 - g. Furnish with a communication transmitter and receiver in the mounting base having a unique identification and capability for status reporting to the FACP.
 - 1) Detector address to be located in base to eliminate false addressing when replacing detectors.
 - 2) Setting of addresses not required for removal of the detector head for cleaning.
 - h. Type: Photoelectric smoke.
3. Provide end-of-line resistors as required.

E. Duct smoke detectors:

- 1. Photoelectric type:
 - a. Sampling tube design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied.
- 2. Duct housing:
 - a. Furnish with supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7A at 28 VDC or 10A at 120 VAC. This auxiliary relay output shall be fully programmable.
 - 1) Auxiliary relay operates when the detector reaches its alarm threshold.
- 3. Compact duct housing:
 - a. Transparent cover to monitor for the presence of smoke.
 - 1) Secured to housing by means of 4 captive fastening screws.
- 4. Duct housing:
 - a. Provide 2 test ports for measuring airflow and for testing.
 - 1) Ports will allow aerosol injection in order to test the activation of the duct smoke detector.
 - b. Provide a magnetic test area.
 - c. Red sensor status LED.
 - d. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.
- 5. Remote test station with an alarm LED and test switch.
- 6. Maintain circulation of conditioned air around the internally mounted addressable duct sensor housing to keep the sensor housing at its rated temperature range.
- 7. UL Listed to Standard 268A.

8. Detectors to provide a trouble signal to the FACP when the detector has reached its limit to compensate for environmental changes.
- F. Heat detectors:
1. Provide heat fire detectors as required by the AHJ.
 2. UL listed and FM approved.
 3. Heat detector:
 - a. Combination fixed-temperature and rate-of-rise unit with plug-in base and alarm indication lamp.
 - b. Fixed-temperature setting: 135 degrees Fahrenheit.
 4. Thermistor-based, rate-compensated, and not be affected by thermal lag.
 5. Detector fixed temperature sensing should be independent of rate-of-rise sensing and programmable to operate at 135 degrees Fahrenheit or 155 degrees Fahrenheit.
 - a. Detector rate-of-rise temperature detection to be selectable at the FACP for either 15 degrees Fahrenheit or 20 degrees Fahrenheit per minute.
 6. Provide end-of-line resistors as required.
- G. Circuit interface modules:
1. Type 1: Monitor circuit interface module:
 - a. For conventional 2-wire smoke detector and/or contact device monitoring with Class B or Class A wiring supervision.
 - 1) Supervision of the zone wiring will be Class B.
 - 2) Module shall communicate status (normal, alarm, trouble) to the FACP.
 - b. For conventional 4-wire smoke detector with Class B wiring supervision.
 - 1) Module shall provide detector reset capability.
 - 2) Fuse to provide over-current power protection for the 4-wire detector: 2 amp.
 - 3) Module will communicate status (normal, alarm, trouble) to the FACP.
 2. Type 2: Control circuit interface module:
 - a. Module for signals and other device control with Style 4 and Style 6 wiring supervision.
 - b. For non-supervised control.
 - c. Provide double pole double throw relay switching for 1 A at 28 VDC resistive, power limited and at 1/2 A at 120 VAC resistive, non-power limited.
 - d. The system shall be capable of energizing 100 percent of the relays connected to the signaling line circuit.
 3. Type 3: Line powered monitor circuit interface module:
 - a. Power and its communications supplied by the 2 wire multiplexing signaling line circuit.
 - b. Provides location specific addressability to an initiating device by monitoring normally open dry contacts.
 - c. Module is required for monitoring water flow and tamper switches.
 4. The circuit interface module to be supervised and uniquely identified by the control unit.
 - a. Identification to be transmitted to the control unit for processing according to the program instructions.
 - b. On-board LED to provide an indication that the module is powered and communicating with the FACP.

- c. LEDs provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

H. Wiring:

- 1. As specified in Section 16123 - 600-Volt or Less Wires and Cables.
- 2. Wire and cable shall be a type listed for its intended use by an approval agency acceptable to the AHJ.
- 3. SLC channel wiring shall be unshielded twisted pair.
 - a. Capacitance rating of less than 60 picofarads per foot.
 - b. Minimum 3 twists (turns) per foot.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install system components and all associated devices in accordance with applicable NFPA Standards and manufacturer's recommendations.
- C. Smoke detectors shall not be installed until after construction cleanup on all trades is complete and final in accordance with NFPA 72.
- D. Locate FACP as indicated on the Drawings.
- E. Device location-indicating lights: Locate in the public space immediately adjacent to the device.
- F. Wiring:
 - 1. System wiring:
 - a. Installed in accordance with the appropriate articles from NEC.
 - 2. Color coding:
 - a. Color-code fire alarm conductors differently from the normal building power wiring.
 - b. Use 1 color code for alarm initiating device circuits wiring and a different color code for supervisory circuits.
 - c. Color-code notification appliance circuits differently from alarm-initiating circuits.

- d. Paint fire alarm system conduits, junction boxes, and covers red.
- e. Circuit that provides power to the FACP shall have a red marking and be identified as "FIRE ALARM CIRCUIT" in accordance with NFPA 72.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01330 - Submittal Procedures.
- B. Owner training:
 - 1. As specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Manufacturer's field services: Provide services of a factory-authorized service representative to:
 - 1. Supervise the field assembly and connection of components and the pre-testing, testing, and adjustment of the system.
 - 2. Verify proper installation, correct deficiencies, and be present at the jobsite during final inspection by the Engineer.
- C. Field tests:
 - 1. Notify the Engineer and the AHJ in writing a minimum of 2 weeks before the scheduled day for the field acceptance tests.
 - 2. Furnish the services of a field service engineer, and any special tools, equipment and labor to perform the tests.
 - 3. Each device and control function shall be individually witness tested and recorded:
 - a. All acceptance tests shall be witnessed by and signed off by the Engineer, the FASS's field engineer, the installing Subcontractor, and a representative of the AHJ.
 - 4. The approved Field Acceptance Test Binder shall form the basis of the documentation of the system acceptance tests:
 - a. Furnish 2 certified copies of the tests.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULE (NOT USED)

END OF SECTION

SECTION 16920

PRE-FABRICATED WALK-IN ELECTRICAL ENCLOSURES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pre-fabricated walk-in electrical enclosures, completely engineered and assembled.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
 - 1. 210/240 - Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.
 - 2. 270 - Sound Rating of Outdoor Unitary Equipment.
 - 3. 340/360 - Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
- C. Air Moving and Conditioning Association International, Inc. (AMCA):
 - 1. Standard 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
- D. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
 - 1. Standard 15 - Safety Standard for Refrigeration Systems.
 - 2. Standard 52.2 - Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size.
 - 3. Standard 62 - Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings.
- E. ASTM International (ASTM):
 - 1. A36 - Standard Specification for Carbon Structural Steel.
 - 2. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
- F. International Organization for Standardization (ISO):
 - 1. 9001 - Quality Management Systems - Requirements.
- G. National Electrical Manufacturer's Association (NEMA):
 - 1. NEMA Type TEFC enclosure in accordance with NEMA 250.
- H. National Fire Protection Association:
 - 1. NFPA 70 - National Electric Code (NEC).
 - 2. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

- I. Steel Structures Painting Council (SSPC):
 - 1. SP-1 - Solvent Cleaning.
 - 2. SP-2 - Hand Tool Cleaning.
 - 3. SP-3 - Solvent Cleaning.
- J. Underwriters Laboratories Inc. (UL).

1.03 DEFINITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.04 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Designed and environmentally controlled to provide protection to all equipment it contains under the specified Project Site conditions.
 - a. Size the enclosure to accommodate the actual equipment furnished including all Code required clearances and access.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. Furnish submittals for all electrical equipment contained within the enclosure as required by the section covering the equipment.
- C. Product data:
 - 1. Manufacturer of enclosure.
 - 2. Manufacturer of component parts of enclosure.
 - 3. Weight of enclosure.
 - 4. Complete bill of material indicating quantity, description, and part number.
 - 5. Anchorage hardware.
 - 6. Enclosure infrastructure, including but not limited to:
 - a. Lighting fixtures.
 - b. Receptacles.
 - c. Raceways.
 - d. Wire.
 - e. Data and telecom jacks.
 - f. HVAC equipment.
- D. Shop drawings:
 - 1. Layout drawings:
 - a. Provide fully dimensioned and to scale equipment layout drawings which include:
 - 1) Enclosure plan view including layout of internal equipment.
 - 2) Enclosure elevations of front, back and both sides.
 - 3) Enclosure base/skid plan including mounting details, cable entry areas and floor openings, and door swing requirements.
 - 2. Wiring diagrams:
 - a. Provide detailed raceway layout and wiring diagrams for all interconnections within the enclosure, including conduit sizes and wire fill.

- E. Installation instructions:
 - 1. Provide written instructions detailing the complete installation of the enclosure, including rigging, moving, setting into place, and combination of shipping splits where applicable.
 - 2. Provide complete instructions and requirements for anchoring the enclosure to meet the seismic requirements at the Project Site as specified in Section 16050 - Common Work Results for Electrical:
 - a. Instructions and requirements must be stamped by a professional engineer licensed in the state where the Project is being constructed.
- F. Calculations:
 - 1. Provide complete structural calculations indicating that the enclosure, anchorage, and any supporting existing structures are suitable for the enclosure vertical loads, seismic loads, and wind loads:
 - a. Calculations must be stamped by a professional civil or structural engineer licensed in the state of Utah.
 - 2. Provide complete heating and cooling calculations indicating that the HVAC system supplied will maintain the internal enclosure temperature specified in this Section under the Project/Site Conditions as specified in Section 16050 - Common Work Results for Electrical and Section 01610 - Project Design Criteria. Calculations shall include the heat rejection from all the internal electrical loads as well as the building loads. The unit shall be sized to meet the maximum calculated sensible load.
 - 3. Provide complete lighting calculations indicating that the lighting system provided meets the requirements specified in this Section.
- G. Provide samples of available exterior finish colors to Owner for selection.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. The manufacturer of the enclosure shall be ISO 9001 certified.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.08 PROJECT/SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Environmental requirements:
 - 1. Provide enclosures that are suitable for operation under the project site conditions specified in the Contract Documents, including, but not limited to, material compatibility, site altitude, site seismic, ambient temperature, and humidity conditions.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. ESS/Metron.
 - 2. Quality Electrical Systems.
 - 3. Atkinson Ind.
 - 4. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. General:
 - 1. Metal construction; self-supporting and freestanding. Free from burrs and sharp edges.
 - 2. Interlocked, self-framing design, or framed design using minimum 3-inch square ASTM A500 structural grade steel tubing and welded connections.
- B. Base:
 - 1. All welded, seamless construction utilizing ASTM A36 structural steel members sized by structural design calculations to meet or exceed the required static and dynamic loads.
 - 2. Locate structural members to coordinate with the enclosed equipment, to properly support it and to allow maximum access to equipment floor openings for cable penetration.
 - 3. Provide lifting lugs capable of lifting the fully equipped electrical enclosure at the specified lifting points with deflection not exceeding L/240.
 - 4. Provide 2 copper grounding pads located at diagonally opposite corners of the structure.
 - a. Mechanically bond ground pads to the base steel of the enclosure.
 - b. Include two 3/8-inch -16 UNC threaded brass studs on each ground pad assembly to permit connection of a NEMA Type 2-hole cable lug.
- C. Floor:
 - 1. Constructed of minimum 1/4-inch thick ASTM A36 smooth steel plate securely welded to the structural steel members of the enclosure base.

2. Rated to withstand not less than 250 pounds per square foot distributed load, and rated to withstand the concentrated load of any equipment installed into the enclosure.
 3. Where bottom access is required for electrical equipment, provide floor cutouts with gasketed removable 12-gauge galvanized steel cover plates.
- D. Walls:
1. Constructed with an exterior wall of minimum 18-gauge steel and an interior wall of minimum 16-gauge steel.
 2. Where wall penetrations are required, cutouts shall be completely framed by coverplates with neoprene gaskets.
- E. Enclosure roof and ceiling:
1. Enclosures shall be constructed with a roof panel of minimum 18-gauge steel and a ceiling panel of minimum 16-gauge steel.
 2. The roof shall be designed to withstand a minimum live load of 40 pounds per square foot, and shall be designed to support interior and exterior equipment loads without compromising roof load design.
 3. Where roof penetrations are required, provide flashing, adequately sealed, to maintain the weatherproof integrity of the roof.
 4. Slope of roof shall match slope of existing electrical enclosure's roof.
 5. Provide a cover to connect new and existing roofs, so that area between existing and new enclosures is covered.
- F. Insulation:
1. Walls and roof insulated to the R-11 level using fiberglass batt material installed between the inner and outer steel panels.
 2. Floor insulated to the R-11 level using polyurethane foam installed on the underside of the floor.
- G. Doors:
1. Personnel and equipment doors:
 - a. Provide doors sized and located as indicated on the Drawings.
 - b. Double wall steel construction with R-15 thermal insulation.
 - c. Include interior panic hardware with exterior knob and cylinder lock, interior automatic closure devices and integrated hold open devices.
 - d. Outwards opening with a minimum swing of 105 degrees.
 - e. Provide drip shields above each door.
 - f. Provide a 24-inch removable transom above each equipment door.
- H. Wiring and raceways:
1. Wire and cable as specified in Section 16123 - 600-Volt or Less Wires and Cables.
 2. Use one of the following raceway types to route wiring within the enclosure:
 - a. Conduit as specified in Section 16130 - Conduits.
 - b. Wireway as specified in Section 16136 - Wireway.

2.05 EQUIPMENT

- A. Furnish, install, and test all equipment within the enclosure in conformance with the applicable equipment section.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

A. HVAC system:

1. Provide an HVAC DX (Direct Expansion) split heat pump system designed to maintain an indoor temperature of between 55 and 85 degrees Fahrenheit under the worst case site conditions specified in Sections 01610 - Project Design Criteria and 16050 - Common Work Results for Electrical.
2. Mount the indoor air handling section to the wall or roof of the enclosure.
3. HVAC equipment shall include a lockable circuit breaker(s) or disconnect switch(s) as required. It is the responsibility of the enclosure supplier to ensure that the overcurrent protection for all HVAC equipment is sized in accordance with NEC.
4. Provide unit with wall mounted thermostat mounted 60 inches above the floor. Locate close to return inlet and away from supply air discharge.
5. Design requirements:
 - a. Electrical components: UL listed and met the design and installation requirements of the NEC.
 - b. Gas, water piping, drains, and venting: In accordance with building code, mechanical code, and plumbing code as specified in Section 01410 - Regulatory Requirements and in accordance with NFPA 90A.
 - c. Fans: Rated in accordance with AMCA 210.
 - d. Unit air conditioners: Rated in accordance with AHRI Standards 210/240 or 340/360 and AHRI 270. In accordance with the latest version of ASHRAE 15.
 - e. Energy efficiency ratio (EER) of 10.3 as rated in accordance with AHRI 210/240 or 340/360 and 270.
6. Compressors:
 - a. Fully hermetically sealed, high efficiency, reciprocating or rotary or scroll type, with rubber grommet vibration isolation.
 - b. Utilize HFC-134a or HFC -410a as the refrigerant.
7. Fans:
 - a. Indoor air fan:
 - 1) Fan centrifugal type, steel with corrosion resistant finish, statically and dynamically balanced.
 - 2) Bearings: Permanently sealed ball bearing type and permanently lubricated.
 - b. Outdoor condenser fan:
 - 1) Propeller type, direct drive, aluminum blades, dynamically balanced.
 - 2) Bearings: Permanently sealed ball bearing type and permanently lubricated.
8. Coils:
 - a. Evaporator and condenser coils: Seamless copper tubes with mechanically bonded aluminum plate fins.
9. Refrigerant components: Refrigerant circuit including:
 - a. Accumulator and filter/drier.
 - b. Expansion device.
 - c. Flow control valves.
 - d. Service and gauge connections on compressor suction and discharge, and liquid lines to charge, evacuate, and contain refrigerant.

10. Controls:
 - a. Provide system controls for a complete functioning system controlled by an electronic, automatic changeover thermostat. Thermostat shall be mounted on an insulated backing plate.
 - b. Provide low ambient controls to zero degrees Fahrenheit.
11. Unit casing:
 - a. Slide out design unit casing manufactured galvanized steel with electrically bonded finish and outdoor components top coated with high solids polyester finish.
 - b. Weatherproof design, reinforced and braced for maximum rigidity.
 - c. Provided with:
 - 1) Filter rack for filters.
 - 2) Non-corrosive drain pan in accordance with ASHRAE Standard 62.
 - 3) Horizontal drain connection.
 - 4) Knockouts for power connections.
12. Air filters: 25 to 30 percent efficiency when rated in accordance with ASHRAE Standard 52.2.
13. Extra materials:
 - a. Provide 2 extra sets of filters per unit installed.

B. Lighting:

1. Interior lighting:
 - a. Provide a lighting system capable of producing 40 foot candles of light at a level 3 feet above enclosure floor at the end of the expected lamp life.
 - b. Industrial grade, totally enclosed, fully gasketed LED fixtures, UL listed for damp locations.
 - 1) Operating voltage: 120 V.
 - c. Provide light switches located adjacent to each door to control interior light fixtures.
2. Emergency lighting:
 - a. Provide an industrial grade emergency lighting fixture with thermoplastic enclosure, 12-volt nickel cadmium battery, and minimum 90-minute operating capacity, mounted above each exterior door.
3. Exterior lighting:
 - a. Provide an industrial grade LED wall pack fixture with lumen output equivalent to a 70W high pressure sodium, IES cutoff distribution, UL listed for wet locations, mounted above each exterior door.
 - b. Exterior lighting fixtures shall be automatically controlled by a photocell.
4. Provide lighting equipment as specified in Section 16510 – Lighting: LED Luminaires.

C. Receptacles:

1. Provide receptacles installed and tested by the enclosure supplier, located on each wall of enclosure in such a way that equipment does not impede access.
2. Provide receptacles as specified in Section 16140 - Wiring Devices.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. General:
 - 1. Thoroughly clean and prepare all surfaces according to SSPC-SP-1 and either SSPC-SP-2 or SSPC-SP-3, as required to remove all oil, grease, soil, rust, and scale before applying any coatings or paint.
- B. Base:
 - 1. Sandblast the entire base to completely remove to rust and scale before painting.
 - 2. Coat the base with an industrial grade, high solid, high build epoxy with a minimum dry film thickness of 4 mils.
- C. Floor:
 - 1. Thoroughly coat the floor with an epoxy primer with a final dry film thickness of 2-3 mils and finish with a coat of non-skid manufacturer's standard gray epoxy with a dry film thickness of 2 to 3 mils.
- D. Interior walls and ceiling:
 - 1. Either electrostatically apply a white polyester powder with a final baked on thickness between 2 and 4 mils or apply a white epoxy paint applied to a dry film thickness of between 2 and 3 mils.
- E. Exterior walls and roof panels:
 - 1. Either electrostatically apply polyester powder with a final baked on thickness between 2 and 4 mils or apply a vinyl wash primer coat with a minimum dry film thickness of 1 mil followed by a final coat of epoxy paint with a dry film thickness of between 2 to 3 mils:
 - a. Provide UV resistant coatings or paint on all exterior walls and roof panels.

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Install the enclosure per manufacturer's guidelines and submitted installation instructions to meet the seismic requirements at the project site.
- C. Any components or panels damaged during installation shall be replaced.
- D. Install enclosures so that their surfaces are plumb and level within 1/8 inch over their entire base.

- E. Install gasket and sealing material under enclosures with floor slab cutouts for conduit and cables to prevent entry of dust, debris, or vermin into the enclosure and equipment contained therein.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16950

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Responsibilities for testing the electrical installation.
 - 2. Adjusting and calibration.
 - 3. Acceptance tests.
- B. Copyright information:
 - 1. Some portions of this Section are copyrighted by the InterNational Electrical Testing Association, Inc. (NETA). See NETA publication ATS for details.

1.02 REFERENCES

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. American National Standards Institute (ANSI).
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - 2. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
 - 3. 95 - IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) With High Direct Voltage.
 - 4. 421.3 - IEEE Standard for High-Potential Test Requirement for Excitation Systems for Synchronous Machines.
 - 5. 450 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
 - 6. 1106 - IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications.
 - 7. 1188 - IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.
 - 8. C57.13 - IEEE Standard Requirements for Instrument Transformers.
 - 9. C57.13.1 - IEEE Guide for Field Testing of Relaying Current Transformers.
 - 10. C57.13.3 - IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.
 - 11. C57.104 - IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers.
- D. Insulated Cable Engineer's Association (ICEA).
- E. InterNational Electrical Testing Association (NETA).

1. ATS-2009 Standard for Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- F. International Electrotechnical Commission (IEC).
- G. Manufacturer's testing recommendations and instruction manuals.
- H. National Fire Protection Association (NFPA):
 1. 70 - National Electrical Code (NEC).
 2. 110 - Standard for Emergency and Standby Power Systems.
- I. National Institute of Standards and Technology (NIST).
- J. Specification sections for the electrical equipment being tested.
- K. Shop drawings.

1.03 DEFINITIONS

- A. As specified in Sections 01756 - Commissioning and 16050 - Common Work Results for Electrical.
- B. Specific definitions:
 1. Testing laboratory: The organization performing acceptance tests.

1.04 SYSTEM DESCRIPTION

- A. Testing of all electrical equipment installed under this Contract in accordance with the manufacturer's requirements and as specified in this Section.
- B. Conduct all tests in the presence of the Engineer or the Engineer's representative:
 1. Engineer will witness all visual, mechanical and electrical tests, and inspections.
- C. The testing and inspections shall verify that the equipment is operational within the tolerances required and expected by the manufacturer, and these Specifications.
- D. Responsibilities:
 1. Contractor responsibilities:
 - a. Ensure that all resources are made available for testing, and that all testing requirements are met.
 2. Electrical subcontractor responsibilities:
 - a. Perform routine tests during installation.
 - b. Demonstrate operation of electrical equipment.
 - c. Commission the electrical installation.
 - d. Provide the necessary services during testing, and provide these services to the testing laboratory, Contractor, and other subcontractors, including but not limited to:
 - 1) Providing electrical power as required.
 - 2) Operating of electrical equipment in conjunction with testing of other equipment.
 - 3) Activating and shutting down electrical circuits.
 - 4) Making and recording electrical measurements.

- 5) Replacing blown fuses.
 - 6) Installing temporary jumpers.
- 3. Testing laboratory responsibilities:
 - a. Perform all acceptance tests specified in this Section.
 - b. Provide all required equipment, materials, labor, and technical support during acceptance tests.
- E. Upon completion of testing or calibration, attach a label to all serviced devices:
 - 1. The label shall indicate the date serviced and the company that performed the service.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 16050 - Common Work Results for Electrical.
- B. LAN cable test form:
 - 1. LAN cable test reports:
 - a. Submit 3 copies of test reports showing the results of all tests specified in this Section:
 - 1) Test type.
 - 2) Test location.
 - 3) Test date.
 - 4) Cable number.
 - 5) Cable length.
 - 6) Certification that the cable meets or exceeds the specified standard.
 - b. Furnish hard copy and electronic copy for all traces.
- C. Manufacturers' testing procedures:
 - 1. Submit manufacturers' recommended testing procedures and acceptable test results for review by the Engineer.
- D. Test report:
 - 1. Include the following:
 - a. Summary of Project.
 - b. Description of equipment tested.
 - c. Description of tests performed.
 - d. Test results.
 - e. Conclusions and recommendations.
 - f. Completed test forms.
 - g. List of test equipment used and calibration dates.
 - h. LAN cable test reports.
- E. Testing laboratory qualifications:
 - 1. Submit a complete resume and statement of qualifications from the proposed testing laboratory detailing their experiences in performing the tests specified:
 - a. This statement will be used to determine whether the laboratory is acceptable, and shall include:
 - 1) Corporate history and references.
 - 2) Resume of individual performing test.
 - 3) Equipment list and test calibration data.

- F. Division of responsibilities:
 - 1. Submit a list identifying who is responsible for performing each portion of the testing.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. Testing laboratory qualifications:
 - 1. The testing laboratory may be qualified testing personnel from the electrical subcontractor's staff or an independent testing company.
 - 2. Selection of the testing laboratory and testing personnel is subject to approval by the Engineer based on testing experience and certifications of the individuals and testing capabilities of the organization.

1.07 DELIVERY, STORAGE, AND PROTECTION (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.09 SEQUENCING

- A. At least 30 days before commencement of the acceptance tests, submit the manufacturer's complete field testing procedures to the Engineer and to the testing laboratory, complete with expected test results and tolerances for all equipment to be tested.
- B. Perform testing in the following sequence:
 - 1. Perform routine tests as the equipment is installed including:
 - a. Insulation-resistance tests.
 - b. Continuity tests.
 - c. Rotational tests.
 - 2. Adjusting and preliminary calibration.
 - 3. Acceptance tests.
 - 4. Demonstration.
 - 5. Commissioning and plant start-up.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050 - Common Work Results for Electrical.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

- A. Test instrument calibration:
 - 1. Utilize a testing laboratory with a calibration program which maintains all applicable test instrumentation within rated accuracy.
 - 2. The accuracy shall be traceable to the NIST in an unbroken chain.
 - 3. Calibrate instruments in accordance with the following frequency schedule:
 - a. Field instruments: 6 months maximum.
 - b. Laboratory instruments: 12 months maximum.
 - c. Leased specialty equipment where the accuracy is guaranteed by the lessor (such as Doble): 12 months maximum.
 - 4. Dated calibration labels shall be visible on all test equipment.
 - 5. Maintain an up-to-date instrument calibration record for each test instrument:
 - a. The records shall show the date and results of each calibration or test.
 - 6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.
- B. Do not begin testing until the following conditions have been met:
 - 1. All instruments required are available and in proper operating condition.
 - 2. All required dispensable materials such as solvents, rags, and brushes are available.
 - 3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment are available or scheduled.
 - 4. All instruction books, calibration curves, or other printed material to cover the electrical devices are available.
 - 5. Data sheets to record all test results are available.

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.

3.08 FIELD QUALITY CONTROL

- A. Dry type transformers:
 - 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.

- b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - e. Inspect equipment for cleanliness.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Verify that as-left tap connections are as specified.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground:
 - 1) Apply voltage in accordance with manufacturer's published data.
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Calculate dielectric absorption ration or polarization index.
 - d. Perform turns ratio tests at all tap positions.
 - e. Verify correct secondary voltage, phase-to-phase and phase-to-neutral after energization and before loading.
 - 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Tap connections are left as found unless otherwise specified.
 - d. Minimum insulation-resistance values of transformer insulation shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - e. The dielectric absorption ratio or polarization index shall not be less than 1.0.
 - f. Turns-ratio results should not deviate more than 1/2 percent from either the adjacent coils or calculated ratio.
 - g. Phase-to-phase and phase-to-neutral secondary voltages shall be in agreement with nameplate data.
- B. Low voltage cables, 600 volt maximum:
- 1. Visual and mechanical inspection:
 - a. Compare cable data with the Drawings and Specifications.
 - b. Inspect exposed sections of cable for physical damage and correct connection as indicated on the Drawings.

- c. Inspect bolted electrical connections for high resistance by 1 of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
- d. Inspect compression applied connectors for correct cable match and indentation.
- e. Inspect for correct identification and arrangement.
- f. Inspect cable jacket insulation and condition.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation resistance test on each conductor with respect to ground and adjacent conductors:
 - 1) Applied potential shall be 500 volts dc for 300 volt rated cable and 1,000 volts dc for 600 volt rated cable.
 - 2) Test duration shall be 1 minute.
 - c. Perform continuity tests to insure correct cable connection.
 - d. Verify uniform resistance of parallel conductors.
- 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Insulation-resistance values shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.
 - c. Cable shall exhibit continuity.
 - d. Investigate deviations in resistance between parallel conductors.

C. Low voltage molded case and insulated case circuit breakers:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage and alignment.
 - d. Verify that all maintenance devices are available for servicing and operating the breaker.
 - e. Verify the unit is clean.
 - f. Verify the arc chutes are intact.
 - g. Inspect moving and stationary contacts for condition and alignment.
 - h. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
 - i. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturers published data.
 - j. Operate circuit breaker to ensure smooth operation.

- k. Inspect bolted electrical connections for high resistance by one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
- l. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
- m. Verify cell fit and element alignment.
- n. Verify racking mechanism operation.
- o. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- p. Perform adjustments for final protective device settings in accordance with the coordination study.
- q. Record as-found and as-left operation counter readings.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole:
 - 1) Apply voltage in accordance with manufacturer's published data.
 - 2) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Perform a contact/pole-resistance test.
 - d. Determine long-time pickup and delay by primary current injection.
 - e. Determine short-time pickup and delay by primary current injection.
 - f. Determine ground-fault pickup and delay by primary current injection.
 - g. Determine instantaneous pickup value by primary current injection.
 - h. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data.
 - i. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function and trip unit battery condition:
 - 1) Reset all trip logs and indicators.
 - j. Verify operation of charging mechanism.
- 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Insulation-resistance values shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.

- d. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
 - 1) If manufacturer's data is not available, investigate any values which deviate from adjacent poles or similar breakers by more than 50 percent of the lowest value.
- e. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band including adjustment factors:
 - 1) If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS tables.
- f. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
- g. Ground fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
- h. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
- i. Pickup values and trip characteristics shall be within manufacturer's published tolerances.
- j. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
- k. Breaker open, close, trip, trip-free, anti-pump, and auxiliary features shall function as designed.
- l. The charging mechanism shall operate in accordance with manufacturer's published data.

D. Instrument transformers:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Verify correct connection of transformers with system requirements.
 - d. Verify that adequate clearances exist between primary and secondary circuit wiring.
 - e. Verify the unit is clean.
 - f. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - g. Verify that all required grounding and shorting connections provide contact.
 - h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
 - i. Verify correct primary and secondary fuse sizes for voltage transformers.
 - j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - k. Verify instrument transformer polarities match the 3-line diagrams.

2. Electrical tests - current transformers:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1,000 VDC for 1 minute:
 - 1) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - c. Perform a polarity test of each current transformer in accordance with IEEE C57.13.1.
 - d. Perform a ratio verification test using the voltage or current method in accordance with IEEE C57.13.1.
 - e. Perform an excitation test on current transformers used for relaying applications in with accordance with IEEE C57.13.1.
 - f. Measure current circuit burdens at transformer terminals in accordance with IEEE C57.13.1.
 - g. Perform an excitation test on transformers used for relaying applications in accordance with IEEE C57.13.1.
 - h. When applicable perform insulation-resistance tests on the primary winding with the secondary grounded:
 - 1) Test voltages shall be in accordance with NETA ATS tables.
 - i. When applicable perform dielectric withstand tests on the primary winding with the secondary grounded:
 - 1) Test voltages shall be in accordance with NETA ATS tables.
 - j. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's published data.
 - k. Verify that current transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
 - 1) That grounding point should be located as specified by the Engineer in the Contract Documents.
3. Electrical tests - voltage transformers:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests winding-to-winding and winding-to-ground:
 - 1) Test voltage shall be applied for 1 minute in accordance with NETA ATS requirements.
 - 2) For solid state devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
 - c. Perform a polarity test on each voltage transformer to verify the polarity marks on H_1 - X_1 relationship as applicable.
 - d. Perform a turns ratio test on all tap positions.
 - e. Measure voltage circuit burdens at transformer terminals.
 - f. Perform a dielectric withstand test on the primary windings with the secondary windings grounded:
 - 1) The dielectric voltage shall be in accordance with NETA ATS tables.
 - 2) Apply the test voltage for 1 minute.
 - g. Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturers published data.
 - h. Verify that voltage transformer secondary circuits are grounded and have only 1 grounding point in accordance with IEEE C57.13.3:
 - 1) That grounding point should be located as specified by the Engineer in the Contract Documents.

4. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Insulation-resistance values of instrument transformers shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - d. Polarity results shall agree with transformer markings.
 - e. Ratio errors shall be in accordance with IEEE C57.13.
 - f. Excitation results for current transformers shall match the curve supplied by the manufacturer or be in accordance with IEEE C57.13.1.
 - g. Measured burdens shall be compared to instrument transformer ratings.
 - h. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the current transformer primary winding is considered to have passed the test.
 - i. Power-factor or dissipation-factor values shall be compared to manufacturer's published data:
 - 1) In the absence manufacturer's published data the comparison shall be made to similar breakers.
 - j. Test results shall indicate that the circuits have only 1 grounding point.

E. Grounding systems:

1. Visual and mechanical inspection:
 - a. Inspect ground system for compliance with that indicated on the Drawings, specified in Specifications, and in the NEC.
 - b. Inspect physical and mechanical condition.
 - c. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - d. Inspect anchorage.
2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform fall of potential test or alternative test in accordance with IEEE 81 on the main grounding electrode or system.
 - c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, the system neutral and any derived neutral points.
3. Test values:
 - a. Grounding system electrical and mechanical connections shall be free of corrosion.

- b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
- c. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
- d. The resistance between the main grounding electrode and ground shall be as specified in Section 16060 - Grounding and Bonding. Investigate point-to-point resistance values that exceed 0.5 ohm.

F. Rotating machinery:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate information with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Inspect air baffles, filter media, cooling fans, slip rings, brushes, brush rigging, and shaft current discharge devices.
 - e. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - f. Perform special tests such as gap spacing and machine alignment if applicable.
 - g. Manually rotate the rotor and check for problems with the bearings or shaft.
 - h. Rotate the shaft and measure and record the shaft extension runout.
 - i. Verify correct application of appropriate lubrication and lubrication systems.
 - j. Verify that resistance temperature detector (RTD) circuits conform to that indicated on the Drawings.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance test in accordance with IEEE 43:
 - 1) On motors 200 horsepower and smaller, test duration shall be 1 minute. Calculate dielectric absorption ratio.
 - 2) On motors larger than 200 horsepower, test duration shall be 10 minutes. Calculate polarization index.
 - c. Perform dc dielectric withstand voltage tests on machines rated at 2,300 volts and greater in accordance with IEEE 95.
 - 1) IEEE 95 for dc dielectric withstand voltage tests.
 - 2) NEMA MG1 for ac dielectric withstand voltage tests.
 - d. Perform phase-to-phase stator resistance test on machines rated at 2,300 volts and greater.
 - e. Perform insulation-resistance test on insulated bearings in accordance with manufacturer's published data.
 - f. Test surge protection devices as specified in this Section.

- g. Test motor starter as specified in this Section.
 - h. Perform resistance tests on resistance temperature detector (RTD) circuits.
 - i. Verify operation of motor space heater.
 - j. Perform a rotation test to ensure correct shaft rotation.
 - k. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.
3. Test values:
- a. Inspection:
 - 1) Air baffles shall be clean and installed in accordance with the manufacturer's published data.
 - 2) Filter media shall be clean and installed in accordance with the manufacturer's published data.
 - 3) Cooling fans shall operate.
 - 4) Slip ring alignment shall be within manufacturer's published tolerances.
 - 5) Brush alignment shall be within manufacturer's published tolerances.
 - 6) Brush rigging shall be within manufacturer's published tolerances.
 - b. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - c. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - d. Air-gap spacing and machine alignment shall be in accordance with manufacturer's published data.
 - e. The recommended minimum insulation-resistance ($IR_{1 \text{ min}}$) test results in megohms shall be as specified in this Section.
 - 1) The polarization index value shall not be less than 2.0.
 - 2) The dielectric absorption ratio shall not be less than 1.4.
 - f. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
 - g. Investigate phase-to-phase stator resistance values that deviate by more than 10 percent.
 - h. Power factor or dissipation factor values shall be compared to manufacturer's published data:
 - 1) In the absence of manufacturer's published data compare values of similar machines.
 - i. Tip-up values shall indicate no significant increase in power factor.
 - j. If no evidence of distress, insulation failure, or waveform nesting is observed by the end of the total time of voltage application during the surge comparison test, the test specimen is considered to have passed the test.
 - k. Bearing insulation-resistance measurements shall be within manufacturer's published tolerances:
 - 1) In the absence of manufacturer's published data compare values of similar machines.
 - l. Test results of surge protection devices shall be as specified in this Section.

- m. Test results of motor starter equipment shall be as specified in this Section.
- n. RTD circuits shall conform to the design intent and machine protection device manufacturer's published data.
- o. Heaters shall be operational.
- p. Vibration amplitudes shall not exceed values in NETA ATS tables:
 - 1) If values exceed those in the NETA ATS tables, perform a complete vibration analysis.
- q. Machine rotation should match required rotation of connected load.
- r. Running phase-to-phase voltages should be within 1.0 percent. Running currents shall be balanced and proportional to load condition and nameplate data.

G. Motor starters, low voltage:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate information with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Inspect contactors:
 - 1) Verify mechanical operation.
 - 2) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
 - f. Motor-running protection:
 - 1) Verify overload element rating is correct for its application.
 - 2) If motor running protection is provided by fuses, verify correct fuse rating.
 - g. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - h. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.
 - 2) Verify appropriate lubrication on moving and sliding surfaces.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests for 1 minute on each pole, phase-to-phase and phase to ground with the starter closed, and across each open pole for 1 minute:
 - 1) Test voltage shall be in accordance with manufacturer's published data.
 - 2) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Test motor protection devices in accordance with manufacturer's published data.
 - d. Test circuit breakers as specified in this Section.
 - e. Perform operational tests by initiating control devices.

3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Insulation-resistance values shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate values of insulation-resistance less than the allowable minimum.
 - d. Motor protection parameters shall be in accordance with manufacturer's published data.
 - e. Circuit breaker test results shall as specified in this Section.
 - f. Control devices shall perform in accordance with system design requirements.

H. Motor control centers, low voltage:

1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding and required clearances.
 - d. Inspect equipment for cleanliness.
 - e. Verify that circuit breaker/fuse sizes and types correspond to the approved submittals and coordination study.
 - f. Verify that current and voltage transformer ratios correspond to that indicated on the Drawings.
 - g. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - h. Mechanical and electrical interlocks:
 - 1) Attempt closure on locked-open devices.
 - 2) Attempt to open locked-closed devices.
 - 3) Make/attempt key-exchanges in all positions.
 - i. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.
 - 2) Verify appropriate lubrication on moving and sliding surfaces.
 - j. Inspect insulators for evidence of physical damage or contaminated surfaces.
 - k. Verify correct barrier and shutter installation and operation.
 - l. Exercise all active components.
 - m. Inspect all indicating devices for correct operation.
 - n. Verify that filters are in place and/or vents are clear.

- o. Perform visual and mechanical inspection of instrument transformers as specified in this Section.
- p. Inspect control power transformers:
 - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - 2) Verify that primary and secondary fuse/circuit breaker ratings match the submittal drawings.
- q. Perform visual and mechanical inspection of circuit breakers as specified in this Section.
- r. Perform visual and mechanical inspection of starters as specified in this Section.
- s. Perform visual and mechanical inspection of variable frequency drives as specified in this Section.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground for 1 minute:
 - 1) Perform test in accordance with NETA ATS tables.
 - c. Perform an dielectric withstand test on each bus section, each phase to ground with phases not under test grounded, in accordance with manufacturer's published data or NETA ATS tables. Apply the test voltage for 1 minute.
 - d. Perform electrical tests on instrument transformers as specified in this Section.
 - e. Perform ground-resistance tests:
 - 1) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral and derived neutral points.
 - f. Determine the accuracy of all meters.
 - g. Control power transformers:
 - 1) Perform insulation-resistance tests, winding-to-winding and winding-to-ground:
 - a) Test voltages shall be in accordance with NETA ATS tables or as specified by the manufacturer.
 - 2) Perform secondary wiring integrity test:
 - a) Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source:
 - (1) Verify correct potential at all devices.
 - 3) Verify correct secondary voltage by energizing primary winding with system voltage:
 - a) Measure secondary voltage with the secondary wiring disconnected.
 - h. Verify operation of space heaters.
 - i. Perform electrical tests of circuit breakers as specified in this Section.
 - j. Perform electrical tests of starters as specified in this Section.
- 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
- c. Insulation-resistance values for bus and control power transformers shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - 3) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
- d. Bus insulation shall withstand the over potential test voltage applied.
- e. Instrument transformer test values shall be as specified in this Section.
- f. Investigate grounding system point-to-point resistance values that exceed 0.5 ohm.
- g. Meter accuracy shall be in accordance with manufacturer's published data.
- h. Control power transformers:
 - 1) Insulation-resistance values of control power transformers shall be in accordance with manufacturer's published data:
 - a) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - b) Investigate insulation values less than the allowable minimum.
 - c) Do not proceed with dielectric withstand voltage tests until insulation-resistance values are above minimum values.
 - 2) Secondary wiring shall be as indicated on the Drawings and specified in the Specifications.
 - 3) Secondary voltage shall be as indicated on the Drawings.
- i. Heaters shall be operational.
- j. Test values for circuit breakers shall be as specified in this Section.
- k. Test values for starters shall be as specified in this Section.

I. Variable frequency drive systems:

- 1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Ensure vent path openings are free from debris and that heat transfer surfaces are clean.
 - f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
 - g. Motor running protection:
 - 1) Verify drive overcurrent setpoints are correct for their application.
 - 2) If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
 - 3) Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.

- 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - i. Verify correct fuse sizing in accordance with manufacturer's published data.
 - j. Perform visual and mechanical inspection of input circuit breaker as specified in this Section.
 - 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with low resistance ohmmeter.
 - b. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
 - c. Test for the following parameters in accordance with relay calibration procedures specified in this Section or as recommended by the manufacturer:
 - 1) Input phase loss protection.
 - 2) Input overvoltage protection.
 - 3) Output phase rotation.
 - 4) Overtemperature protection.
 - 5) Direct current overvoltage protection.
 - 6) Overfrequency protection.
 - 7) Drive overload protection.
 - 8) Fault alarm outputs.
 - d. Perform continuity tests on bonding conductors as specified in this Section.
 - e. Perform start-up of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum and maximum speed control signals.
 - f. Perform operational tests by initiating control devices:
 - 1) Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
 - 2) Verify operation of drive from remote start/stop and speed control signals.
 - g. Perform electrical tests of input circuit breaker as specified in this Section.
 - 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Overload test trip times at 300 percent of overload element rating shall be in accordance with manufacturer's published time-current curve.
 - d. Test values for input circuit breaker shall be as specified in this Section.
 - e. Relay calibration results shall be as specified in this Section.
 - f. Continuity of bonding conductors shall be as specified in this Section.
 - g. Control devices shall perform in accordance with system requirements.
 - h. Operational tests shall conform to system design requirements.

- J. Surge arresters, low-voltage:
1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and clearances.
 - d. Verify the arresters are clean.
 - e. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by the calibrated torque wrench method:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
 - f. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
 - g. Verify that stroke counter is correctly mounted and electrically connected, if applicable.
 - h. Record stroke counter reading.
 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform an insulation-resistance test on each arrester, phase terminal- to- ground:
 - 1) Apply voltage in accordance with manufacturers published data.
 - 2) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Test grounding connection as specified in this Section.
 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Insulation-resistance values shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - 2) Investigate insulation values less than the allowable minimum.
 - d. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.
- K. Automatic transfer switches:
1. Visual and mechanical inspection:
 - a. Compare equipment nameplate data with the Contract Documents.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and required clearances.
 - d. Verify the unit is clean.
 - e. Lubrication requirements:
 - 1) Verify appropriate lubrication on moving current-carrying parts.

- 2) Verify appropriate lubrication on moving and sliding surfaces.
- f. Verify that manual transfer warnings are attached and visible.
- g. Verify tightness of all control connections.
- h. Inspect bolted electrical connections for high resistance using one of the following methods:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque wrench:
 - a) Refer to manufacturer's instructions for proper foot-pound levels or NETA ATS tables.
- i. Perform manual transfer operation.
- j. Verify positive mechanical interlocking between normal and alternate sources.
- 2. Electrical tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
 - b. Perform a contact/pole-resistance test.
 - c. Verify settings and operation of control devices.
 - d. Calibrate and set all relays and timers as specified in this Section.
 - e. Verify phase rotation, phasing, and synchronized operation as required by the application.
 - f. Perform automatic transfer tests:
 - 1) Simulate loss of normal power.
 - 2) Return to normal power.
 - 3) Simulate loss of emergency power.
 - 4) Simulate all forms of single-phase conditions.
 - g. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing relays.
 - 2) Engine start sequence.
 - 3) Time delay upon transfer.
 - 4) Alternate source voltage-sensing relays.
 - 5) Automatic transfer operation.
 - 6) Interlocks and limit switch function.
 - 7) Time delay and retransfer upon normal power restoration.
 - 8) Engine cool down and shutdown feature.
- 3. Test values:
 - a. Compare bolted connection resistance values to values of similar connections:
 - 1) Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - b. Bolt-torque levels shall be in accordance with manufacturer's published data:
 - 1) Refer to NETA ATS tables in the absence of manufacturer's published data.
 - c. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data:
 - 1) If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - d. Control devices shall operate in accordance with manufacturer's published data.
 - e. Relay test results shall be as specified in this Section.

- f. Phase rotation, phasing, and synchronization shall be as specified in the system design specifications.
- g. Automatic transfers shall operate in accordance with manufacturer's design.
- h. Operation and timing shall be in accordance with manufacturer's and system design requirements.

L. Fiber-optic cables:

- 1. Visual and mechanical inspection:
 - a. Compare cable, connector, and splice data with the Contract Documents.
 - b. Inspect cable and connections for physical and mechanical damage.
 - c. Verify that all connectors and splices are correctly installed.
- 2. Electrical tests:
 - a. Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
 - 1) OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
 - 2) Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.
 - b. Perform connector and splice integrity test using an optical time domain reflectometer.
 - c. Perform cable attenuation loss measurement with an optical power loss test set:
 - 1) Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.
 - 2) Test multimode fibers at 850 nanometer and 1,300 nanometer.
 - 3) Test single mode fibers at 1,310 nanometer and 1,550 nanometer.
 - d. Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
 - 1) At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.
 - e. Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:
 - 1) OTDR traces shall be from both directions on each fiber at the 2 optimal wavelengths, 850 nanometer, and 1,300 nanometer for multimode fibers.
 - 2) Optical loss testing shall be done with handheld test sets in 1 direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.
- 3. Test values:
 - a. Cable and connections shall not have been subjected to physical or mechanical damage.
 - b. Connectors and splices shall be installed in accordance with industry standards.
 - c. The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.

- d. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
- e. Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

M. LAN cable testing:

- 1. Visual and mechanical inspections:
 - a. Compare cable type and connections with that indicated on the Drawings and specified in the Specifications.
 - b. Inspect cable and connectors for physical and mechanical damage.
 - c. Verify that all connectors are correctly installed.
- 2. Pre-testing:
 - a. Test individual cables before installation:
 - 1) Before physical placement of the cable, test each cable while on the spool with a LAN certification test device.
 - 2) Before the cable is installed, verify that the cable conforms to the manufacturer's attenuation specification and that no damage has been done to the cable during shipping or handling.
 - 3) The test shall be fully documented and the results submitted to the Engineer, including a hard copy of all traces, before placement of the cable.
 - 4) The Engineer shall be notified if a cable fails to meet specification and the cable shall not be installed unless otherwise directed by the Engineer.
- 3. Electrical tests:
 - a. Perform cable end-to-end testing on all installed cables after installation of connectors from both ends of the cable.
 - b. Test shall include cable system performance tests and confirm the absence of wiring errors.
- 4. Test results:
 - a. Cables shall meet or exceed TIA standards for a Category 6 installation.
- 5. Test equipment:
 - a. LAN certification equipment used for the testing shall be capable of testing Category 6 cable installation to TIA proposed Level III accuracy. Tests performed shall include:
 - 1) Near end cross talk.
 - 2) Attenuation.
 - 3) Equal level far end cross talk.
 - 4) Return loss.
 - 5) Ambient noise.
 - 6) Effective cable length.
 - 7) Propagation delay.
 - 8) Continuity/loop resistance.
 - b. LAN certification test equipment shall be able to store and produce plots of the test results.
 - c. Manufacturers: The following or equal:
 - 1) Agilent Technologies, WireScope 350.

3.09 ADJUSTING (NOT USED)

3.10 CLEANING

- A. As specified in Section 16050 - Common Work Results for Electrical.
- B. After the acceptance tests have been completed, dispose of all testing expendables, vacuum all cabinets, and sweep clean all surrounding areas.

3.11 PROTECTION

- A. As specified in Section 16050 - Common Work Results for Electrical.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16990

CONDUIT SCHEDULE

PART 1 GENERAL

1.01 SUMMARY

A. Specific definitions:

1. Conduits:

- a. GRC: Galvanized rigid conduit.
- b. PCS: PVC jacketed rigid steel conduit.
- c. PVC: Polyvinyl chloride rigid plastic conduit.
- d. SLT: Sealtight - liquidtight flexible conduit.

2. Cables:

- a. PBDP: Profibus DP cable.
- b. PBDPP: Profibus DP cable with 24VDC power.
- c. RS-485: RS-485 cable.
- d. CAT5e: Category 5 enhanced Ethernet cable.
- e. CAT6: Category 6 Ethernet cable.
- f. MODB: Modbus cable.
- g. */FO: Fiber optic cable (* indicates number of fibers).
- h. 2/C#16S: 2 conductor, 16 gauge, twisted shielded pair.
(*2/C#16S * indicates number of pairs).
- i. 3/C#16S: 3 conductor, 16 gauge, twisted shielded triplet.
(*3/C#16S * indicates number of triplets).
- j. */C#Y: Multiconductor cable (* indicates number of conductors,
Y indicates conductor size and insulation).
- k. MFR: Manufacturer or vendor furnished cable.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

- A. Conduit Schedule is presented on the following pages.

SECTION 16990.16A

CONDUIT SCHEDULE AREA 16

PART 1 GENERAL

1.01 SUMMARY

- A. Conduit requirements:
 - 1. As defined in Section 16050 - Common Work Results for Electrical and Section 16130 - Conduits.
- B. Cable requirements and definitions:
 - 1. As defined in Section 16050 -Common Work Results for Electrical and Section 16123 - 600-Volt or Less Wires and Cables.
 - 2. 3/CS#16: 3 conductor, 16 gauge, twisted shielded triplet.
 - 3. */FO: Fiber optic cable (* indicates number of fibers).
 - 4. CAT6A: Category 6A Ethernet cable.
 - 5. MFR: Manufacturer or vendor furnished cable.
 - 6. PBDP: Profibus DP cable.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

- A. Conduit Schedule is presented on the following pages.

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-16-205	E16-7	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.210 TO: CONDUIT TEE 4 #14 >> LCP-16.210 CONTROL	C-16-207
C-16-207	E16-7	0.75"	2 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.210 CONTROL 2 #12 >> AIT-16.253 POWER	C-16-210 C-16-205 L-16-205
C-16-208	E16-7	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.209 TO: CONDUIT TEE 4 #14 >> LCP-16.209 CONTROL	C-16-210
C-16-210	E16-7	0.75"	2 8	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.209 CONTROL 4 #14 >> LCP-16.210 CONTROL 2 #12 >> AIT-16.253 POWER	C-16-213 C-16-208 C-16-207 C-16-207
C-16-211	E16-7	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.208 TO: CONDUIT TEE 4 #14 >> LCP-16.208 CONTROL	C-16-213
C-16-213	E16-7	1"	2 12	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.208 CONTROL 4 #14 >> LCP-16.209 CONTROL 4 #14 >> LCP-16.210 CONTROL 2 #12 >> AIT-16.253 POWER	C-16-216 C-16-211 C-16-210 C-16-210 C-16-210
C-16-214	E16-7	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.207 TO: JBOX 4 #14 >> LCP-16.207 CONTROL	C-16-216
C-16-216	E16-7	1"	2 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.207 CONTROL 4 #14 >> LCP-16.208 CONTROL 4 #14 >> LCP-16.209 CONTROL 4 #14 >> LCP-16.210 CONTROL 2 #12 >> AIT-16.253 POWER	C-16-220 C-16-214 C-16-213 C-16-213 C-16-213 C-16-213
C-16-220	E16-7	1.5"	4 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.207 CONTROL 4 #14 >> LCP-16.208 CONTROL 4 #14 >> LCP-16.209 CONTROL 4 #14 >> LCP-16.210 CONTROL 2 #12 >> AIT-16.253 POWER 2 #12 >> AIT-16.245 POWER	C-16-230 C-16-216 C-16-216 C-16-216 C-16-216 C-16-216 L-16-201
C-16-230	E16-7	1.5"	8 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: J-BOX 4 #14 >> LCP-16.207 CONTROL 4 #14 >> LCP-16.208 CONTROL 4 #14 >> LCP-16.209 CONTROL 4 #14 >> LCP-16.210 CONTROL 2 #12 >> AIT-16.253 POWER 2 #12 >> AIT-16.245 POWER 2 #12 >> AIT-16.246 POWER 2 #12 >> AIT-16.241 POWER	C-16-235 C-16-220 C-16-220 C-16-220 C-16-220 C-16-220 C-16-220 L-16-245 L-16-245
C-16-235	E16-7	1.5"	10 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: CONDUIT TEE 4 #14 >> LCP-16.207 CONTROL 4 #14 >> LCP-16.208 CONTROL 4 #14 >> LCP-16.209 CONTROL 4 #14 >> LCP-16.210 CONTROL 2 #12 >> AIT-16.253 POWER 2 #12 >> AIT-16.245 POWER 2 #12 >> AIT-16.246 POWER 2 #12 >> AIT-16.241 POWER 2 #12 >> NJB-16.200 POWER	C-16-238 C-16-230 C-16-230 C-16-230 C-16-230 C-16-230 C-16-230 C-16-230 C-16-230 L-16-232

March 2019

16990.16A-2

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND					
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION		CONNECTING SEGMENTS
C-16-238	E16-7	1.5"	12 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR:	CONDUIT TEE	C-16-240
									TO:	CONDUIT TEE	
									2 #12	>> AIT-16.247 POWER	L-16-237
									4 #14	>> LCP-16.207 CONTROL	C-16-235
									4 #14	>> LCP-16.208 CONTROL	C-16-235
									4 #14	>> LCP-16.209 CONTROL	C-16-235
									4 #14	>> LCP-16.210 CONTROL	C-16-235
									2 #12	>> AIT-16.253 POWER	C-16-235
									2 #12	>> AIT-16.245 POWER	C-16-235
									2 #12	>> AIT-16.246 POWER	C-16-235
2 #12	>> AIT-16.241 POWER	C-16-235									
2 #12	>> NJB-16.200 POWER	C-16-235									
C-16-240	E16-7 E16-10	1.5"	16 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR:	CONDUIT TEE	C-16-242
									TO:	CONDUIT TEE	
									2 #12	>> AIT-16.242 POWER	L-16-265
									2 #12	>> AIT-16.244 POWER	L-16-265
									2 #12	>> AIT-16.247 POWER	C-16-238
									4 #14	>> LCP-16.207 CONTROL	C-16-238
									4 #14	>> LCP-16.208 CONTROL	C-16-238
									4 #14	>> LCP-16.209 CONTROL	C-16-238
									4 #14	>> LCP-16.210 CONTROL	C-16-238
									2 #12	>> AIT-16.253 POWER	C-16-238
2 #12	>> AIT-16.245 POWER	C-16-238									
2 #12	>> AIT-16.246 POWER	C-16-238									
2 #12	>> AIT-16.241 POWER	C-16-238									
2 #12	>> NJB-16.200 POWER	C-16-238									
C-16-242	E16-10	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR:	CONDUIT TEE	
									TO:	BR-MCC-2	
									4 #14	>> LCP-16.207 CONTROL	C-16-240
									4 #14	>> LCP-16.208 CONTROL	C-16-240
4 #14	>> LCP-16.209 CONTROL	C-16-240									
4 #14	>> LCP-16.210 CONTROL	C-16-240									
C-16-244	E16-10	1.5"	16	#12	XHHW-2	1	#12	XHHW-2	FR:	CONDUIT TEE	
									TO:	PCM-600A	
									2 #12	>> AIT-16.242 POWER	C-16-240
									2 #12	>> AIT-16.244 POWER	C-16-240
									2 #12	>> AIT-16.247 POWER	C-16-240
									2 #12	>> AIT-16.253 POWER	C-16-240
									2 #12	>> AIT-16.245 POWER	C-16-240
									2 #12	>> AIT-16.246 POWER	C-16-240
									2 #12	>> AIT-16.241 POWER	C-16-240
									2 #12	>> NJB-16.200 POWER	C-16-240
C-16-281	E16-7	1"	12	#14	XHHW-2	1	#14	XHHW-2	FR:	LCP-16.262	C-16-283
									TO:	CONDUIT TEE	
12 #14	>> LCP-16.262 CONTROL										
C-16-282	E16-7	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR:	LCPB-602	C-16-283
									TO:	CONDUIT TEE	
4 #14	>> LCPB-602 CONTROL										
C-16-283	E16-7	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR:	CONDUIT TEE	C-16-285
									TO:	CONDUIT TEE	
									4 #14	>> LCPB-602 CONTROL	C-16-282
									12 #14	>> LCP-16.262 CONTROL	C-16-281
C-16-284	E16-7	1"	12	#14	XHHW-2	1	#14	XHHW-2	FR:	LCP-16.261	C-16-285
									TO:	CONDUIT TEE	
12 #14	>> LCP-16.261 CONTROL										
C-16-285	E16-7	1.5"	28	#14	XHHW-2	1	#14	XHHW-2	FR:	CONDUIT TEE	C-16-287
									TO:	CONDUIT TEE	
									12 #14	>> LCP-16.261 CONTROL	C-16-284
									4 #14	>> LCPB-602 CONTROL	C-16-283
12 #14	>> LCP-16.262 CONTROL	C-16-283									
C-16-286	E16-7	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR:	LCPA-602	C-16-287
									TO:	CONDUIT TEE	
4 #14	>> LCPA-602 CONTROL										
C-16-287	E16-7	1.5"	32	#14	XHHW-2	1	#14	XHHW-2	FR:	CONDUIT TEE	
									TO:	CONTROL WIREWAY	
									4 #14	>> LCPA-602 CONTROL	C-16-286
									12 #14	>> LCP-16.261 CONTROL	C-16-285
									4 #14	>> LCPB-602 CONTROL	C-16-285
12 #14	>> LCP-16.262 CONTROL	C-16-285									

March 2019

16990.16A-3

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-16-001	E16-10	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: PCM-600A TO: CONDUIT TEE 2 #12 >> PCM-600A CONTROL POWER 2 #12 >> PCM-600A AUXILIARY POWER	L-16-003
L-16-002	E16-10	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: ELECTRICAL ENCLOSURE J-BOX TO: CONDUIT TEE 2 #12 >> ENCLOSURE LIGHTS 2 #12 >> ENCLOSURE RECEPTACLES	L-16-003
L-16-003	E16-10	0.75"	8	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: LP-MCC-BR 2 #12 >> ENCLOSURE LIGHTS 2 #12 >> ENCLOSURE RECEPTACLES 2 #12 >> PCM-600A CONTROL POWER 2 #12 >> PCM-600A AUXILIARY POWER	L-16-002 L-16-002 L-16-001 L-16-001
L-16-201	E16-7	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.245 TO: CONDUIT TEE 2 #12 >> AIT-16.245 POWER	C-16-220
L-16-205	E16-7	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.253 TO: CONDUIT TEE 2 #12 >> AIT-16.253 POWER	C-16-207
L-16-232	E16-7	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: NJB-16.200 TO: J-BOX 2 #12 >> NJB-16.200 POWER	C-16-235
L-16-237	E16-7	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.247 TO: CONDUIT TEE 2 #12 >> AIT-16.247 POWER	C-16-238
L-16-240	E16-7	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.241 TO: CONDUIT TEE 2 #12 >> AIT-16.241 POWER	L-16-245
L-16-243	E16-7	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.246 TO: CONDUIT TEE 2 #12 >> AIT-16.246 POWER	L-16-245
L-16-245	E16-7	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.246 POWER 2 #12 >> AIT-16.241 POWER	C-16-230 L-16-243 L-16-240
L-16-260	E16-7	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.244 TO: CONDUIT TEE 2 #12 >> AIT-16.244 POWER	L-16-265
L-16-262	E16-7	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.242 TO: CONDUIT TEE 2 #12 >> AIT-16.242 POWER	L-16-265
L-16-265	E16-7	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.242 POWER 2 #12 >> AIT-16.244 POWER	C-16-240 L-16-262 L-16-260
N-16-001	E16-10	1.5"	1		24/FO-SM	1	#14	XHHW-2	FR: PCM-600A TO: WIREWAY ABOVE PCM-600 1 24/FO-SM >> VCP-610>PCM-600A NETWORK	
N-16-004	E16-10	0.75"	2 1	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: BR-MCC-3 TO: CONDUIT TEE 1 CAT6A >> BR-MCC-3 NETWORK 2 #12 >> BR-MCC-3 ETHERNET SWITCH 24VDC	N-16-006
N-16-005	E16-10	0.75"	2 1	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: BR-MCC-4 TO: CONDUIT TEE 1 CAT6A >> BR-MCC-4 NETWORK 2 #12 >> BR-MCC-4 ETHERNET SWITCH 24VDC	N-16-006
N-16-006	E16-10	1"	4 2	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> BR-MCC-4 NETWORK 2 #12 >> BR-MCC-4 ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-3 NETWORK 2 #12 >> BR-MCC-3 ETHERNET SWITCH 24VDC	N-16-008 N-16-005 N-16-005 N-16-004 N-16-004

March 2019

16990.16A-4

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-16-007	E16-10	0.75"	2 1	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: BR-MCC-2 TO: CONDUIT TEE 1 CAT6A >> BR-MCC-2 NETWORK 2 #12 >> BR-MCC-2 ETHERNET SWITCH 24VDC	N-16-008
N-16-008	E16-10	1.5"	6 3	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> BR-MCC-2 NETWORK 2 #12 >> BR-MCC-2 ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-4 NETWORK 2 #12 >> BR-MCC-4 ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-3 NETWORK 2 #12 >> BR-MCC-3 ETHERNET SWITCH 24VDC	N-16-010 N-16-007 N-16-007 N-16-006 N-16-006 N-16-006 N-16-006
N-16-009	E16-10	0.75"	2 1	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: BR-MCC-4A TO: CONDUIT TEE 1 CAT6A >> BR-MCC-4A NETWORK 2 #12 >> BR-MCC-4A ETHERNET SWITCH 24VDC	N-16-010
N-16-010	E16-10	1.5"	8 4	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> BR-MCC-4A NETWORK 2 #12 >> BR-MCC-4A ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-2 NETWORK 2 #12 >> BR-MCC-2 ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-4 NETWORK 2 #12 >> BR-MCC-4 ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-3 NETWORK 2 #12 >> BR-MCC-3 ETHERNET SWITCH 24VDC	N-16-012 N-16-009 N-16-009 N-16-008 N-16-008 N-16-008 N-16-008 N-16-008 N-16-008
N-16-011	E16-10	0.75"	2 1	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: BR-MCC-2A TO: CONDUIT TEE 1 CAT6A >> BR-MCC-2A NETWORK 2 #12 >> BR-MCC-2A ETHERNET SWITCH 24VDC	N-16-012
N-16-012	E16-10	1.5"	10 5	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> BR-MCC-4A NETWORK 2 #12 >> BR-MCC-4A ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-2 NETWORK 2 #12 >> BR-MCC-2 ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-4 NETWORK 2 #12 >> BR-MCC-4 ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-3 NETWORK 2 #12 >> BR-MCC-3 ETHERNET SWITCH 24VDC 1 CAT6A >> BR-MCC-2A NETWORK 2 #12 >> BR-MCC-2A ETHERNET SWITCH 24VDC	N-16-010 N-16-010 N-16-010 N-16-010 N-16-010 N-16-010 N-16-010 N-16-010 N-16-011 N-16-011
N-16-013	E16-10	0.75"	2 1	#12	XHHW-2 CAT6A	1	#12	XHHW-2	FR: BR-MCC-3A TO: CONDUIT TEE 1 CAT6A >> BR-MCC-3A NETWORK 2 #12 >> BR-MCC-3A ETHERNET SWITCH 24VDC	
N-16-201	E16-7	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.245 TO: CONDUIT TEE 1 CAT6A >> AIT-16.245 NETWORK	N-16-208
N-16-205	E16-7	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.253 TO: CONDUIT TEE 1 CAT6A >> AIT-16.253 NETWORK	N-16-208
N-16-208	E16-7	0.75"	2		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> AIT-16.253 NETWORK 1 CAT6A >> AIT-16.245 NETWORK	N-16-255 N-16-205 N-16-201
N-16-210	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.230> PCM-600A NETWORK	N-16-220 N-16-299
N-16-212	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.234>EAM-16.235 NETWORK 1 PBDP >> PCM-600A>EAM16.233 NETWORK	N-16-271
N-16-213	E16-7	1.5"	1		12/FO-SM	1	#14	XHHW-2	FR: NJB-16.200 TO: J-BOX 1 12/FO-SM >> NJB-16.200 NETWORK	N-16-215
N-16-215	E16-7	1.5"	1 1		PBDP 12/FO-SM	1	#14	XHHW-2	FR: J-BOX TO: CONDUIT TEE 1 12/FO-SM >> NJB-16.200 NETWORK 1 PBDP >> PCM-600A>EAM16.233 NETWORK	N-16-220 N-16-213

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND			DESCRIPTION	CONNECTING SEGMENTS
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		
N-16-217	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 1 PBDP >> PCM-600A>EAM16.233 NETWORK	
N-16-220	E16-7 E16-10	2"	2 1		PBDP 12/FO-SM	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-600A 1 12/FO-SM >> NJB-16.200 NETWORK 1 PBDP >> PCM-600A>EAM16.233 NETWORK 1 PBDP >> EAM-16.230> PCM-600A NETWORK	N-16-215 N-16-215 N-16-210
N-16-240	E16-7	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.241 TO: CONDUIT TEE 1 CAT6A >> AIT-16.241 NETWORK	N-16-250
N-16-245	E16-7	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.246 TO: CONDUIT TEE 1 CAT6A >> AIT-16.246 NETWORK	N-16-250
N-16-250	E16-7	0.75"	2		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> AIT-16.246 NETWORK 1 CAT6A >> AIT-16.241 NETWORK	N-16-255 N-16-245 N-16-240
N-16-255	E16-7	1"	4		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: NJB-16.200 1 CAT6A >> AIT-16.246 NETWORK 1 CAT6A >> AIT-16.241 NETWORK 1 CAT6A >> AIT-16.253 NETWORK 1 CAT6A >> AIT-16.245 NETWORK	N-16-250 N-16-250 N-16-208 N-16-208
N-16-260	E16-7	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.244 TO: CONDUIT TEE 1 CAT6A >> AIT-16.244 NETWORK	N-16-265
N-16-262	E16-7	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.242 TO: CONDUIT TEE 1 CAT6A >> AIT-16.242 NETWORK	N-16-265
N-16-265	E16-7	0.75"	2		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> AIT-16.242 NETWORK 1 CAT6A >> AIT-16.244 NETWORK	N-16-267 N-16-262 N-16-260
N-16-266	E16-7	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.247 TO: CONDUIT TEE 1 CAT6A >> AIT-16.247 NETWORK	N-16-267
N-16-267	E16-7	1"	3		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: NJB-16.200 1 CAT6A >> AIT-16.247 NETWORK 1 CAT6A >> AIT-16.242 NETWORK 1 CAT6A >> AIT-16.244 NETWORK	N-16-266 N-16-265 N-16-265
N-16-270	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.233 TO: CONDUIT TEE 1 PBDP >> EAM-16.233>EAM-16.234 NETWORK 1 PBDP >> PCM-600A>EAM16.233 NETWORK	N-16-271
N-16-271	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.234 TO: CONDUIT TEE 1 PBDP >> EAM-16.233>EAM-16.234 NETWORK 1 PBDP >> EAM-16.234>EAM-16.235 NETWORK	N-16-212 N-16-270
N-16-272	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.234>EAM-16.235 NETWORK	N-16-273 N-16-271
N-16-273	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.235 TO: CONDUIT TEE 1 PBDP >> EAM-16.234>EAM-16.235 NETWORK 1 PBDP >> EAM-16.235>EAM-16.236 NETWORK	N-16-274 N-16-272
N-16-274	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.235>EAM-16.236 NETWORK	N-16-275 N-16-273
N-16-275	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.236 TO: CONDUIT TEE 1 PBDP >> EAM-16.235>EAM-16.236 NETWORK 1 PBDP >> EAM-16.236>EAM-16.225 NETWORK	N-16-276 N-16-274

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-16-276	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.236>EAM-16.225 NETWORK	N-16-277 N-16-275
N-16-277	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.225 TO: CONDUIT TEE 1 PBDP >> EAM-16.236>EAM-16.225 NETWORK 1 PBDP >> EAM-16.225>EAM-16.224 NETWORK	N-16-278 N-16-276
N-16-278	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.225>EAM-16.224 NETWORK	N-16-279 N-16-277
N-16-279	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.224 TO: CONDUIT TEE 1 PBDP >> EAM-16.225>EAM-16.224 NETWORK 1 PBDP >> EAM-16.224>EAM-16.223 NETWORK	N-16-280 N-16-278
N-16-280	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.224>EAM-16.223 NETWORK	N-16-281 N-16-279
N-16-281	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.223 TO: CONDUIT TEE 1 PBDP >> EAM-16.224>EAM-16.223 NETWORK 1 PBDP >> EAM-16.223>EAM-16.226 NETWORK	N-16-282 N-16-280
N-16-282	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.223>EAM-16.226 NETWORK	N-16-283 N-16-281
N-16-283	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.226 TO: CONDUIT TEE 1 PBDP >> EAM-16.223>EAM-16.226 NETWORK 1 PBDP >> EAM-16.226>EAM-16.222 NETWORK	N-16-284 N-16-282
N-16-284	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.226>EAM-16.222 NETWORK	N-16-285 N-16-283
N-16-285	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.222 TO: CONDUIT TEE 1 PBDP >> EAM-16.226>EAM-16.222 NETWORK 1 PBDP >> EAM-16.222>EAM-16.221 NETWORK	N-16-286 N-16-284
N-16-286	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.222>EAM-16.221 NETWORK	N-16-287 N-16-285
N-16-287	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.221 TO: CONDUIT TEE 1 PBDP >> EAM-16.222>EAM-16.221 NETWORK 1 PBDP >> EAM-16.221>EAM-16.227 NETWORK	N-16-288 N-16-286
N-16-288	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.221>EAM-16.227 NETWORK	N-16-289 N-16-287
N-16-289	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.227 TO: CONDUIT TEE 1 PBDP >> EAM-16.221>EAM-16.227 NETWORK 1 PBDP >> EAM-16.227>EAM-16.228 NETWORK	N-16-290 N-16-288
N-16-290	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.227>EAM-16.228 NETWORK	N-16-291 N-16-289
N-16-291	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.227>EAM-16.228 NETWORK 1 PBDP >> EAM-16.232>EAM-16.229 NETWORK	N-16-292 N-16-290 N-16-293
N-16-292	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.228 TO: CONDUIT TEE 1 PBDP >> EAM-16.227>EAM-16.228 NETWORK 1 PBDP >> EAM-16.228>EAM-16.232 NETWORK	N-16-293 N-16-291
N-16-293	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.232 TO: CONDUIT TEE 1 PBDP >> EAM-16.228>EAM-16.232 NETWORK 1 PBDP >> EAM-16.232>EAM-16.229 NETWORK	N-16-291 N-16-292

March 2019

16990.16A-7

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND			DESCRIPTION	CONNECTING SEGMENTS
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		
N-16-294	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.232>EAM-16.229 NETWORK	N-16-295 N-16-293
N-16-295	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.231>EAM-16.230 NETWORK 1 PBDP >> EAM-16.232>EAM-16.229 NETWORK	N-16-296 N-16-297 N-16-294
N-16-296	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.229 TO: CONDUIT TEE 1 PBDP >> EAM-16.232>EAM-16.229 NETWORK 1 PBDP >> EAM-16.229>EAM-16.231 NETWORK	N-16-297 N-16-295 N-16-295
N-16-297	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.231 TO: CONDUIT TEE 1 PBDP >> EAM-16.229>EAM-16.231 NETWORK 1 PBDP >> EAM-16.231>EAM-16.230 NETWORK	N-16-295 N-16-296
N-16-298	E16-7	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.231>EAM-16.230 NETWORK	N-16-299 N-16-295
N-16-299	E16-7	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.230 TO: CONDUIT TEE 1 PBDP >> EAM-16.231>EAM-16.230 NETWORK 1 PBDP >> EAM-16.230> PCM-600A NETWORK	N-16-210 N-16-298
P-16-001	E16-10	1.5"	3	#1/0	XHHW-2	1	#6	XHHW-2	FR: BR-MCC-4A TO: BR-MCC-4 3 #1/0 >> BR-MCC-4A POWER	
P-16-002	E16-10	1.5"	3	#1/0	XHHW-2	1	#6	XHHW-2	FR: BR-MCC-2A TO: BR-MCC-2 3 #1/0 >> BR-MCC-2A POWER	
P-16-003	E16-10	1.5"	3	#1/0	XHHW-2	1	#6	XHHW-2	FR: BR-MCC-3A TO: BR-MCC-3 3 #1/0 >> BR-MCC-3A POWER	
P-16-011	E16-10	1.5"	6	#8	XHHW-2	1	#8	XHHW-2	FR: BR-MCC-4A TO: POWER WIREWAY ABOVE BR-MCC-4 3 #8 >> PMP-16.461 POWER 3 #8 >> PMP-16.462 POWER	
P-16-012	E16-10	1.5"	6	#8	XHHW-2	1	#8	XHHW-2	FR: BR-MCC-2A TO: POWER WIREWAY ABOVE BR-MCC-2 3 #8 >> PMP-16.261 POWER 3 #8 >> PMP-16.262 POWER	
P-16-013	E16-10	1.5"	6	#8	XHHW-2	1	#8	XHHW-2	FR: BR-MCC-3A TO: POWER WIREWAY ABOVE BR-MCC-3 3 #8 >> PMP-16.361 POWER 3 #8 >> PMP-16.362 POWER	
P-16-201	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.228 TO: DISC-16.228 3 #10 >> EAM-16.228 POWER	P-16-202
P-16-202	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.228 TO: CONDUIT TEE 3 #10 >> EAM-16.228 POWER	P-16-205 P-16-201
P-16-203	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.232 TO: DISC-16.232 3 #10 >> EAM-16.232 POWER	P-16-204
P-16-204	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.232 TO: CONDUIT TEE 3 #10 >> EAM-16.232 POWER	P-16-205 P-16-203
P-16-205	E16-3	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.232 POWER 3 #10 >> EAM-16.228 POWER	P-16-215 P-16-204 P-16-202
P-16-208	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.233 TO: DISC-16.233 3 #10 >> EAM-16.233 POWER	P-16-209
P-16-209	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.233 TO: CONDUIT TEE 3 #10 >> EAM-16.233 POWER	P-16-213 P-16-208

March 2019

16990.16A-8

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-16-211	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.234 TO: DISC-16.234 3 #10 >> EAM-16.234 POWER	P-16-212
P-16-212	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.234 TO: CONDUIT TEE 3 #10 >> EAM-16.234 POWER	P-16-213 P-16-211
P-16-213	E16-3	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.234 POWER 3 #10 >> EAM-16.233 POWER	P-16-215 P-16-212 P-16-209
P-16-215	E16-3 E16-10	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: MCC-2A 3 #10 >> EAM-16.234 POWER 3 #10 >> EAM-16.233 POWER 3 #10 >> EAM-16.232 POWER 3 #10 >> EAM-16.228 POWER	P-16-213 P-16-213 P-16-205 P-16-205
P-16-221	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: BRX-16.210 TO: J-BOX 3 #10 >> BRX-16.210 POWER	P-16-222
P-16-222	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.210 TO: CONDUIT TEE 3 #10 >> BRX-16.210 POWER	P-16-225 P-16-221
P-16-223	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: BRX-16.209 TO: J-BOX 3 #10 >> BRX-16.209 POWER	P-16-224
P-16-224	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.209 TO: CONDUIT TEE 3 #10 >> BRX-16.209 POWER	P-16-225 P-16-223
P-16-225	E16-3	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> BRX-16.209 POWER 3 #10 >> BRX-16.210 POWER	P-16-228 P-16-224 P-16-222
P-16-227	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.208 TO: CONDUIT TEE 3 #10 >> BRX-16.208 POWER	P-16-228
P-16-228	E16-3	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> BRX-16.208 POWER 3 #10 >> BRX-16.209 POWER 3 #10 >> BRX-16.210 POWER	P-16-230 P-16-227 P-16-225 P-16-225
P-16-229	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.207 TO: CONDUIT TEE 3 #10 >> BRX-16.207 POWER	P-16-230
P-16-230	E16-3 E16-10	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: MCC-2 3 #10 >> BRX-16.207 POWER 3 #10 >> BRX-16.208 POWER 3 #10 >> BRX-16.209 POWER 3 #10 >> BRX-16.210 POWER	P-16-229 P-16-228 P-16-228 P-16-228
P-16-232	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.222 TO: DISC-16.222 3 #10 >> EAM-16.222 POWER	P-16-233
P-16-233	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.222 TO: CONDUIT TEE 3 #10 >> EAM-16.222 POWER	P-16-237 P-16-232
P-16-234	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.226 TO: DISC-16.226 3 #10 >> EAM-16.226 POWER	P-16-235
P-16-235	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.226 TO: CONDUIT TEE 3 #10 >> EAM-16.226 POWER	P-16-237 P-16-234
P-16-237	E16-3	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.226 POWER 3 #10 >> EAM-16.222 POWER	P-16-245 P-16-235 P-16-233

March 2019

16990.16A-9

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND			DESCRIPTION	CONNECTING SEGMENTS
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		
P-16-240	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.227 TO: DISC-16.227 3 #10 >> EAM-16.227 POWER	P-16-241
P-16-241	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.227 TO: CONDUIT TEE 3 #10 >> EAM-16.227 POWER	P-16-244 P-16-240
P-16-242	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.221 TO: DISC-16.221 3 #10 >> EAM-16.221 POWER	P-16-243
P-16-243	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.221 TO: CONDUIT TEE 3 #10 >> EAM-16.221 POWER	P-16-244 P-16-242
P-16-244	E16-3	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.221 POWER 3 #10 >> EAM-16.227 POWER	P-16-245 P-16-243 P-16-241
P-16-245	E16-3 E16-10	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: MCC-2A 3 #10 >> EAM-16.226 POWER 3 #10 >> EAM-16.222 POWER 3 #10 >> EAM-16.221 POWER 3 #10 >> EAM-16.227 POWER	P-16-237 P-16-237 P-16-244 P-16-244
P-16-250	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.231 TO: DISC-16.231 3 #10 >> EAM-16.231 POWER	P-16-251
P-16-251	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.231 TO: CONDUIT TEE 3 #10 >> EAM-16.231 POWER	P-16-255 P-16-250
P-16-252	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.230 TO: DISC-16.230 3 #10 >> EAM-16.230 POWER	P-16-253
P-16-253	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.230 TO: CONDUIT TEE 3 #10 >> EAM-16.230 POWER	P-16-255 P-16-252
P-16-255	E16-3	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.230 POWER 3 #10 >> EAM-16.231 POWER	P-16-259 P-16-253 P-16-251
P-16-257	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.229 TO: DISC-16.229 3 #10 >> EAM-16.229 POWER	P-16-258
P-16-258	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.229 TO: CONDUIT TEE 3 #10 >> EAM-16.229 POWER	P-16-259 P-16-257
P-16-259	E16-3 E16-10	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: MCC-2A 3 #10 >> EAM-16.230 POWER 3 #10 >> EAM-16.231 POWER 3 #10 >> EAM-16.229 POWER	P-16-255 P-16-255 P-16-258
P-16-261	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.223 TO: DISC-16.223 3 #10 >> EAM-16.223 POWER	P-16-262
P-16-262	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.223 TO: CONDUIT TEE 3 #10 >> EAM-16.223 POWER	P-16-265 P-16-261
P-16-263	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.224 TO: DISC-16.224 3 #10 >> EAM-16.224 POWER	P-16-264
P-16-264	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.224 TO: CONDUIT TEE 3 #10 >> EAM-16.224 POWER	P-16-265 P-16-263
P-16-265	E16-3	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.224 POWER 3 #10 >> EAM-16.223 POWER	P-16-269 P-16-264 P-16-262

March 2019

16990.16A-10

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-16-267	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.225 TO: DISC-16.225 3 #10 >> EAM-16.225 POWER	P-16-268
P-16-268	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.225 TO: CONDUIT TEE 3 #10 >> EAM-16.225 POWER	P-16-269 P-16-267
P-16-269	E16-3	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.225 POWER 3 #10 >> EAM-16.224 POWER 3 #10 >> EAM-16.223 POWER	P-16-276 P-16-268 P-16-265 P-16-265
P-16-271	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.235 TO: DISC-16.235 3 #10 >> EAM-16.235 POWER	P-16-272
P-16-272	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.235 TO: CONDUIT TEE 3 #10 >> EAM-16.235 POWER	P-16-275 P-16-271
P-16-273	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.236 TO: DISC-16.236 3 #10 >> EAM-16.236 POWER	P-16-274
P-16-274	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.236 TO: CONDUIT TEE 3 #10 >> EAM-16.236 POWER	P-16-275 P-16-273
P-16-275	E16-3	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.236 POWER 3 #10 >> EAM-16.235 POWER	P-16-276 P-16-274 P-16-272
P-16-276	E16-3 E16-10	1.5"	15	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: MCC-2A 3 #10 >> EAM-16.225 POWER 3 #10 >> EAM-16.224 POWER 3 #10 >> EAM-16.223 POWER 3 #10 >> EAM-16.236 POWER 3 #10 >> EAM-16.235 POWER	P-16-269 P-16-269 P-16-269 P-16-275 P-16-275
P-16-281	E16-3	0.75"	5 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: BRXA-602 TO: DISCONNECT 3 #12 >> BRXA-602 POWER 2 #12 >> MWA-602 2 #14 >> TSHA-602	P-16-282
P-16-282	E16-3	0.75"	5 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> BRXA-602 POWER 2 #12 >> MWA-602 2 #14 >> TSHA-602	P-16-285 P-16-281 P-16-281 P-16-281
P-16-283	E16-3	0.75"	5 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: BRXB-602 TO: DISCONNECT 3 #12 >> BRXB-602 POWER 2 #12 >> MWA-602 2 #14 >> TSHA-602	P-16-284
P-16-284	E16-3	0.75"	5 2	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> BRXB-602 POWER 2 #12 >> MWA-602 2 #14 >> TSHA-602	P-16-285 P-16-283 P-16-283 P-16-283
P-16-285	E16-3	1"	10 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: BIOREACTOR 2 POWER WIREWAY 3 #12 >> BRXB-602 POWER 2 #12 >> MWA-602 2 #14 >> TSHA-602 3 #12 >> BRXA-602 POWER 2 #12 >> MWA-602 2 #14 >> TSHA-602	P-16-284 P-16-284 P-16-284 P-16-282 P-16-282 P-16-282
P-16-286	E16-3	0.75"	3	#8	XHHW-2	1	#8	XHHW-2	FR: PMP-16.261 J-BOX TO: BIOREACTOR 2 POWER WIREWAY 3 #8 >> PMP-16.261 POWER	
P-16-287	E16-3	0.75"	3	#8	XHHW-2	1	#8	XHHW-2	FR: PMP-16.262 J-BOX TO: BIOREACTOR 2 POWER WIREWAY 3 #8 >> PMP-16.262 POWER	

March 2019

16990.16A-11

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 2 AND ELECTRICAL ROOMS

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND			DESCRIPTION	CONNECTING SEGMENTS
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE		
P-16-291	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.210 3 #10 >> BRX-16.210 POWER	P-16-221
P-16-292	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.209 3 #10 >> BRX-16.209 POWER	P-16-223
P-16-293	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.208 3 #10 >> BRX-16.208 POWER	
P-16-294	E16-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.207 3 #10 >> BRX-16.207 POWER	
S-16-245	E16-7	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.243 TO: AIT-16.241 1 MFR >> AE-16.243 SIGNAL	
S-16-251	E16-7	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.251 TO: CONDUIT TEE 1 MFR >> AE-16.251 SIGNAL	S-16-254
S-16-252	E16-7	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.252 TO: CONDUIT TEE 1 MFR >> AE-16.252 SIGNAL	S-16-254
S-16-253	E16-7	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.246 TO: AIT-16.246 1 MFR >> AE-16.246 SIGNAL	
S-16-254	E16-7	0.75"	2	MFR	CABLE	1	#14	XHHW-2	FR: CONDUIT TEE TO: AIT-16.246 1 MFR >> AE-16.252 SIGNAL 1 MFR >> AE-16.251 SIGNAL	S-16-252 S-16-251
S-16-281	E16-7	0.75"	4 1	#14 3/CS-#16	XHHW-2	1	#14	XHHW-2	FR: LCP-16.262 TO: CONDUIT TEE 4 #14 >> LCP-16.262 24VDC CONTROL 1 3/CS-#16 >> LCP-16.262 SPEED POT	S-16-283
S-16-282	E16-7	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LCPB-602 TO: CONDUIT TEE 2 #14 >> LCPB-602 24VDC CONTROL	S-16-283
S-16-283	E16-7	0.75"	6 1	#14 3/CS-#16	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> LCPB-602 24VDC CONTROL 4 #14 >> LCP-16.262 24VDC CONTROL 1 3/CS-#16 >> LCP-16.262 SPEED POT	S-16-285 S-16-282 S-16-281 S-16-281
S-16-284	E16-7	0.75"	4 1	#14 3/CS-#16	XHHW-2	1	#14	XHHW-2	FR: LCP-16.261 TO: CONDUIT TEE 4 #14 >> LCP-16.261 24VDC CONTROL 1 3/CS-#16 >> LCP-16.261 SPEED POT	S-16-285
S-16-285	E16-7	1.5"	10 2	#14 3/CS-#16	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.261 24VDC CONTROL 1 3/CS-#16 >> LCP-16.261 SPEED POT 2 #14 >> LCPB-602 24VDC CONTROL 4 #14 >> LCP-16.262 24VDC CONTROL 1 3/CS-#16 >> LCP-16.262 SPEED POT	S-16-287 S-16-284 S-16-284 S-16-283 S-16-283 S-16-283
S-16-286	E16-7	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: LCPA-602 TO: CONDUIT TEE 2 #14 >> LCPA-602 24VDC CONTROL	S-16-287
S-16-287	E16-7	1.5"	12 2	#14 3/CS-#16	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONTROL WIREWAY 2 #14 >> LCPA-602 24VDC CONTROL 4 #14 >> LCP-16.261 24VDC CONTROL 1 3/CS-#16 >> LCP-16.261 SPEED POT 2 #14 >> LCPB-602 24VDC CONTROL 4 #14 >> LCP-16.262 24VDC CONTROL 1 3/CS-#16 >> LCP-16.262 SPEED POT	S-16-286 S-16-285 S-16-285 S-16-285 S-16-285 S-16-285

END OF CONDUIT SCHEDULE

END OF SECTION

March 2019

16990.16A-12

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

SECTION 16990.16B

CONDUIT SCHEDULE AREA 16

PART 1 GENERAL

1.01 SUMMARY

- A. Conduit requirements:
 - 1. As defined in Section 16050 - Common Work Results for Electrical and Section 16130 - Conduits.
- B. Cable requirements and definitions:
 - 1. As defined in Section 16050 - Common Work Results for Electrical and Section 16123 - 600-Volt or Less Wires and Cables.
 - 2. */FO: Fiber optic cable (* indicates number of fibers).
 - 3. CAT6A: Category 6A Ethernet cable.
 - 4. MFR: Manufacturer or vendor furnished cable.
 - 5. PBDP: Profibus DP cable.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

- A. Conduit Schedule is presented on the following pages.

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 3

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-16-305	E16-8	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.310 TO: CONDUIT TEE 4 #14 >> LCP-16.310 CONTROL	C-16-307
C-16-307	E16-8	0.75"	2 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.310 CONTROL 2 #12 >> AIT-16.353 POWER	C-16-310 C-16-305 L-16-305
C-16-308	E16-8	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.309 TO: CONDUIT TEE 4 #14 >> LCP-16.309 CONTROL	C-16-310
C-16-310	E16-8	0.75"	2 8	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.309 CONTROL 4 #14 >> LCP-16.310 CONTROL 2 #12 >> AIT-16.353 POWER	C-16-313 C-16-308 C-16-307 C-16-307
C-16-311	E16-8	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.308 TO: CONDUIT TEE 4 #14 >> LCP-16.308 CONTROL	C-16-313
C-16-313	E16-8	1"	2 12	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.308 CONTROL 4 #14 >> LCP-16.309 CONTROL 4 #14 >> LCP-16.310 CONTROL 2 #12 >> AIT-16.353 POWER	C-16-316 C-16-311 C-16-310 C-16-310 C-16-310
C-16-314	E16-8	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.307 TO: CONDUIT TEE 4 #14 >> LCP-16.307 CONTROL	C-16-316
C-16-316	E16-8	1"	2 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.307 CONTROL 4 #14 >> LCP-16.308 CONTROL 4 #14 >> LCP-16.309 CONTROL 4 #14 >> LCP-16.310 CONTROL 2 #12 >> AIT-16.353 POWER	C-16-320 C-16-314 C-16-313 C-16-313 C-16-313 C-16-313
C-16-320	E16-8	1.5"	4 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.307 CONTROL 4 #14 >> LCP-16.308 CONTROL 4 #14 >> LCP-16.309 CONTROL 4 #14 >> LCP-16.310 CONTROL 2 #12 >> AIT-16.353 POWER 2 #12 >> AIT-16.345 POWER	C-16-330 C-16-316 C-16-316 C-16-316 C-16-316 C-16-316 L-16-301
C-16-330	E16-8	1.5"	8 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: J-BOX 4 #14 >> LCP-16.307 CONTROL 4 #14 >> LCP-16.308 CONTROL 4 #14 >> LCP-16.309 CONTROL 4 #14 >> LCP-16.310 CONTROL 2 #12 >> AIT-16.353 POWER 2 #12 >> AIT-16.345 POWER 2 #12 >> AIT-16.346 POWER 2 #12 >> AIT-16.341 POWER	C-16-335 C-16-320 C-16-320 C-16-320 C-16-320 C-16-320 C-16-320 L-16-345 L-16-345
C-16-335	E16-8	1.5"	10 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: CONDUIT TEE 4 #14 >> LCP-16.307 CONTROL 4 #14 >> LCP-16.308 CONTROL 4 #14 >> LCP-16.309 CONTROL 4 #14 >> LCP-16.310 CONTROL 2 #12 >> AIT-16.353 POWER 2 #12 >> AIT-16.345 POWER 2 #12 >> AIT-16.346 POWER 2 #12 >> AIT-16.341 POWER 2 #12 >> NJB-16.300 POWER	C-16-338 C-16-330 C-16-330 C-16-330 C-16-330 C-16-330 C-16-330 C-16-330 C-16-330 L-16-332

March 2019

16990.16B-2

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 3

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-16-338	E16-8	1.5"	12 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.347 POWER 4 #14 >> LCP-16.307 CONTROL 4 #14 >> LCP-16.308 CONTROL 4 #14 >> LCP-16.309 CONTROL 4 #14 >> LCP-16.310 CONTROL 2 #12 >> AIT-16.353 POWER 2 #12 >> AIT-16.345 POWER 2 #12 >> AIT-16.346 POWER 2 #12 >> AIT-16.341 POWER 2 #12 >> NJB-16.300 POWER	C-16-340 L-16-337 C-16-335 C-16-335 C-16-335 C-16-335 C-16-335 C-16-335 C-16-335 C-16-335
C-16-340	E16-8 E16-10	1.5"	16 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.342 POWER 2 #12 >> AIT-16.344 POWER 2 #12 >> AIT-16.347 POWER 4 #14 >> LCP-16.307 CONTROL 4 #14 >> LCP-16.308 CONTROL 4 #14 >> LCP-16.309 CONTROL 4 #14 >> LCP-16.310 CONTROL 2 #12 >> AIT-16.353 POWER 2 #12 >> AIT-16.345 POWER 2 #12 >> AIT-16.346 POWER 2 #12 >> AIT-16.341 POWER 2 #12 >> NJB-16.300 POWER	C-16-342 L-16-365 L-16-365 C-16-338 C-16-338 C-16-338 C-16-338 C-16-338 C-16-338 C-16-338 C-16-338 C-16-338
C-16-342	E16-10	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-3 4 #14 >> LCP-16.307 CONTROL 4 #14 >> LCP-16.308 CONTROL 4 #14 >> LCP-16.309 CONTROL 4 #14 >> LCP-16.310 CONTROL	C-16-340 C-16-340 C-16-340 C-16-340
C-16-344	E16-10	1.5"	16	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: PCM-600A 2 #12 >> AIT-16.342 POWER 2 #12 >> AIT-16.344 POWER 2 #12 >> AIT-16.347 POWER 2 #12 >> AIT-16.353 POWER 2 #12 >> AIT-16.345 POWER 2 #12 >> AIT-16.346 POWER 2 #12 >> AIT-16.341 POWER 2 #12 >> NJB-16.300 POWER	C-16-340 C-16-340 C-16-340 C-16-340 C-16-340 C-16-340 C-16-340 C-16-340
L-16-301	E16-8	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.345 TO: CONDUIT TEE 2 #12 >> AIT-16.345 POWER	C-16-320
L-16-305	E16-8	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.353 TO: CONDUIT TEE 2 #12 >> AIT-16.353 POWER	C-16-307
L-16-332	E16-8	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: NJB-16.300 TO: J-BOX 2 #12 >> NJB-16.300 POWER	C-16-335
L-16-337	E16-8	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.347 TO: CONDUIT TEE 2 #12 >> AIT-16.347 POWER	C-16-338
L-16-340	E16-8	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.341 TO: CONDUIT TEE 2 #12 >> AIT-16.341 POWER	L-16-345
L-16-343	E16-8	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.346 TO: CONDUIT TEE 2 #12 >> AIT-16.346 POWER	L-16-345
L-16-345	E16-8	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.346 POWER 2 #12 >> AIT-16.341 POWER	C-16-330 L-16-343 L-16-340
L-16-360	E16-8	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.344 TO: CONDUIT TEE 2 #12 >> AIT-16.344 POWER	L-16-365
L-16-362	E16-8	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.342 TO: CONDUIT TEE 2 #12 >> AIT-16.342 POWER	L-16-365

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 3

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-16-365	E16-8	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.342 POWER 2 #12 >> AIT-16.344 POWER	C-16-340 L-16-362 L-16-360
N-16-301	E16-8	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.345 TO: CONDUIT TEE 1 CAT6A >> AIT-16.345 NETWORK	N-16-308
N-16-305	E16-8	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.353 TO: CONDUIT TEE 1 CAT6A >> AIT-16.353 NETWORK	N-16-308
N-16-308	E16-8	0.75"	2		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> AIT-16.353 NETWORK 1 CAT6A >> AIT-16.345 NETWORK	N-16-355 N-16-305 N-16-301
N-16-310	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.330> PCM-600A NETWORK	N-16-320 N-16-399
N-16-312	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.334>EAM-16.335 NETWORK 1 PBDP >> PCM-600A>EAM16.333 NETWORK	N-16-371
N-16-313	E16-8	1.5"	1		12/FO-SM	1	#14	XHHW-2	FR: NJB-16.300 TO: J-BOX 1 12/FO-SM >> NJB-16.300 NETWORK	N-16-315
N-16-315	E16-8	1.5"	1 1		PBDP 12/FO-SM	1	#14	XHHW-2	FR: J-BOX TO: CONDUIT TEE 1 12/FO-SM >> NJB-16.300 NETWORK 1 PBDP >> PCM-600A>EAM16.333 NETWORK	N-16-320 N-16-313
N-16-317	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 1 PBDP >> PCM-600A>EAM16.333 NETWORK	
N-16-320	E16-8	1.5"	2 1		PBDP 12/FO-SM	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-600A 1 12/FO-SM >> NJB-16.300 NETWORK 1 PBDP >> PCM-600A>EAM16.333 NETWORK 1 PBDP >> EAM-16.330> PCM-600A NETWORK	N-16-315 N-16-315 N-16-310
N-16-340	E16-8	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.341 TO: CONDUIT TEE 1 CAT6A >> AIT-16.341 NETWORK	N-16-350
N-16-345	E16-8	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.346 TO: CONDUIT TEE 1 CAT6A >> AIT-16.346 NETWORK	N-16-350
N-16-350	E16-8	0.75"	2		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> AIT-16.346 NETWORK 1 CAT6A >> AIT-16.341 NETWORK	N-16-355 N-16-345 N-16-340
N-16-355	E16-8	1"	4		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: NJB-16.300 1 CAT6A >> AIT-16.346 NETWORK 1 CAT6A >> AIT-16.341 NETWORK 1 CAT6A >> AIT-16.353 NETWORK 1 CAT6A >> AIT-16.345 NETWORK	N-16-350 N-16-350 N-16-308 N-16-308
N-16-360	E16-8	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.344 TO: CONDUIT TEE 1 CAT6A >> AIT-16.344 NETWORK	N-16-365
N-16-362	E16-8	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.342 TO: CONDUIT TEE 1 CAT6A >> AIT-16.342 NETWORK	N-16-365
N-16-365	E16-8	0.75"	2		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> AIT-16.342 NETWORK 1 CAT6A >> AIT-16.344 NETWORK	N-16-367 N-16-362 N-16-360
N-16-366	E16-8	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.347 TO: CONDUIT TEE 1 CAT6A >> AIT-16.347 NETWORK	N-16-367

March 2019

16990.16B-4

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 3

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-16-367	E16-8	1"	3		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: NJB-16.300 1 CAT6A >> AIT-16.347 NETWORK 1 CAT6A >> AIT-16.342 NETWORK 1 CAT6A >> AIT-16.344 NETWORK	N-16-366 N-16-365 N-16-365
N-16-370	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.333 TO: CONDUIT TEE 1 PBDP >> EAM-16.333>EAM-16.334 NETWORK 1 PBDP >> PCM-600A>EAM16.333 NETWORK	N-16-371
N-16-371	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.334 TO: CONDUIT TEE 1 PBDP >> EAM-16.333>EAM-16.334 NETWORK 1 PBDP >> EAM-16.334>EAM-16.335 NETWORK	N-16-312 N-16-370
N-16-372	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.334>EAM-16.335 NETWORK	N-16-373 N-16-371
N-16-373	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.335 TO: CONDUIT TEE 1 PBDP >> EAM-16.334>EAM-16.335 NETWORK 1 PBDP >> EAM-16.335>EAM-16.336 NETWORK	N-16-374 N-16-372
N-16-374	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.335>EAM-16.336 NETWORK	N-16-375 N-16-373
N-16-375	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.336 TO: CONDUIT TEE 1 PBDP >> EAM-16.335>EAM-16.336 NETWORK 1 PBDP >> EAM-16.336>EAM-16.325 NETWORK	N-16-376 N-16-374
N-16-376	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.336>EAM-16.325 NETWORK	N-16-377 N-16-375
N-16-377	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.325 TO: CONDUIT TEE 1 PBDP >> EAM-16.336>EAM-16.325 NETWORK 1 PBDP >> EAM-16.325>EAM-16.324 NETWORK	N-16-378 N-16-376
N-16-378	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.325>EAM-16.324 NETWORK	N-16-379 N-16-377
N-16-379	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.324 TO: CONDUIT TEE 1 PBDP >> EAM-16.325>EAM-16.324 NETWORK 1 PBDP >> EAM-16.324>EAM-16.323 NETWORK	N-16-380 N-16-378
N-16-380	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.324>EAM-16.323 NETWORK	N-16-381 N-16-379
N-16-381	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.323 TO: CONDUIT TEE 1 PBDP >> EAM-16.324>EAM-16.323 NETWORK 1 PBDP >> EAM-16.323>EAM-16.326 NETWORK	N-16-382 N-16-380
N-16-382	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.323>EAM-16.326 NETWORK	N-16-383 N-16-381
N-16-383	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.326 TO: CONDUIT TEE 1 PBDP >> EAM-16.323>EAM-16.326 NETWORK 1 PBDP >> EAM-16.326>EAM-16.322 NETWORK	N-16-384 N-16-382
N-16-384	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.326>EAM-16.322 NETWORK	N-16-385 N-16-383
N-16-385	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.322 TO: CONDUIT TEE 1 PBDP >> EAM-16.326>EAM-16.322 NETWORK 1 PBDP >> EAM-16.322>EAM-16.321 NETWORK	N-16-386 N-16-384
N-16-386	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.322>EAM-16.321 NETWORK	N-16-387 N-16-385

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 3

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-16-387	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.321 TO: CONDUIT TEE 1 PBDP >> EAM-16.322>EAM-16.321 NETWORK 1 PBDP >> EAM-16.321>EAM-16.327 NETWORK	N-16-388 N-16-386
N-16-388	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.321>EAM-16.327 NETWORK	N-16-389 N-16-387
N-16-389	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.327 TO: CONDUIT TEE 1 PBDP >> EAM-16.321>EAM-16.327 NETWORK 1 PBDP >> EAM-16.327>EAM-16.328 NETWORK	N-16-390 N-16-388
N-16-390	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.327>EAM-16.328 NETWORK	N-16-391 N-16-389
N-16-391	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.327>EAM-16.328 NETWORK 1 PBDP >> EAM-16.332>EAM-16.329 NETWORK	N-16-392 N-16-390 N-16-393
N-16-392	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.328 TO: CONDUIT TEE 1 PBDP >> EAM-16.327>EAM-16.328 NETWORK 1 PBDP >> EAM-16.328>EAM-16.332 NETWORK	N-16-393 N-16-391
N-16-393	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.332 TO: CONDUIT TEE 1 PBDP >> EAM-16.328>EAM-16.332 NETWORK 1 PBDP >> EAM-16.332>EAM-16.329 NETWORK	N-16-391 N-16-392
N-16-394	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.332>EAM-16.329 NETWORK	N-16-395 N-16-393
N-16-395	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.331>EAM-16.330 NETWORK 1 PBDP >> EAM-16.332>EAM-16.329 NETWORK	N-16-396 N-16-397 N-16-394
N-16-396	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.329 TO: CONDUIT TEE 1 PBDP >> EAM-16.332>EAM-16.329 NETWORK 1 PBDP >> EAM-16.329>EAM-16.331 NETWORK	N-16-397 N-16-395 N-16-395
N-16-397	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.331 TO: CONDUIT TEE 1 PBDP >> EAM-16.329>EAM-16.331 NETWORK 1 PBDP >> EAM-16.331>EAM-16.330 NETWORK	N-16-395 N-16-396
N-16-398	E16-8	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.331>EAM-16.330 NETWORK	N-16-399 N-16-395
N-16-399	E16-8	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.330 TO: CONDUIT TEE 1 PBDP >> EAM-16.331>EAM-16.330 NETWORK 1 PBDP >> EAM-16.330> PCM-600A NETWORK	N-16-310 N-16-398
P-16-301	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.328 TO: DISC-16.328 3 #10 >> EAM-16.328 POWER	P-16-302
P-16-302	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.328 TO: CONDUIT TEE 3 #10 >> EAM-16.328 POWER	P-16-305 P-16-301
P-16-303	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.332 TO: DISC-16.332 3 #10 >> EAM-16.332 POWER	P-16-304
P-16-304	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.332 TO: CONDUIT TEE 3 #10 >> EAM-16.332 POWER	P-16-305 P-16-303
P-16-305	E16-4	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.332 POWER 3 #10 >> EAM-16.328 POWER	P-16-315 P-16-304 P-16-302

March 2019

16990.16B-6

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 3

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-16-308	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.333 TO: DISC-16.333 3 #10 >> EAM-16.333 POWER	P-16-309
P-16-309	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.333 TO: CONDUIT TEE 3 #10 >> EAM-16.333 POWER	P-16-313 P-16-308
P-16-311	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.334 TO: DISC-16.334 3 #10 >> EAM-16.334 POWER	P-16-312
P-16-312	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.334 TO: CONDUIT TEE 3 #10 >> EAM-16.334 POWER	P-16-313 P-16-311
P-16-313	E16-4	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.334 POWER 3 #10 >> EAM-16.333 POWER	P-16-315 P-16-312 P-16-309
P-16-315	E16-4 E16-10	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-3A 3 #10 >> EAM-16.334 POWER 3 #10 >> EAM-16.333 POWER 3 #10 >> EAM-16.332 POWER 3 #10 >> EAM-16.328 POWER	P-16-313 P-16-313 P-16-305 P-16-305
P-16-321	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: BRX-16.310 TO: J-BOX 3 #10 >> BRX-16.310 POWER	P-16-322
P-16-322	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.310 TO: CONDUIT TEE 3 #10 >> BRX-16.310 POWER	P-16-325 P-16-321
P-16-323	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: BRX-16.309 TO: J-BOX 3 #10 >> BRX-16.309 POWER	P-16-324
P-16-324	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.309 TO: CONDUIT TEE 3 #10 >> BRX-16.309 POWER	P-16-325 P-16-323
P-16-325	E16-4	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> BRX-16.309 POWER 3 #10 >> BRX-16.310 POWER	P-16-328 P-16-324 P-16-322
P-16-327	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.308 TO: CONDUIT TEE 3 #10 >> BRX-16.308 POWER	P-16-328
P-16-328	E16-4	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> BRX-16.308 POWER 3 #10 >> BRX-16.309 POWER 3 #10 >> BRX-16.310 POWER	P-16-330 P-16-327 P-16-325 P-16-325
P-16-329	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.307 TO: CONDUIT TEE 3 #10 >> BRX-16.307 POWER	P-16-330
P-16-330	E16-4 E16-10	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-3 3 #10 >> BRX-16.307 POWER 3 #10 >> BRX-16.308 POWER 3 #10 >> BRX-16.309 POWER 3 #10 >> BRX-16.310 POWER	P-16-329 P-16-328 P-16-328 P-16-328
P-16-332	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.322 TO: DISC-16.322 3 #10 >> EAM-16.322 POWER	P-16-333
P-16-333	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.322 TO: CONDUIT TEE 3 #10 >> EAM-16.322 POWER	P-16-337 P-16-332
P-16-334	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.326 TO: DISC-16.326 3 #10 >> EAM-16.326 POWER	P-16-335

March 2019

16990.16B-7

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 3

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-16-335	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.326 TO: CONDUIT TEE 3 #10 >> EAM-16.326 POWER	P-16-337 P-16-334
P-16-337	E16-4	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.326 POWER 3 #10 >> EAM-16.322 POWER	P-16-345 P-16-335 P-16-333
P-16-340	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.327 TO: DISC-16.327 3 #10 >> EAM-16.327 POWER	P-16-341
P-16-341	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.327 TO: CONDUIT TEE 3 #10 >> EAM-16.327 POWER	P-16-344 P-16-340
P-16-342	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.321 TO: DISC-16.321 3 #10 >> EAM-16.321 POWER	P-16-343
P-16-343	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.321 TO: CONDUIT TEE 3 #10 >> EAM-16.321 POWER	P-16-344 P-16-342
P-16-344	E16-4	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.321 POWER 3 #10 >> EAM-16.327 POWER	P-16-345 P-16-343 P-16-341
P-16-345	E16-4 E16-10	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-3A 3 #10 >> EAM-16.326 POWER 3 #10 >> EAM-16.322 POWER 3 #10 >> EAM-16.321 POWER 3 #10 >> EAM-16.327 POWER	P-16-337 P-16-337 P-16-344 P-16-344
P-16-350	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.331 TO: DISC-16.331 3 #10 >> EAM-16.331 POWER	P-16-351
P-16-351	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.331 TO: CONDUIT TEE 3 #10 >> EAM-16.331 POWER	P-16-355 P-16-350
P-16-352	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.330 TO: DISC-16.330 3 #10 >> EAM-16.330 POWER	P-16-353
P-16-353	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.330 TO: CONDUIT TEE 3 #10 >> EAM-16.330 POWER	P-16-355 P-16-352
P-16-355	E16-4	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.330 POWER 3 #10 >> EAM-16.331 POWER	P-16-359 P-16-353 P-16-351
P-16-357	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.329 TO: DISC-16.329 3 #10 >> EAM-16.329 POWER	P-16-358
P-16-358	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.329 TO: CONDUIT TEE 3 #10 >> EAM-16.329 POWER	P-16-359 P-16-357
P-16-359	E16-4 E16-10	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-3A 3 #10 >> EAM-16.330 POWER 3 #10 >> EAM-16.331 POWER 3 #10 >> EAM-16.329 POWER	P-16-355 P-16-355 P-16-358
P-16-361	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.323 TO: DISC-16.323 3 #10 >> EAM-16.323 POWER	P-16-362
P-16-362	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.323 TO: CONDUIT TEE 3 #10 >> EAM-16.323 POWER	P-16-365 P-16-361
P-16-363	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.324 TO: DISC-16.324 3 #10 >> EAM-16.324 POWER	P-16-364

March 2019

16990.16B-8

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 3

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-16-364	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.324 TO: CONDUIT TEE 3 #10 >> EAM-16.324 POWER	P-16-365 P-16-363
P-16-365	E16-4	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.324 POWER 3 #10 >> EAM-16.323 POWER	P-16-369 P-16-364 P-16-362
P-16-367	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.325 TO: DISC-16.325 3 #10 >> EAM-16.325 POWER	P-16-368
P-16-368	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.325 TO: CONDUIT TEE 3 #10 >> EAM-16.325 POWER	P-16-369 P-16-367
P-16-369	E16-4	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.325 POWER 3 #10 >> EAM-16.324 POWER 3 #10 >> EAM-16.323 POWER	P-16-376 P-16-368 P-16-365 P-16-365
P-16-371	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.335 TO: DISC-16.335 3 #10 >> EAM-16.335 POWER	P-16-372
P-16-372	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.335 TO: CONDUIT TEE 3 #10 >> EAM-16.335 POWER	P-16-375 P-16-371
P-16-373	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.336 TO: DISC-16.336 3 #10 >> EAM-16.336 POWER	P-16-374
P-16-374	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.336 TO: CONDUIT TEE 3 #10 >> EAM-16.336 POWER	P-16-375 P-16-373
P-16-375	E16-4	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.336 POWER 3 #10 >> EAM-16.335 POWER	P-16-376 P-16-374 P-16-372
P-16-376	E16-4 E16-10	1.5"	15	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-3A 3 #10 >> EAM-16.325 POWER 3 #10 >> EAM-16.324 POWER 3 #10 >> EAM-16.323 POWER 3 #10 >> EAM-16.336 POWER 3 #10 >> EAM-16.335 POWER	P-16-369 P-16-369 P-16-369 P-16-375 P-16-375
P-16-391	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.310 3 #10 >> BRX-16.310 POWER	P-16-321
P-16-392	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.309 3 #10 >> BRX-16.309 POWER	P-16-323
P-16-393	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.308 3 #10 >> BRX-16.308 POWER	
P-16-394	E16-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.307 3 #10 >> BRX-16.307 POWER	
S-16-345	E16-8	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.343 TO: AIT-16.341 1 MFR >> AE-16.343 SIGNAL	
S-16-351	E16-8	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.351 TO: CONDUIT TEE 1 MFR >> AE-16.351 SIGNAL	S-16-354
S-16-352	E16-8	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.352 TO: CONDUIT TEE 1 MFR >> AE-16.352 SIGNAL	S-16-354
S-16-353	E16-8	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.346 TO: AIT-16.346 1 MFR >> AE-16.346 SIGNAL	

March 2019

16990.16B-9

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 3

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-16-354	E16-8	0.75"	2	MFR	CABLE	1	#14	XHHW-2	FR: CONDUIT TEE TO: AIT-16.346 1 MFR >> AE-16.352 SIGNAL 1 MFR >> AE-16.351 SIGNAL	S-16-352 S-16-351
R1320	E16-4	0.75"	3	#8	XHHW-2	1	#8	XHHW-2	FR: PMP-16.361 JBOX TO: POWER WIREWAY 3 #8 >> PMP-16.361 POWER EXISTING CONDUIT, NEW CONDUCTOR	
R1322	E16-4	0.75"	3	#8	XHHW-2	1	#8	XHHW-2	FR: PMP-16.362 JBOX TO: POWER WIREWAY 3 #8 >> PMP-16.362 POWER EXISTING CONDUIT, NEW CONDUCTOR	

END OF CONDUIT SCHEDULE

END OF SECTION

SECTION 16990.16C

CONDUIT SCHEDULE AREA 16

PART 1 GENERAL

1.01 SUMMARY

- A. Conduit requirements:
 - 1. As defined in Section 16050 - Common Work Results for Electrical and Section 16130 - Conduits.
- B. Cable requirements and definitions:
 - 1. As defined in Section 16050 - Common Work Results for Electrical and Section 16123 - 600-Volt or Less Wires and Cables.
 - 2. */FO: Fiber optic cable (* indicates number of fibers).
 - 3. CAT6A: Category 6A Ethernet cable.
 - 4. MFR: Manufacturer or vendor furnished cable.
 - 5. PBDP: Profibus DP cable.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

- A. Conduit Schedule is presented on the following pages.

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 4

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-16-405	E16-9	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.410 TO: CONDUIT TEE 4 #14 >> LCP-16.410 CONTROL	C-16-407
C-16-407	E16-9	0.75"	2 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.410 CONTROL 2 #12 >> AIT-16.453 POWER	C-16-410 C-16-405 L-16-405
C-16-408	E16-9	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.409 TO: CONDUIT TEE 4 #14 >> LCP-16.409 CONTROL	C-16-410
C-16-410	E16-9	0.75"	2 8	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.409 CONTROL 4 #14 >> LCP-16.410 CONTROL 2 #12 >> AIT-16.453 POWER	C-16-413 C-16-408 C-16-407 C-16-407
C-16-411	E16-9	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.408 TO: CONDUIT TEE 4 #14 >> LCP-16.408 CONTROL	C-16-413
C-16-413	E16-9	1"	2 12	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.408 CONTROL 4 #14 >> LCP-16.409 CONTROL 4 #14 >> LCP-16.410 CONTROL 2 #12 >> AIT-16.453 POWER	C-16-416 C-16-411 C-16-410 C-16-410
C-16-414	E16-9	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-16.407 TO: CONDUIT TEE 4 #14 >> LCP-16.407 CONTROL	C-16-416
C-16-416	E16-9	1"	2 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.407 CONTROL 4 #14 >> LCP-16.408 CONTROL 4 #14 >> LCP-16.409 CONTROL 4 #14 >> LCP-16.410 CONTROL 2 #12 >> AIT-16.453 POWER	C-16-420 C-16-414 C-16-413 C-16-413 C-16-413
C-16-420	E16-9	1.5"	4 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> LCP-16.407 CONTROL 4 #14 >> LCP-16.408 CONTROL 4 #14 >> LCP-16.409 CONTROL 4 #14 >> LCP-16.410 CONTROL 2 #12 >> AIT-16.453 POWER 2 #12 >> AIT-16.445 POWER	C-16-430 C-16-416 C-16-416 C-16-416 C-16-416 C-16-416 L-16-401
C-16-430	E16-9	1.5"	8 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: J-BOX 4 #14 >> LCP-16.407 CONTROL 4 #14 >> LCP-16.408 CONTROL 4 #14 >> LCP-16.409 CONTROL 4 #14 >> LCP-16.410 CONTROL 2 #12 >> AIT-16.453 POWER 2 #12 >> AIT-16.445 POWER 2 #12 >> AIT-16.446 POWER 2 #12 >> AIT-16.441 POWER	C-16-435 C-16-420 C-16-420 C-16-420 C-16-420 C-16-420 C-16-420 L-16-445 L-16-445
C-16-435	E16-9	1.5"	10 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: J-BOX TO: CONDUIT TEE 4 #14 >> LCP-16.407 CONTROL 4 #14 >> LCP-16.408 CONTROL 4 #14 >> LCP-16.409 CONTROL 4 #14 >> LCP-16.410 CONTROL 2 #12 >> AIT-16.453 POWER 2 #12 >> AIT-16.445 POWER 2 #12 >> AIT-16.446 POWER 2 #12 >> AIT-16.441 POWER 2 #12 >> NJB-16.400 POWER	C-16-438 C-16-430 C-16-430 C-16-430 C-16-430 C-16-430 C-16-430 C-16-430 C-16-430 L-16-432

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 4

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-16-438	E16-9	1.5"	12 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.447 POWER 4 #14 >> LCP-16.407 CONTROL 4 #14 >> LCP-16.408 CONTROL 4 #14 >> LCP-16.409 CONTROL 4 #14 >> LCP-16.410 CONTROL 2 #12 >> AIT-16.453 POWER 2 #12 >> AIT-16.445 POWER 2 #12 >> AIT-16.446 POWER 2 #12 >> AIT-16.441 POWER 2 #12 >> NJB-16.400 POWER	C-16-440 L-16-437 C-16-435 C-16-435 C-16-435 C-16-435 C-16-435 C-16-435 C-16-435 C-16-435
C-16-440	E16-9 E16-10	1.5"	16 16	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.442 POWER 2 #12 >> AIT-16.444 POWER 2 #12 >> AIT-16.447 POWER 4 #14 >> LCP-16.407 CONTROL 4 #14 >> LCP-16.408 CONTROL 4 #14 >> LCP-16.409 CONTROL 4 #14 >> LCP-16.410 CONTROL 2 #12 >> AIT-16.453 POWER 2 #12 >> AIT-16.445 POWER 2 #12 >> AIT-16.446 POWER 2 #12 >> AIT-16.441 POWER 2 #12 >> NJB-16.400 POWER	C-16-442 L-16-465 L-16-465 C-16-438 C-16-438 C-16-438 C-16-438 C-16-438 C-16-438 C-16-438 C-16-438 C-16-438
C-16-442	E16-10	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-4 4 #14 >> LCP-16.407 CONTROL 4 #14 >> LCP-16.408 CONTROL 4 #14 >> LCP-16.409 CONTROL 4 #14 >> LCP-16.410 CONTROL	C-16-440 C-16-440 C-16-440 C-16-440
C-16-444	E16-10	1.5"	16	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: PCM-600A 2 #12 >> AIT-16.442 POWER 2 #12 >> AIT-16.444 POWER 2 #12 >> AIT-16.447 POWER 2 #12 >> AIT-16.453 POWER 2 #12 >> AIT-16.445 POWER 2 #12 >> AIT-16.446 POWER 2 #12 >> AIT-16.441 POWER 2 #12 >> NJB-16.400 POWER	C-16-440 C-16-440 C-16-440 C-16-440 C-16-440 C-16-440 C-16-440 C-16-440
L-16-401	E16-9	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.445 TO: CONDUIT TEE 2 #12 >> AIT-16.445 POWER	C-16-420
L-16-405	E16-9	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.453 TO: CONDUIT TEE 2 #12 >> AIT-16.453 POWER	C-16-407
L-16-432	E16-9	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: NJB-16.400 TO: J-BOX 2 #12 >> NJB-16.400 POWER	C-16-435
L-16-437	E16-9	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.447 TO: CONDUIT TEE 2 #12 >> AIT-16.447 POWER	C-16-438
L-16-440	E16-9	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.441 TO: CONDUIT TEE 2 #12 >> AIT-16.441 POWER	L-16-445
L-16-443	E16-9	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.446 TO: CONDUIT TEE 2 #12 >> AIT-16.446 POWER	L-16-445
L-16-445	E16-9	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.446 POWER 2 #12 >> AIT-16.441 POWER	C-16-430 L-16-443 L-16-440
L-16-460	E16-9	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.444 TO: CONDUIT TEE 2 #12 >> AIT-16.444 POWER	L-16-465
L-16-462	E16-9	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-16.442 TO: CONDUIT TEE 2 #12 >> AIT-16.442 POWER	L-16-465

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 4

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-16-465	E16-9	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-16.442 POWER 2 #12 >> AIT-16.444 POWER	C-16-440 L-16-462 L-16-460
N-16-401	E16-9	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.445 TO: CONDUIT TEE 1 CAT6A >> AIT-16.445 NETWORK	N-16-408
N-16-405	E16-9	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.453 TO: CONDUIT TEE 1 CAT6A >> AIT-16.453 NETWORK	N-16-408
N-16-408	E16-9	0.75"	2		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> AIT-16.453 NETWORK 1 CAT6A >> AIT-16.445 NETWORK	N-16-455 N-16-405 N-16-401
N-16-410	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.430> PCM-600A NETWORK	N-16-420 N-16-499
N-16-412	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.434>EAM-16.435 NETWORK 1 PBDP >> PCM-600A>EAM16.433 NETWORK	N-16-471
N-16-413	E16-9	1.5"	1		12/FO-SM	1	#14	XHHW-2	FR: NJB-16.400 TO: J-BOX 1 12/FO-SM >> NJB-16.400 NETWORK	N-16-415
N-16-415	E16-9	1.5"	1 1		PBDP 12/FO-SM	1	#14	XHHW-2	FR: J-BOX TO: CONDUIT TEE 1 12/FO-SM >> NJB-16.400 NETWORK 1 PBDP >> PCM-600A>EAM16.433 NETWORK	N-16-420 N-16-413
N-16-417	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: J-BOX 1 PBDP >> PCM-600A>EAM16.433 NETWORK	
N-16-420	E16-9 E16-10	1.5"	2 1		PBDP 12/FO-SM	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-600A 1 12/FO-SM >> NJB-16.400 NETWORK 1 PBDP >> PCM-600A>EAM16.433 NETWORK 1 PBDP >> EAM-16.430> PCM-600A NETWORK	N-16-415 N-16-415 N-16-410
N-16-440	E16-9	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.441 TO: CONDUIT TEE 1 CAT6A >> AIT-16.441 NETWORK	N-16-450
N-16-445	E16-9	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.446 TO: CONDUIT TEE 1 CAT6A >> AIT-16.446 NETWORK	N-16-450
N-16-450	E16-9	0.75"	2		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> AIT-16.446 NETWORK 1 CAT6A >> AIT-16.441 NETWORK	N-16-455 N-16-445 N-16-440
N-16-455	E16-9	1"	4		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: NJB-16.400 1 CAT6A >> AIT-16.446 NETWORK 1 CAT6A >> AIT-16.441 NETWORK 1 CAT6A >> AIT-16.453 NETWORK 1 CAT6A >> AIT-16.445 NETWORK	N-16-450 N-16-450 N-16-408 N-16-408
N-16-460	E16-9	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.444 TO: CONDUIT TEE 1 CAT6A >> AIT-16.444 NETWORK	N-16-465
N-16-462	E16-9	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.442 TO: CONDUIT TEE 1 CAT6A >> AIT-16.442 NETWORK	N-16-465
N-16-465	E16-9	0.75"	2		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 CAT6A >> AIT-16.442 NETWORK 1 CAT6A >> AIT-16.444 NETWORK	N-16-467 N-16-462 N-16-460
N-16-466	E16-9	0.75"	1		CAT6A	1	#14	XHHW-2	FR: AIT-16.447 TO: CONDUIT TEE 1 CAT6A >> AIT-16.447 NETWORK	N-16-467

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 4

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-16-467	E16-9	1"	3		CAT6A	1	#14	XHHW-2	FR: CONDUIT TEE TO: NJB-16.400 1 CAT6A >> AIT-16.447 NETWORK 1 CAT6A >> AIT-16.442 NETWORK 1 CAT6A >> AIT-16.444 NETWORK	N-16-466 N-16-465 N-16-465
N-16-470	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.433 TO: CONDUIT TEE 1 PBDP >> EAM-16.433>EAM-16.434 NETWORK 1 PBDP >> PCM-600A>EAM16.433 NETWORK	N-16-471
N-16-471	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.434 TO: CONDUIT TEE 1 PBDP >> EAM-16.433>EAM-16.434 NETWORK 1 PBDP >> EAM-16.434>EAM-16.435 NETWORK	N-16-412 N-16-470
N-16-472	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.434>EAM-16.435 NETWORK	N-16-473 N-16-471
N-16-473	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.435 TO: CONDUIT TEE 1 PBDP >> EAM-16.434>EAM-16.435 NETWORK 1 PBDP >> EAM-16.435>EAM-16.436 NETWORK	N-16-474 N-16-472
N-16-474	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.435>EAM-16.436 NETWORK	N-16-475 N-16-473
N-16-475	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.436 TO: CONDUIT TEE 1 PBDP >> EAM-16.435>EAM-16.436 NETWORK 1 PBDP >> EAM-16.436>EAM-16.425 NETWORK	N-16-476 N-16-474
N-16-476	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.436>EAM-16.425 NETWORK	N-16-477 N-16-475
N-16-477	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.425 TO: CONDUIT TEE 1 PBDP >> EAM-16.436>EAM-16.425 NETWORK 1 PBDP >> EAM-16.425>EAM-16.424 NETWORK	N-16-478 N-16-476
N-16-478	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.425>EAM-16.424 NETWORK	N-16-479 N-16-477
N-16-479	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.424 TO: CONDUIT TEE 1 PBDP >> EAM-16.425>EAM-16.424 NETWORK 1 PBDP >> EAM-16.424>EAM-16.423 NETWORK	N-16-480 N-16-478
N-16-480	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.424>EAM-16.423 NETWORK	N-16-481 N-16-479
N-16-481	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.423 TO: CONDUIT TEE 1 PBDP >> EAM-16.424>EAM-16.423 NETWORK 1 PBDP >> EAM-16.423>EAM-16.426 NETWORK	N-16-482 N-16-480
N-16-482	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.423>EAM-16.426 NETWORK	N-16-483 N-16-481
N-16-483	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.426 TO: CONDUIT TEE 1 PBDP >> EAM-16.423>EAM-16.426 NETWORK 1 PBDP >> EAM-16.426>EAM-16.422 NETWORK	N-16-484 N-16-482
N-16-484	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.426>EAM-16.422 NETWORK	N-16-485 N-16-483
N-16-485	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.422 TO: CONDUIT TEE 1 PBDP >> EAM-16.426>EAM-16.422 NETWORK 1 PBDP >> EAM-16.422>EAM-16.421 NETWORK	N-16-486 N-16-484
N-16-486	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.422>EAM-16.421 NETWORK	N-16-487 N-16-485

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 4

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-16-487	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.421 TO: CONDUIT TEE 1 PBDP >> EAM-16.422>EAM-16.421 NETWORK 1 PBDP >> EAM-16.421>EAM-16.427 NETWORK	N-16-488 N-16-486
N-16-488	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.421>EAM-16.427 NETWORK	N-16-489 N-16-487
N-16-489	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.427 TO: CONDUIT TEE 1 PBDP >> EAM-16.421>EAM-16.427 NETWORK 1 PBDP >> EAM-16.427>EAM-16.428 NETWORK	N-16-490 N-16-488
N-16-490	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.427>EAM-16.428 NETWORK	N-16-491 N-16-489
N-16-491	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.427>EAM-16.428 NETWORK 1 PBDP >> EAM-16.432>EAM-16.429 NETWORK	N-16-492 N-16-490 N-16-493
N-16-492	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.428 TO: CONDUIT TEE 1 PBDP >> EAM-16.427>EAM-16.428 NETWORK 1 PBDP >> EAM-16.428>EAM-16.432 NETWORK	N-16-493 N-16-491
N-16-493	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.432 TO: CONDUIT TEE 1 PBDP >> EAM-16.428>EAM-16.432 NETWORK 1 PBDP >> EAM-16.432>EAM-16.429 NETWORK	N-16-491 N-16-492
N-16-494	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.432>EAM-16.429 NETWORK	N-16-495 N-16-493
N-16-495	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.431>EAM-16.430 NETWORK 1 PBDP >> EAM-16.432>EAM-16.429 NETWORK	N-16-496 N-16-497 N-16-494
N-16-496	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.429 TO: CONDUIT TEE 1 PBDP >> EAM-16.432>EAM-16.429 NETWORK 1 PBDP >> EAM-16.429>EAM-16.431 NETWORK	N-16-497 N-16-495 N-16-495
N-16-497	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.431 TO: CONDUIT TEE 1 PBDP >> EAM-16.429>EAM-16.431 NETWORK 1 PBDP >> EAM-16.431>EAM-16.430 NETWORK	N-16-495 N-16-496
N-16-498	E16-9	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> EAM-16.431>EAM-16.430 NETWORK	N-16-499 N-16-495
N-16-499	E16-9	1"	2		PBDP	1	#14	XHHW-2	FR: EAM-16.430 TO: CONDUIT TEE 1 PBDP >> EAM-16.431>EAM-16.430 NETWORK 1 PBDP >> EAM-16.430> PCM-600A NETWORK	N-16-410 N-16-498
P-16-401	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.428 TO: DISC-16.428 3 #10 >> EAM-16.428 POWER	P-16-402
P-16-402	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.428 TO: CONDUIT TEE 3 #10 >> EAM-16.428 POWER	P-16-405 P-16-401
P-16-403	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.432 TO: DISC-16.432 3 #10 >> EAM-16.432 POWER	P-16-404
P-16-404	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.432 TO: CONDUIT TEE 3 #10 >> EAM-16.432 POWER	P-16-405 P-16-403
P-16-405	E16-5	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.432 POWER 3 #10 >> EAM-16.428 POWER	P-16-415 P-16-404 P-16-402

March 2019

16990.16C-6

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 4

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-16-408	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.433 TO: DISC-16.433 3 #10 >> EAM-16.433 POWER	P-16-409
P-16-409	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.433 TO: CONDUIT TEE 3 #10 >> EAM-16.433 POWER	P-16-413 P-16-408
P-16-411	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.434 TO: DISC-16.434 3 #10 >> EAM-16.434 POWER	P-16-412
P-16-412	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.434 TO: CONDUIT TEE 3 #10 >> EAM-16.434 POWER	P-16-413 P-16-411
P-16-413	E16-5	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.434 POWER 3 #10 >> EAM-16.433 POWER	P-16-415 P-16-412 P-16-409
P-16-415	E16-5 E16-10	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-4A 3 #10 >> EAM-16.434 POWER 3 #10 >> EAM-16.433 POWER 3 #10 >> EAM-16.432 POWER 3 #10 >> EAM-16.428 POWER	P-16-413 P-16-413 P-16-405 P-16-405
P-16-421	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: BRX-16.410 TO: J-BOX 3 #10 >> BRX-16.410 POWER	P-16-422
P-16-422	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.410 TO: CONDUIT TEE 3 #10 >> BRX-16.410 POWER	P-16-425 P-16-421
P-16-423	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: BRX-16.409 TO: J-BOX 3 #10 >> BRX-16.409 POWER	P-16-424
P-16-424	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.409 TO: CONDUIT TEE 3 #10 >> BRX-16.409 POWER	P-16-425 P-16-423
P-16-425	E16-5	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> BRX-16.409 POWER 3 #10 >> BRX-16.410 POWER	P-16-428 P-16-424 P-16-422
P-16-427	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.408 TO: CONDUIT TEE 3 #10 >> BRX-16.408 POWER	P-16-428
P-16-428	E16-5	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> BRX-16.408 POWER 3 #10 >> BRX-16.409 POWER 3 #10 >> BRX-16.410 POWER	P-16-430 P-16-427 P-16-425 P-16-425
P-16-429	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.407 TO: CONDUIT TEE 3 #10 >> BRX-16.407 POWER	P-16-430
P-16-430	E16-5 E16-10	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-4 3 #10 >> BRX-16.407 POWER 3 #10 >> BRX-16.408 POWER 3 #10 >> BRX-16.409 POWER 3 #10 >> BRX-16.410 POWER	P-16-429 P-16-428 P-16-428 P-16-428
P-16-432	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.422 TO: DISC-16.422 3 #10 >> EAM-16.422 POWER	P-16-433
P-16-433	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.422 TO: CONDUIT TEE 3 #10 >> EAM-16.422 POWER	P-16-437 P-16-432
P-16-434	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.426 TO: DISC-16.426 3 #10 >> EAM-16.426 POWER	P-16-435

March 2019

16990.16C-7

10548A10

pw://Carollo/Documents/Client/UT/SVWRF\10548A10\Specifications\16990(100%)

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 4

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-16-435	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.426 TO: CONDUIT TEE 3 #10 >> EAM-16.426 POWER	P-16-437 P-16-434
P-16-437	E16-5	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.426 POWER 3 #10 >> EAM-16.422 POWER	P-16-445 P-16-435 P-16-433
P-16-440	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.427 TO: DISC-16.427 3 #10 >> EAM-16.427 POWER	P-16-441
P-16-441	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.427 TO: CONDUIT TEE 3 #10 >> EAM-16.427 POWER	P-16-444 P-16-440
P-16-442	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.421 TO: DISC-16.421 3 #10 >> EAM-16.421 POWER	P-16-443
P-16-443	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.421 TO: CONDUIT TEE 3 #10 >> EAM-16.421 POWER	P-16-444 P-16-442
P-16-444	E16-5	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.421 POWER 3 #10 >> EAM-16.427 POWER	P-16-445 P-16-443 P-16-441
P-16-445	E16-5 E16-10	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-4A 3 #10 >> EAM-16.426 POWER 3 #10 >> EAM-16.422 POWER 3 #10 >> EAM-16.421 POWER 3 #10 >> EAM-16.427 POWER	P-16-437 P-16-437 P-16-444 P-16-444
P-16-450	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.431 TO: DISC-16.431 3 #10 >> EAM-16.431 POWER	P-16-451
P-16-451	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.431 TO: CONDUIT TEE 3 #10 >> EAM-16.431 POWER	P-16-455 P-16-450
P-16-452	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.430 TO: DISC-16.430 3 #10 >> EAM-16.430 POWER	P-16-453
P-16-453	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.430 TO: CONDUIT TEE 3 #10 >> EAM-16.430 POWER	P-16-455 P-16-452
P-16-455	E16-5	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.430 POWER 3 #10 >> EAM-16.431 POWER	P-16-459 P-16-453 P-16-451
P-16-457	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.429 TO: DISC-16.429 3 #10 >> EAM-16.429 POWER	P-16-458
P-16-458	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.429 TO: CONDUIT TEE 3 #10 >> EAM-16.429 POWER	P-16-459 P-16-457
P-16-459	E16-5 E16-10	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-4A 3 #10 >> EAM-16.430 POWER 3 #10 >> EAM-16.431 POWER 3 #10 >> EAM-16.429 POWER	P-16-455 P-16-455 P-16-458
P-16-461	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.423 TO: DISC-16.423 3 #10 >> EAM-16.423 POWER	P-16-462
P-16-462	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.423 TO: CONDUIT TEE 3 #10 >> EAM-16.423 POWER	P-16-465 P-16-461
P-16-463	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.424 TO: DISC-16.424 3 #10 >> EAM-16.424 POWER	P-16-464

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 4

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-16-464	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.424 TO: CONDUIT TEE 3 #10 >> EAM-16.424 POWER	P-16-465 P-16-463
P-16-465	E16-5	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.424 POWER 3 #10 >> EAM-16.423 POWER	P-16-469 P-16-464 P-16-462
P-16-467	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.425 TO: DISC-16.425 3 #10 >> EAM-16.425 POWER	P-16-468
P-16-468	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.425 TO: CONDUIT TEE 3 #10 >> EAM-16.425 POWER	P-16-469 P-16-467
P-16-469	E16-5	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.425 POWER 3 #10 >> EAM-16.424 POWER 3 #10 >> EAM-16.423 POWER	P-16-476 P-16-468 P-16-465 P-16-465
P-16-471	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.435 TO: DISC-16.435 3 #10 >> EAM-16.435 POWER	P-16-472
P-16-472	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.435 TO: CONDUIT TEE 3 #10 >> EAM-16.435 POWER	P-16-475 P-16-471
P-16-473	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EAM-16.436 TO: DISC-16.436 3 #10 >> EAM-16.436 POWER	P-16-474
P-16-474	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISC-16.436 TO: CONDUIT TEE 3 #10 >> EAM-16.436 POWER	P-16-475 P-16-473
P-16-475	E16-5	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EAM-16.436 POWER 3 #10 >> EAM-16.435 POWER	P-16-476 P-16-474 P-16-472
P-16-476	E16-5 E16-10	1.5"	15	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: BR-MCC-4A 3 #10 >> EAM-16.425 POWER 3 #10 >> EAM-16.424 POWER 3 #10 >> EAM-16.423 POWER 3 #10 >> EAM-16.436 POWER 3 #10 >> EAM-16.435 POWER	P-16-469 P-16-469 P-16-469 P-16-475 P-16-475
P-16-491	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.410 3 #10 >> BRX-16.410 POWER	P-16-421
P-16-492	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.409 3 #10 >> BRX-16.409 POWER	P-16-423
P-16-493	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.408 3 #10 >> BRX-16.408 POWER	
P-16-494	E16-5	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: J-BOX TO: DISC-16.407 3 #10 >> BRX-16.407 POWER	
S-16-445	E16-9	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.443 TO: AIT-16.441 1 MFR >> AE-16.443 SIGNAL	
S-16-451	E16-9	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.451 TO: CONDUIT TEE 1 MFR >> AE-16.451 SIGNAL	S-16-454
S-16-452	E16-9	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.452 TO: CONDUIT TEE 1 MFR >> AE-16.452 SIGNAL	S-16-454
S-16-453	E16-9	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: AE-16.446 TO: AIT-16.446 1 MFR >> AE-16.446 SIGNAL	

CONDUIT SCHEDULE AREA 16

SOUTH VALLEY WRF PROJECT 5

BIOREACTOR 4

ENGINEER

KTW

REVISION

0

DATE

3/1/19

CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-16-454	E16-9	0.75"	2	MFR	CABLE	1	#14	XHHW-2	FR: CONDUIT TEE TO: AIT-16.446 1 MFR >> AE-16.452 SIGNAL 1 MFR >> AE-16.451 SIGNAL	S-16-452 S-16-451
R1420	E16-5	0.75"	3	#8	XHHW-2	1	#8	XHHW-2	FR: PMP-16.461 JBOX TO: POWER WIREWAY 3 #8 >> PMP-16.461 POWER EXISTING CONDUIT, NEW CONDUCTOR	
R1422	E16-5	0.75"	3	#8	XHHW-2	1	#8	XHHW-2	FR: PMP-16.462 JBOX TO: POWER WIREWAY 3 #8 >> PMP-16.462 POWER EXISTING CONDUIT, NEW CONDUCTOR	

END OF CONDUIT SCHEDULE

END OF SECTION

SECTION 16990.21

CONDUIT SCHEDULE AREA 21

PART 1 GENERAL

1.01 SUMMARY

- A. Conduit requirements:
 - 1. As defined in Section 16050 - Common Work Results for Electrical and Section 16130 - Conduits.
- B. Cable requirements and definitions:
 - 1. As defined in Section 16050- Common Work Results for Electrical and Section 16123 - 600-Volt or Less Wires and Cables.
 - 2. 2/CS#16: 2 conductor, 16 gauge, twisted shielded pair.
 - 3. 3/CS#16: 3 conductor, 16 gauge, twisted shielded triplet.
 - 4. */FO: Fiber optic cable (* indicates number of fibers).
 - 5. CAT6A: Category 6A Ethernet cable.
 - 6. MFR: Manufacturer or vendor furnished cable.
 - 7. PBDP: Profibus DP cable.
 - 8. PULL: Pull Rope.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 CONDUIT SCHEDULE

- A. Conduit Schedule is presented on the following pages.

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-11-101 GE-SE-18	E11-1	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: PB-107 TO: SG-EDA 3 #4/0 >> GRB-MCC-1 BACKUP POWER	P-11-105
P-11-102 GE-SE-18	E11-1	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: PB-107 TO: SG-EDA 3 #4/0 >> GRB-MCC-1 BACKUP POWER	P-11-106
P-11-105	GE-SE-37	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: PB-107 TO: PB-106 3 #4/0 >> GRB-MCC-1 BACKUP POWER EXISTING CONDUIT, NEW CONDUCTOR	P-11-109 P-11-101
P-11-106	GE-SE-37	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: PB-107 TO: PB-106 3 #4/0 >> GRB-MCC-1 BACKUP POWER EXISTING CONDUIT, NEW CONDUCTOR	P-11-110 P-11-102
P-11-109	GE-SE-37	3"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: PB-106 TO: EMH-1 3 #4/0 >> GRB-MCC-1 BACKUP POWER	P-21-103 P-11-105
P-11-110	GE-SE-37	3"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: PB-106 TO: EMH-1 3 #4/0 >> GRB-MCC-1 BACKUP POWER	P-21-104 P-11-106
X-11-101	GE-SE-37	3"	1	PULL	ROPE				FR: PB-106 TO: EMH-1 1 PULL >> SPARE	
X-11-102	GE-SE-37	3"	1	PULL	ROPE				FR: PB-106 TO: EMH-1 1 PULL >> SPARE	
X-11-103	GE-SE-37	3"	1	PULL	ROPE				FR: PB-106 TO: EMH-1 1 PULL >> SPARE	
X-11-104	GE-SE-37	3"	1	PULL	ROPE				FR: PB-106 TO: EMH-1 1 PULL >> SPARE	
X-11-105	GE-SE-37	3"	1	PULL	ROPE				FR: PB-106 TO: EMH-1 1 PULL >> SPARE	
X-11-106	GE-SE-37	3"	1	PULL	ROPE				FR: PB-106 TO: EMH-1 1 PULL >> SPARE	
C-21-025	E21-7	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: SV-21.523 TO: CONDUIT TEE 2 #14 >> SV-21.523 CONTROL	C-21-027
C-21-026	E21-7	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: SV-21.524 TO: CONDUIT TEE 2 #14 >> SV-21.524 CONTROL	C-21-027
C-21-027	E21-7 E21-1 E21-3	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 2 #14 >> SV-21.523 CONTROL 2 #14 >> SV-21.524 CONTROL	C-21-025 C-21-026
C-21-112	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.210 TO: CONDUIT TEE 6 #14 >> LCP-21.210 CONTROL	C-21-116 C-21-111
C-21-113	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: SEAL WATER PANEL TO: CONDUIT TEE 2 #14 >> SV-21.214 CONTROL 4 #14 >> FSL-21.216 CONTROL	C-21-115
C-21-114	E21-2	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSL-21.212 TO: CONDUIT TEE 2 #14 >> PSL-21.212 CONTROL	C-21-115
C-21-115	E21-2	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> SV-21.214 CONTROL 4 #14 >> FSL-21.216 CONTROL 2 #14 >> PSL-21.212 CONTROL	C-21-116 C-21-113 C-21-113 C-21-114

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-21-116	E21-1 E21-2	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 6 #14 >> LCP-21.210 CONTROL 2 #14 >> SV-21.214 CONTROL 4 #14 >> FSL-21.216 CONTROL 2 #14 >> PSL-21.212 CONTROL	C-21-112 C-21-115 C-21-115 C-21-115
C-21-121	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.220 TO: CONDUIT TEE 6 #14 >> LCP-21.220 CONTROL	C-21-127
C-21-123	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: SEAL WATER PANEL TO: CONDUIT TEE 2 #14 >> SV-21.224 CONTROL 4 #14 >> FSL-21.226 CONTROL	C-21-125 C-21-125 C-21-125
C-21-124	E21-2	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSL-21.222 TO: CONDUIT TEE 2 #14 >> PSL-21.222 CONTROL	C-21-125
C-21-125	E21-2	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> SV-21.224 CONTROL 4 #14 >> FSL-21.226 CONTROL 2 #14 >> PSL-21.222 CONTROL	C-21-127 C-21-123 C-21-123 C-21-124
C-21-127	E21-1 E21-2	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 6 #14 >> LCP-21.220 CONTROL 2 #14 >> SV-21.224 CONTROL 4 #14 >> FSL-21.226 CONTROL 2 #14 >> PSL-21.222 CONTROL	C-21-121 C-21-125 C-21-125 C-21-125
C-21-132	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.230 TO: CONDUIT TEE 6 #14 >> LCP-21.230 CONTROL	C-21-136 C-21-131
C-21-133	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: SEAL WATER PANEL TO: CONDUIT TEE 2 #14 >> SV-21.234 CONTROL 4 #14 >> FSL-21.236 CONTROL	C-21-135 C-21-135 C-21-135
C-21-134	E21-2	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSL-21.232 TO: CONDUIT TEE 2 #14 >> PSL-21.232 CONTROL	C-21-135
C-21-135	E21-2	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> SV-21.234 CONTROL 4 #14 >> FSL-21.236 CONTROL 2 #14 >> PSL-21.232 CONTROL	C-21-136 C-21-133 C-21-133 C-21-134
C-21-136	E21-1 E21-2	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 6 #14 >> LCP-21.230 CONTROL 2 #14 >> SV-21.234 CONTROL 4 #14 >> FSL-21.236 CONTROL 2 #14 >> PSL-21.232 CONTROL	C-21-132 C-21-135 C-21-135 C-21-135
C-21-141	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.240 TO: CONDUIT TEE 6 #14 >> LCP-21.240 CONTROL	C-21-147
C-21-143	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: SEAL WATER PANEL TO: CONDUIT TEE 2 #14 >> SV-21.244 CONTROL 4 #14 >> FSL-21.246 CONTROL	C-21-145 C-21-145 C-21-145
C-21-144	E21-2	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSL-21.242 TO: CONDUIT TEE 2 #14 >> PSL-21.242 CONTROL	C-21-145
C-21-145	E21-2	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> SV-21.244 CONTROL 4 #14 >> FSL-21.246 CONTROL 2 #14 >> PSL-21.242 CONTROL	C-21-147 C-21-143 C-21-143 C-21-144

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-21-147	E21-1 E21-2	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: DISCONNECT TO: GRB-MCC-1 6 #14 >> LCP-21.240 CONTROL 2 #14 >> SV-21.244 CONTROL 4 #14 >> FSL-21.246 CONTROL 2 #14 >> PSL-21.242 CONTROL	C-21-141 C-21-145 C-21-145 C-21-145
C-21-152	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.250 TO: CONDUIT TEE 6 #14 >> LCP-21.250 CONTROL	C-21-156 C-21-151
C-21-153	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: SEAL WATER PANEL TO: CONDUIT TEE 2 #14 >> SV-21.254 CONTROL 4 #14 >> FSL-21.256 CONTROL	C-21-155 C-21-155 C-21-155
C-21-154	E21-2	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSL-21.252 TO: CONDUIT TEE 2 #14 >> PSL-21.252 CONTROL	C-21-155 C-21-155
C-21-155	E21-2	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> SV-21.254 CONTROL 4 #14 >> FSL-21.256 CONTROL 2 #14 >> PSL-21.252 CONTROL	C-21-156 C-21-153 C-21-153 C-21-154
C-21-156	E21-1 E21-2	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 6 #14 >> LCP-21.250 CONTROL 2 #14 >> SV-21.254 CONTROL 4 #14 >> FSL-21.256 CONTROL 2 #14 >> PSL-21.252 CONTROL	C-21-152 C-21-155 C-21-155 C-21-155
C-21-161	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.260 TO: CONDUIT TEE 6 #14 >> LCP-21.260 CONTROL	C-21-167 C-21-167
C-21-163	E21-2	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: SEAL WATER PANEL TO: CONDUIT TEE 2 #14 >> SV-21.264 CONTROL 4 #14 >> FSL-21.266 CONTROL	C-21-165 C-21-165 C-21-165
C-21-164	E21-2	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: PSL-21.262 TO: CONDUIT TEE 2 #14 >> PSL-21.262 CONTROL	C-21-165 C-21-165
C-21-165	E21-2	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #14 >> SV-21.264 CONTROL 4 #14 >> FSL-21.266 CONTROL 2 #14 >> PSL-21.262 CONTROL	C-21-167 C-21-163 C-21-163 C-21-164
C-21-167	E21-1 E21-2	1"	14	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 6 #14 >> LCP-21.260 CONTROL 2 #14 >> SV-21.264 CONTROL 4 #14 >> FSL-21.266 CONTROL 2 #14 >> PSL-21.262 CONTROL	C-21-161 C-21-165 C-21-165 C-21-165
C-21-310	E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: ZSC-21.310 TO: JUNCTION BOX 2 #14 >> ZSC-21.310 CONTROL	C-21-315 C-21-315
C-21-312	E21-4	1"	10	#12	XHHW-2	1	#12	XHHW-2	FR: EDR-21.312 TO: JUNCTION BOX 2 #12 >> EDR-21.312 POWER 8 #12 >> EDR-21.312 PANEL CONTROLS	C-21-315 C-21-315 C-21-315
C-21-314	E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: SV-21.314 TO: JUNCTION BOX 2 #14 >> SV-21.314 CONTROL	C-21-315 C-21-315
C-21-315	E21-4	1"	10 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: JUNCTION BOX TO: VCP1-21.310 2 #14 >> ZSC-21.310 CONTROL 2 #12 >> EDR-21.312 POWER 8 #12 >> EDR-21.312 PANEL CONTROLS 2 #14 >> SV-21.314 CONTROL	C-21-310 C-21-312 C-21-312 C-21-314
C-21-316	E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: VCP2-21.310 TO: VCP1-21.310 2 #14 >> VCP2-21.310 CONTROL	C-21-316 C-21-316

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-21-320	E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: ZSC-21.320 TO: JUNCTION BOX 2 #14 >> ZSC-21.320 CONTROL	C-21-325
C-21-322	E21-4	1"	10	#12	XHHW-2	1	#12	XHHW-2	FR: EDR-21.322 TO: JUNCTION BOX 2 #12 >> EDR-21.322 POWER 8 #12 >> EDR-21.322 PANEL CONTROLS	C-21-325
C-21-324	E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: SV-21.323 TO: JUNCTION BOX 2 #14 >> SV-21.323 CONTROL	C-21-325
C-21-325	E21-4	1"	10 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: JUNCTION BOX TO: VCP1-21.320 2 #14 >> ZSC-21.320 CONTROL 2 #12 >> EDR-21.322 POWER 8 #12 >> EDR-21.322 PANEL CONTROLS 2 #14 >> SV-21.323 CONTROL	C-21-320 C-21-322 C-21-322 C-21-324
C-21-326	E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: VCP2-21.320 TO: VCP1-21.320 2 #14 >> VCP2-21.320 CONTROL	
C-21-330	E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: ZSC-21.330 TO: JUNCTION BOX 2 #14 >> ZSC-21.330 CONTROL	C-21-335
C-21-332	E21-4	1"	10	#12	XHHW-2	1	#12	XHHW-2	FR: EDR-21.332 TO: JUNCTION BOX 2 #12 >> EDR-21.332 POWER 8 #12 >> EDR-21.332 PANEL CONTROLS	C-21-335
C-21-334	E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: SV-21.333 TO: JUNCTION BOX 2 #14 >> SV-21.333 CONTROL	C-21-335
C-21-335	E21-4	1"	10 4	#12 #14	XHHW-2 XHHW-2	1	#12	XHHW-2	FR: JUNCTION BOX TO: VCP1-21.330 2 #12 >> EDR-21.332 POWER 8 #12 >> EDR-21.332 PANEL CONTROLS 2 #14 >> SV-21.333 CONTROL 2 #14 >> ZSC-21.330 CONTROL	C-21-332 C-21-332 C-21-334 C-21-330
C-21-336	E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: VCP2-21.330 TO: VCP1-21.330 2 #14 >> VCP2-21.330 CONTROL	
C-21-348		0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: ZSOC-21.305 TO: CONDUIT TEE 4 #14 >> ZSOC-21.305 CONTROL	C-21-352
C-21-349		0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: ZSOC-21.325 TO: CONDUIT TEE 4 #14 >> ZSOC-21.325 CONTROL	C-21-351
C-21-350	E21-4	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: ZSOC-21.335 TO: CONDUIT TEE 4 #14 >> ZSOC-21.335 CONTROL	C-21-351
C-21-351	E21-4	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> ZSOC-21.325 CONTROL 4 #14 >> ZSOC-21.335 CONTROL	C-21-352 C-21-349 C-21-350
C-21-352	E21-4	1"	12	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 4 #14 >> ZSOC-21.325 CONTROL 4 #14 >> ZSOC-21.335 CONTROL 4 #14 >> ZSOC-21.305 CONTROL	C-21-354 C-21-351 C-21-351 C-21-348
C-21-353	E21-4	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: ZSOC-21.315 TO: CONDUIT TEE 4 #14 >> ZSOC-21.315 CONTROL	C-21-354
C-21-354	E21-3 E21-4	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 4 #14 >> ZSOC-21.325 CONTROL 4 #14 >> ZSOC-21.335 CONTROL 4 #14 >> ZSOC-21.305 CONTROL 4 #14 >> ZSOC-21.315 CONTROL	C-21-352 C-21-352 C-21-352 C-21-353

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
C-21-401	E21-3	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.500 TO: CONDUIT TEE 6 #14 >> LCP-21.500 CONTROL	C-21-403
C-21-402	E21-3	0.75"	3	#14	XHHW-2	1	#14	XHHW-2	FR: FSL-21.502 TO: CONDUIT TEE 3 #14 >> FSL-21.502 CONTROL	C-21-403
C-21-403	E21-3	0.75"	9	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 6 #14 >> LCP-21.500 CONTROL 3 #14 >> FSL-21.502 CONTROL	C-21-401 C-21-402
C-21-800	E21-3	0.75"	6	#14	XHHW-2	1	#14	XHHW-2	FR: FACP-21.800 TO: PCM-2100 6 #14 >> FACP-21.800 CONTROL	
C-21-801	E21-3 E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: MAU-21.810 TO: CONDUIT TEE 2 #14 >> MAU-21.810 FACP INTERLOCK	
C-21-802	E21-3 E21-4	0.75"	2	#14	XHHW-2	1	#14	XHHW-2	FR: MAU-21.820 TO: CONDUIT TEE 2 #14 >> MAU-21.820 FACP INTERLOCK	
C-21-803	E21-3	0.75"	4	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: FACP-21.800 2 #14 >> MAU-21.810 FACP INTERLOCK 2 #14 >> MAU-21.820 FACP INTERLOCK	C-21.801 C-21.802
C-21-805	E21-3	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: GRB-MCC-1 TO: FACP-21.800 2 #14 >> EF-21.830 FACP INTERLOCK 2 #14 >> EF-21.840 FACP INTERLOCK 2 #14 >> EF-21.850 FACP INTERLOCK 2 #14 >> EF-21.860 FACP INTERLOCK	
C-21-810	E21-3 E21-4	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: MAU-21.810 TO: CONDUIT TEE 8 #14 >> MAU-21.810 CONTROL	C-21-821
C-21-820	E21-3 E21-4	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: MAU-21.820 TO: CONDUIT TEE 8 #14 >> MAU-21.820 CONTROL	C-21-821
C-21-821	E21-3	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 8 #14 >> MAU-21.810 CONTROL 8 #14 >> MAU-21.820 CONTROL	C-21-810 C-21-820
C-21-850	E21-3	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.911 TO: CONDUIT TEE 8 #14 >> LCP-21.911 CONTROL	C-21-852
C-21-851	E21-3	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.921 TO: CONDUIT TEE 8 #14 >> LCP-21.921 CONTROL	C-21-852
C-21-852	E21-3	1"	16	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 8 #14 >> LCP-21.911 CONTROL 8 #14 >> LCP-21.921 CONTROL	C-21-854 C-21-850 C-21-851
C-21-853	E21-3	0.75"	8	#14	XHHW-2	1	#14	XHHW-2	FR: LCP-21.910 TO: CONDUIT TEE 8 #14 >> t	C-21-854
C-21-854	E21-3	1.5"	24	#14	XHHW-2	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 8 #14 >> LCP-21.911 CONTROL 8 #14 >> LCP-21.921 CONTROL 8 #14 >> LCP-21.910 CONTROL	C-21-852 C-21-852 C-21-853
L-21-010	E21-3	2"	4	#1/0	XHHW-2	1	#6	XHHW-2	FR: GRB-LP-1 TO: GRB-XFMR-1 3 #1/0 >> PHASE 1 #1/0 >> NEUTRAL	
L-21-015	E21-3	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: PCM-2100 TO: GRB-LP-1 4 #12 >> PCM-2100 POWER	

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-21-020	E21-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: RESTROOM WATER HEATER TO: GRB-LP-1 3 #10 >> POWER	
L-21-025	E21-7 E21-1	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: VCP-21.531 TO: GRB-LP-1 2 #12 >> VCP-21.531 POWER	
L-21-110	E21-4	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-21.112 TO: CONDUIT TEE 2 #12 >> LIT-21.112 POWER	L-21-111
L-21-111	E21-3 E21-4	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 2 #12 >> LIT-21.132 POWER 2 #12 >> LIT-21.122 POWER 2 #12 >> LIT-21.112 POWER	L-21-121 L-21-121 L-21-110
L-21-113	E21-3	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FIT-21.215 TO: CONDUIT TEE 2 #12 >> FIT-21.215 POWER	L-21-114
L-21-114	E21-3	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 2 #12 >> FIT-21.255 POWER 2 #12 >> FIT-21.235 POWER 2 #12 >> FIT-21.215 POWER	L-21-124 L-21-124 L-21-113
L-21-120	E21-4	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-21.122 TO: CONDUIT TEE 2 #12 >> LIT-21.122 POWER	L-21-121
L-21-121	E21-4	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> LIT-21.132 POWER 2 #12 >> LIT-21.122 POWER	L-21-111 L-21-130 L-21-120
L-21-123	E21-3	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FIT-21.235 TO: CONDUIT TEE 2 #12 >> FIT-21.235 POWER	L-21-124
L-21-124	E21-3	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> FIT-21.255 POWER 2 #12 >> FIT-21.235 POWER	L-21-114 L-21-133 L-21-123
L-21-130	E21-4	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: LIT-21.132 TO: CONDUIT TEE 2 #12 >> LIT-21.132 POWER	L-21-121
L-21-133	E21-3	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FIT-21.255 TO: CONDUIT TEE 2 #12 >> FIT-21.255 POWER	L-21-124
L-21-213	E21-2	0.75"	2	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.113 TO: DISCONNECT 2 #10 >> EDR-21.113 POWER	
L-21-214	E21-2	0.75"	2	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 2 #10 >> EDR-21.113 POWER	L-21-261
L-21-233	E21-2	0.75"	2	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.123 TO: DISCONNECT 2 #10 >> EDR-21.123 POWER	L-21-234
L-21-234	E21-2	0.75"	2	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 2 #10 >> EDR-21.123 POWER	L-21-260 L-21-233
L-21-253	E21-2	0.75"	2	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.133 TO: DISCONNECT 2 #10 >> EDR-21.133 POWER	L-21-254
L-21-254	E21-2	0.75"	2	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 2 #10 >> EDR-21.133 POWER	L-21-260 L-21-253
L-21-260	E21-3	0.75"	4	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #10 >> EDR-21.123 POWER 2 #10 >> EDR-21.133 POWER	L-21-261 L-21-234 L-21-254

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
L-21-261	E21-3	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: GRB-LP-1 2 #10 >> EDR-21.113 POWER 2 #10 >> EDR-21.123 POWER 2 #10 >> EDR-21.133 POWER	L-21-214 L-21-260 L-21-260
L-21-800	E21-3	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: FACP-21.800 TO: GRB-LP-1 2 #12 >> FACP-21.800 POWER	
L-21-805	E21-3	0.75"	2	#8	XHHW-2	1	#10	XHHW-2	FR: HP-21.880 TO: GRB-LP-1 2 #8 >> HP-21.880 POWER	
L-21-806	E21-3	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AHU-21.880 TO: GRB-LP-1 2 #12 >> AHU-21.880 POWER	
L-21-850	E21-3	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-21.934 TO: CONDUIT TEE 2 #12 >> AIT-21.934 POWER	L-21-852
L-21-851	E21-3	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-21.935 TO: CONDUIT TEE 2 #12 >> AIT-21.935 POWER	L-21-852
L-21-852	E21-3	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-21.934 POWER 2 #12 >> AIT-21.935 POWER	L-21-856 L-21-850 L-21-851
L-21-853	E21-3	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-21.931 TO: CONDUIT TEE 2 #12 >> AIT-21.931 POWER	L-21-855
L-21-854	E21-3	0.75"	2	#12	XHHW-2	1	#12	XHHW-2	FR: AIT-21.932 TO: CONDUIT TEE 2 #12 >> AIT-21.932 POWER	L-21-855
L-21-855	E21-3	0.75"	4	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 2 #12 >> AIT-21.931 POWER 2 #12 >> AIT-21.932 POWER	L-21-856 L-21-853 L-21-854
L-21-856	E21-3	0.75"	8	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 2 #12 >> AIT-21.934 POWER 2 #12 >> AIT-21.935 POWER 2 #12 >> AIT-21.931 POWER 2 #12 >> AIT-21.932 POWER	L-21-852 L-21-852 L-21-855 L-21-855
N-21-050	GE-SE-37	2"	1		24/FO-SM	1	#14	XHHW-2	FR: 4C-CB-3 TO: EMH-1 1 24/FO-SM >> VCP-610>PCM-2100 NETWORK	N-21-101 M4025
N-21-051	GE-SE-37	2"	1		24/FO-SM	1	#14	XHHW-2	FR: 4C-CB-3 TO: EMH-1 1 24/FO-SM >> PCM-605>PCM-2100 NETWORK	N-21-102 L4702
N-21-100	E21-3	0.75"	1		CAT6A	1	#14	XHHW-2	FR: GRB-MCC-1 TO: PCM-2100 1 CAT6A >> GRB-MCC-1 NETWORK	
N-21-101	GE-SE-37	1.5"	1		24/FO-SM	1	#14	XHHW-2	FR: PCM-2100 TO: EMH-1 1 24/FO-SM >> VCP-610>PCM-2100 NETWORK	N-21-050
N-21-102	GE-SE-37	1.5"	1		24/FO-SM	1	#14	XHHW-2	FR: PCM-2100 TO: EMH-1 1 24/FO-SM >> PCM-605>PCM-2100 NETWORK	N-21-051
N-21-109	E21-4	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.111 TO: JUNCTION BOX 1 PBDP >> PCM2100-DP-1A 1 PBDP >> PCM2100-DP-1B	N-21-112
N-21-110	E21-4	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.121 TO: JUNCTION BOX 1 PBDP >> PCM2100-DP-2A 1 PBDP >> PCM2100-DP-2B	N-21-112

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-21-111	E21-4	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.131 TO: JUNCTION BOX 1 PBDP >> PCM2100-DP-3A 1 PBDP >> PCM2100-DP-3B	N-21-112
N-21-112	E21-3	1.5"	6		PBDP	1	#14	XHHW-2	FR: JUNCTION BOX TO: JUNCTION BOX 1 PBDP >> PCM2100-DP-1A 1 PBDP >> PCM2100-DP-1B 1 PBDP >> PCM2100-DP-2A 1 PBDP >> PCM2100-DP-2B 1 PBDP >> PCM2100-DP-3A 1 PBDP >> PCM2100-DP-3B	N-21-109 N-21-109 N-21-110 N-21-110 N-21-111 N-21-111
N-21-113	E21-3 E21-4	1"	3		PBDP	1	#14	XHHW-2	FR: JUNCTION BOX TO: PCM-2100 1 PBDP >> PCM2100-DP-1A 1 PBDP >> PCM2100-DP-2A 1 PBDP >> PCM2100-DP-3A	
N-21-115	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: EDR-21.115 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-1F	
N-21-116	E21-2	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.221 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-1E 1 PBDP >> PCM2100-DP-1F	
N-21-117	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-1E	
N-21-118	E21-2	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.211 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-1D 1 PBDP >> PCM2100-DP-1E	
N-21-119	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-1D	
N-21-120	E21-2	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.116 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-1C 1 PBDP >> PSM2100-DP-1D	
N-21-121	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: EDR-21.113 1 PBDP >> PCM2100-DP-1C	
N-21-122	E21-2 E21-3	0.75"	1		PBDP	1	#14	XHHW-2	FR: EDR-21.113 TO: JUNCTION BOX 1 PBDP >> PCM2100-DP-1B	
N-21-125	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: EDR-21.125 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-2F	
N-21-126	E21-2	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.241 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-2E 1 PBDP >> PCM2100-DP-2F	
N-21-127	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-2E	
N-21-128	E21-2	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.231 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-2D 1 PBDP >> PSM2100-DP-2E	
N-21-129	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-2D	
N-21-130	E21-2	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.126 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-2C 1 PBDP >> PSM2100-DP-2D	

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
N-21-131	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: EDR-21.123 1 PBDP >> PCM2100-DP-2C	
N-21-132	E21-2 E21-3	0.75"	1		PBDP	1	#14	XHHW-2	FR: EDR-21.123 TO: JUNCTION BOX 1 PBDP >> PCM2100-DP-2B	
N-21-135	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: EDR-21.135 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-3F	
N-21-136	E21-2	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.261 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-3E 1 PBDP >> PCM2100-DP-3F	
N-21-137	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-3E	
N-21-138	E21-2	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.251 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-3D 1 PBDP >> PCM2100-DP-3E	
N-21-139	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-3D	
N-21-140	E21-2	1"	2		PBDP	1	#14	XHHW-2	FR: EDR-21.136 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-3C 1 PBDP >> PCM2100-DP-3D	
N-21-141	E21-2	0.75"	1		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: EDR-21.133 1 PBDP >> PCM2100-DP-3C	
N-21-142	E21-2 E21-3	0.75"	1		PBDP	1	#14	XHHW-2	FR: EDR-21.133 TO: JUNCTION BOX 1 PBDP >> PCM2100-DP-3B	
N-21-150		0.75"	1		PBDP	1	#14	XHHW-2	FR: EDR-21.221 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-1G	N-21-172
N-21-160		0.75"	1		PBDP	1	#14	XHHW-2	FR: EDR-21.241 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-2G	N-21-171
N-21-170		0.75"	1		PBDP	1	#14	XHHW-2	FR: EDR-21.261 TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-3G	N-21-171
N-21-171		1"	2		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 PBDP >> PCM2100-DP-2G 1 PBDP >> PCM2100-DP-3G	N-21-172 N-21-160 N-21-170
N-21-172		1"	3		PBDP	1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 1 PBDP >> PCM2100-DP-1G 1 PBDP >> PCM2100-DP-2G 1 PBDP >> PCM2100-DP-3G	N-21-150 N-21-171 N-21-171
N-21-301	E21-4	0.75"	1		CAT6A	1	#14	XHHW-2	FR: VCP1-21.310 TO: JUNCTION BOX 1 CAT6A >> VCP1-21.310 NETWORK	N-21-304
N-21-302	E21-4	0.75"	1		CAT6A	1	#14	XHHW-2	FR: VCP1-21.320 TO: JUNCTION BOX 1 CAT6A >> VCP1-21.320 NETWORK	N-21-304
N-21-303	E21-4	0.75"	1		CAT6A	1	#14	XHHW-2	FR: VCP1-21.330 TO: JUNCTION BOX 1 CAT6A >> VCP1-21.330 NETWORK	N-21-304
N-21-304	E21-3 E21-4	1"	3		CAT6A	1	#14	XHHW-2	FR: JUNCTION BOX TO: PCM-2100 1 CAT6A >> VCP1-21.310 NETWORK 1 CAT6A >> VCP1-21.320 NETWORK 1 CAT6A >> VCP1-21.330 NETWORK	N-21-301 N-21-302 N-21-303

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-21-010	E21-3	1.5"	3	#1	XHHW-2	1	#6	XHHW-2	FR: GRB-XFMR-1 TO: GRB-MCC-1 3 #1 >> GRB-XFMR-1 POWER	
P-21-050	GE-SE-37	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: 4C-PB-7 TO: EMH-1 3 #4/0 >> GRB-MCC-1 POWER	M1051
P-21-051	GE-SE-37	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: 4C-PB-7 TO: EMH-1 3 #4/0 >> GRB-MCC-1 POWER	M1056
P-21-060	E21-3	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> 103-4 DOOR OPERATOR POWER	P-21-062
P-21-061	E21-3	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> 103-3 DOOR OPERATOR POWER	P-21-062
P-21-062	E21-3	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #12 >> 103-4 DOOR OPERATOR POWER 3 #12 >> 103-3 DOOR OPERATOR POWER	P-21-064 P-21-060 P-21-061
P-21-063	E21-3	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> 103-2 DOOR OPERATOR POWER	P-21-064
P-21-064	E21-3	1"	9	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 3 #12 >> 103-4 DOOR OPERATOR POWER 3 #12 >> 103-3 DOOR OPERATOR POWER 3 #12 >> 103-2 DOOR OPERATOR POWER	P-21-062 P-21-062 P-21-063
P-21-101	E21-1 GE-SE-37	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: GRB-MCC-1 TO: EMH-1 3 #4/0 >> GRB-MCC-1 POWER	
P-21-102	E21-1 GE-SE-37	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: GRB-MCC-1 TO: EMH-1 3 #4/0 >> GRB-MCC-1 POWER	
P-21-103	E21-1 GE-SE-37	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: GRB-MCC-1 TO: EMH-1 3 #4/0 >> GRB-MCC-1 BACKUP POWER	P-11-109
P-21-104	E21-1 GE-SE-37	2"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: GRB-MCC-1 TO: EMH-1 3 #4/0 >> GRB-MCC-1 BACKUP POWER	P-11-110
P-21-110	E21-2	1"	3	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-21.210 TO: DISCONNECT 3 #12 >> PMP-21.210 POWER	
P-21-111	E21-1 E21-2	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: GRB-MCC-1 3 #12 >> PMP-21.210 POWER	
P-21-112	E21-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.111 TO: DISCONNECT 3 #10 >> EDR-21.111 POWER	P-21-113
P-21-113	E21-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: JUNCTION BOX 3 #10 >> EDR-21.111 POWER	P-21-114 P-21-112
P-21-114	E21-3 E21-4	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: JUNCTION BOX TO: GRB-MCC-1 3 #10 >> EDR-21.111 POWER 3 #10 >> EDR-21.121 POWER 3 #10 >> EDR-21.131 POWER	P-21-113 P-21-123 P-21-133
P-21-120	E21-2	1"	3	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-21.220 TO: DISCONNECT 3 #12 >> PMP-21.220 POWER	
P-21-121	E21-1 E21-2	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: GRB-MCC-1 3 #12 >> PMP-21.220 POWER	

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-21-122	E21-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.121 TO: DISCONNECT 3 #10 >> EDR-21.121 POWER	P-21-123
P-21-123	E21-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: JUNCTION BOX 3 #10 >> EDR-21.121 POWER	P-21-114 P-21-122
P-21-130	E21-2	1"	3	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-21.230 TO: DISCONNECT 3 #12 >> PMP-21.230 POWER	
P-21-131	E21-1 E21-2	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: DISCONNECT 3 #12 >> PMP-21.230 POWER	
P-21-132	E21-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.131 TO: DISCONNECT 3 #10 >> EDR-21.131 POWER	P-21-133
P-21-133	E21-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: JUNCTION BOX 3 #10 >> EDR-21.131 POWER	P-21-114 P-21-132
P-21-140	E21-2	1"	3	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-21.240 TO: DISCONNECT 3 #12 >> PMP-21.240 POWER	
P-21-141	E21-1 E21-2	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: DISCONNECT 3 #12 >> PMP-21.240 POWER	
P-21-150	E21-2	1"	3	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-21.250 TO: DISCONNECT 3 #12 >> PMP-21.250 POWER	
P-21-151	E21-1 E21-2	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: DISCONNECT 3 #12 >> PMP-21.250 POWER	
P-21-160	E21-2	1"	3	#12	XHHW-2	1	#12	XHHW-2	FR: PMP-21.210 TO: DISCONNECT 3 #12 >> PMP-21.210 POWER	
P-21-161	E21-1 E21-2	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: DISCONNECT 3 #12 >> PMP-21.260 POWER	
P-21-215	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.115 TO: DISCONNECT 3 #10 >> EDR-21.115 POWER	
P-21-216	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.116 TO: DISCONNECT 3 #10 >> EDR-21.116 POWER	
P-21-217	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.116 POWER	P-21-220
P-21-218	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.115 POWER	P-21-220
P-21-220	E21-2	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EDR-21.116 POWER 3 #10 >> EDR-21.115 POWER	P-21-223 P-21-217 P-21-218
P-21-221	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.221 TO: DISCONNECT 3 #10 >> EDR-21.221 POWER	
P-21-222	E21-2 E21-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.221 POWER	P-21-223
P-21-223	E21-2	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EDR-21.116 POWER 3 #10 >> EDR-21.115 POWER 3 #10 >> EDR-21.221 POWER	P-21-224 P-21-220 P-21-220 P-21-222

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-21-224	E21-2 E21-3	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 3 #10 >> EDR-21.116 POWER 3 #10 >> EDR-21.115 POWER 3 #10 >> EDR-21.221 POWER 3 #10 >> EDR-21.211 POWER	P-21-223 P-21-223 P-21-223 P-21-242
P-21-231	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.211 TO: DISCONNECT 3 #10 >> EDR-21.211 POWER	P-21-232
P-21-232	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.211 POWER	P-21-231
P-21-235	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.125 TO: DISCONNECT 3 #10 >> EDR-21.125 POWER	P-21-238
P-21-236	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.126 TO: DISCONNECT 3 #10 >> EDR-21.126 POWER	P-21-237
P-21-237	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.126 POWER	P-21-240 P-21-236
P-21-238	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.125 POWER	P-21-240 P-21-235
P-21-240	E21-2	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EDR-21.125 POWER 3 #10 >> EDR-21.126 POWER	P-21-243 P-21-238 P-21-237
P-21-241	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.241 TO: DISCONNECT 3 #10 >> EDR-21.241 POWER	P-21-242
P-21-242	E21-2 E21-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.241 POWER	P-21-224 P-21-241
P-21-243	E21-2	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EDR-21.241 POWER 3 #10 >> EDR-21.125 POWER 3 #10 >> EDR-21.126 POWER	P-21-244 P-21-242 P-21-240 P-21-240
P-21-244	E21-2 E21-3	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 3 #10 >> EDR-21.241 POWER 3 #10 >> EDR-21.125 POWER 3 #10 >> EDR-21.126 POWER 3 #10 >> EDR-21.231 POWER	P-21-243 P-21-243 P-21-243 P-21-252
P-21-251	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.231 TO: DISCONNECT 3 #10 >> EDR-21.231 POWER	P-21-252
P-21-252	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.231 POWER	P-21-244 P-21-251
P-21-255	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.135 TO: DISCONNECT 3 #10 >> EDR-21.135 POWER	P-21-258
P-21-256	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.136 TO: DISCONNECT 3 #10 >> EDR-21.136 POWER	P-21-257
P-21-257	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.136 POWER	P-21-260 P-21-256
P-21-258	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.135 POWER	P-21-260 P-21-255

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-21-260	E21-2	0.75"	6	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EDR-21.135 POWER 3 #10 >> EDR-21.136 POWER	P-21-263 P-21-258 P-21-257
P-21-261	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.261 TO: DISCONNECT 3 #10 >> EDR-21.261 POWER	P-21-262
P-21-262	E21-2 E21-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.261 POWER	P-21-263 P-21-261
P-21-263	E21-2	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 3 #10 >> EDR-21.135 POWER 3 #10 >> EDR-21.136 POWER 3 #10 >> EDR-21.261 POWER	P-21-264 P-21-260 P-21-260 P-21-262
P-21-264	E21-2 E21-3	1.5"	12	#10	XHHW-2	1	#10	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 3 #10 >> EDR-21.251 POWER 3 #10 >> EDR-21.135 POWER 3 #10 >> EDR-21.136 POWER 3 #10 >> EDR-21.261 POWER	P-21-272 P-21-263 P-21-263 P-21-263
P-21-271	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: EDR-21.251 TO: DISCONNECT 3 #10 >> EDR-21.251 POWER	P-21-272
P-21-272	E21-2	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #10 >> EDR-21.251 POWER	P-21-264 P-21-271
P-21-301	E21-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: VCP1-21.310 TO: JUNCTION BOX 3 #10 >> VCP1-21.310 POWER	P-21-304
P-21-302	E21-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: VCP1-21.320 TO: JUNCTION BOX 3 #10 >> VCP1-21.320 POWER	P-21-304
P-21-303	E21-4	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: VCP1-21.330 TO: JUNCTION BOX 3 #10 >> VCP1-21.330 POWER	P-21-304
P-21-304	E21-3 E21-4	1"	9	#10	XHHW-2	1	#10	XHHW-2	FR: JUNCTION BOX TO: GRB-MCC-1 3 #10 >> VCP1-21.310 POWER 3 #10 >> VCP1-21.320 POWER 3 #10 >> VCP1-21.330 POWER	P-21-301 P-21-302 P-21-303
P-21-310	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: GRW-21.310 TO: VCP1-21.310 3 #12 >> GRW-21.310 POWER	
P-21-311	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: GRC-21.311 TO: VCP1-21.310 3 #12 >> GRC-21.311 POWER	
P-21-320	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: GRW-21.320 TO: VCP1-21.320 3 #12 >> GRW-21.320 POWER	
P-21-321	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: GRC-21.321 TO: VCP1-21.320 3 #12 >> GRC-21.321 POWER	
P-21-330	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: GRW-21.330 TO: VCP1-21.330 3 #12 >> GRW-21.330 POWER	
P-21-331	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: GRC-21.331 TO: VCP1-21.330 3 #12 >> GRC-21.331 POWER	
P-21-401	E21-3	0.75"	3	#10	XHHW-2	1	#10	XHHW-2	FR: FAB-21.500 TO: GRB-MCC-1 3 #10 >> FAB-21.500 POWER	
P-21-810	E21-3 E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: MAU-21.810 TO: MCC-GRB-1 3 #12 >> MAU-21.810 POWER	

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
P-21-820	E21-3 E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: MAU-21.820 TO: MCC-GRB-1 3 #12 >> MAU-21.820 POWER	
P-21-830	E21-3	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: EF-21.830 TO: DISCONNECT 3 #12 >> EF-21.830 POWER	
P-21-831	E21-3	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> EF-21.830 POWER	P-21-842
P-21-840	E21-3	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: EF-21.840 TO: DISCONNECT 3 #12 >> EF-21.840 POWER	
P-21-841	E21-3	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> EF-21.840 POWER	P-21-842
P-21-842	E21-3	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: MCC-GRB-1 3 #12 >> EF-21.830 POWER 3 #12 >> EF-21.840 POWER	P-21-831 P-21-841
P-21-850	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: EF-21.850 TO: DISCONNECT 3 #12 >> EF-21.850 POWER	
P-21-851	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> EF-21.850 POWER	P-21-862
P-21-860	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: EF-21.860 TO: DISCONNECT 3 #12 >> EF-21.860 POWER	
P-21-861	E21-4	0.75"	3	#12	XHHW-2	1	#12	XHHW-2	FR: DISCONNECT TO: CONDUIT TEE 3 #12 >> EF-21.860 POWER	P-21-862
P-21-862	E21-3 E21-4	0.75"	6	#12	XHHW-2	1	#12	XHHW-2	FR: CONDUIT TEE TO: GRB-MCC-1 3 #12 >> EF-21.850 POWER 3 #12 >> EF-21.860 POWER	P-21-851 P-21-861
S-21-025	E21-7	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-21.521 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-21.521 SIGNAL	S-21-027
S-21-026	E21-7	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-21.522 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-21.522 SIGNAL	S-21-027
S-21-027	E21-7 E21-1 E21-3	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 1 2/CS-#16 >> PIT-21.522 SIGNAL 1 2/CS-#16 >> PIT-21.521 SIGNAL	S-21-026 S-21-025
S-21-100	E21-4	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-21.001 TO: PCM-2100 1 2/CS-#16 >> LIT-21.001 SIGNAL	
S-21-110		1"	1	MFR	CABLE	1	#14	XHHW-2	FR: LE-21.112 TO: LIT-21.112 1 MFR >> LE-21.112 SIGNAL	
S-21-111	E21-4	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-21.112 TO: CONDUIT TEE 1 2/CS-#16 >> LIT-21.112 SIGNAL	S-21-112
S-21-112	E21-3 E21-4	1.5"	5	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 1 2/CS-#16 >> LIT-21.112 SIGNAL 1 2/CS-#16 >> LIT-21.132 SIGNAL 1 2/CS-#16 >> TIT-21.822 SIGNAL 1 2/CS-#16 >> PDIT-21.823 SIGNAL 1 2/CS-#16 >> LIT-21.122 SIGNAL	S-21-111 S-21-122 S-21-122 S-21-122 S-21-122
S-21-113	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-21.215 TO: CONDUIT TEE 1 2/CS-#16 >> FIT-21.215 SIGNAL	S-21-114

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-21-114	E21-3	1"	3	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 1 2/CS-#16 >> FIT-21.255 SIGNAL 1 2/CS-#16 >> FIT-21.235 SIGNAL 1 2/CS-#16 >> FIT-21.215 SIGNAL	S-21-124 S-21-124 S-21-113
S-21-120	E21-4	1"	1	MFR	CABLE	1	#14	XHHW-2	FR: LE-21.1212 TO: LIT-21.122 1 MFR >> LE-21.1212 SIGNAL	
S-21-121	E21-4	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-21.122 TO: CONDUIT TEE 1 2/CS-#16 >> LIT-21.122 SIGNAL	S-21-122
S-21-122	E21-4	1"	4	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> LIT-21.132 SIGNAL 1 2/CS-#16 >> TIT-21.822 SIGNAL 1 2/CS-#16 >> PDIT-21.823 SIGNAL 1 2/CS-#16 >> LIT-21.122 SIGNAL	S-21-112 S-21-132 S-21-132 S-21-132 S-21-121
S-21-123	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-21.235 TO: CONDUIT TEE 1 2/CS-#16 >> FIT-21.235 SIGNAL	S-21-124
S-21-124	E21-3	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> FIT-21.255 SIGNAL 1 2/CS-#16 >> FIT-21.235 SIGNAL	S-21-114 S-21-133 S-21-123
S-21-130	E21-4	1"	1	MFR	CABLE	1	#14	XHHW-2	FR: LE-21.132 TO: LIT-21.132 1 MFR >> LE-21.132 SIGNAL	
S-21-131	E21-4	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: LIT-21.132 TO: CONDUIT TEE 1 2/CS-#16 >> LIT-21.132 SIGNAL	S-21-132
S-21-132	E21-4	1"	3	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> LIT-21.132 SIGNAL 1 2/CS-#16 >> TIT-21.822 SIGNAL 1 2/CS-#16 >> PDIT-21.823 SIGNAL	S-21-122 S-21-131 S-21-837 S-21-837
S-21-133	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: FIT-21.255 TO: CONDUIT TEE 1 2/CS-#16 >> FIT-21.255 SIGNAL	S-21-124
S-21-313	E21-4	0.75"	1	2/CS-#16					FR: PT-21.313 TO: VCP1-21.310 1 2/CS-#16 >> PT-21.313 SIGNAL	
S-21-323	E21-4	0.75"	1	2/CS-#16					FR: PT-21.321 TO: VCP1-21.320 1 2/CS-#16 >> PT-21.321 SIGNAL	
S-21-333	E21-4	0.75"	1	2/CS-#16					FR: PT-21.331 TO: VCP1-21.330 1 2/CS-#16 >> PT-21.331 SIGNAL	
S-21-401	E21-3	0.75"	1	3/CS-#16		1	#14	XHHW-2	FR: LCP-21.500 TO: GRB-MCC-1 1 3/CS-#16 >> LCP-21.500 SIGNAL	
S-21-410	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PDIT-21.503 TO: CONDUIT TEE 1 2/CS-#16 >> PDIT-21.503 SIGNAL	S-21-412
S-21-411	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-21.511 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-21.511 SIGNAL	S-21-412
S-21-412	E21-3	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> PDIT-21.503 SIGNAL 1 2/CS-#16 >> PIT-21.511 SIGNAL	S-21-414 S-21-410 S-21-411
S-21-413	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-21.512 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-21.512 SIGNAL	S-21-414

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-21-414	E21-3	1"	3	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> PDIT-21.503 SIGNAL 1 2/CS-#16 >> PIT-21.511 SIGNAL 1 2/CS-#16 >> PIT-21.512 SIGNAL	S-21-416 S-21-412 S-21-412 S-21-413
S-21-415	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-21.513 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-21.513 SIGNAL	S-21-416
S-21-416	E21-3	1"	4	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 1 2/CS-#16 >> PDIT-21.503 SIGNAL 1 2/CS-#16 >> PIT-21.511 SIGNAL 1 2/CS-#16 >> PIT-21.512 SIGNAL 1 2/CS-#16 >> PIT-21.513 SIGNAL	S-21-414 S-21-414 S-21-414 S-21-415
S-21-417	E21-4 E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-21.514 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-21.514 SIGNAL	S-21-419
S-21-418	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PIT-21.515 TO: CONDUIT TEE 1 2/CS-#16 >> PIT-21.515 SIGNAL	S-21-419
S-21-419	E21-3	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 1 2/CS-#16 >> PIT-21.514 SIGNAL 1 2/CS-#16 >> PIT-21.515 SIGNAL	S-21-417 S-21-418
S-21-800	E21-4	0.75"	1	MFR	CABLE	1	#14	XHHW-2	FR: TE-21.811 TO: TIT-21.811 1 MFR >> TE-21.811 SIGNAL	
S-21-801	E21-4	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: TIT-21.811 TO: MAU-21.810 1 2/CS-#16 >> TIT-21.811 SIGNAL	S-21-810
S-21-802	E21-4	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: TIT-21.821 TO: MAU-21.820 1 2/CS-#16 >> TIT-21.821 SIGNAL	S-21-820
S-21-810	E21-3 E21-4	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: MAU-21.810 TO: CONDUIT TEE 4 2/CS-#16 >> MAU-21.810 SIGNAL 1 2/CS-#16 >> TIT-21.811 SIGNAL 1 2/CS-#16 >> TIT-21.810 SIGNAL	S-21-821 S-21-801
S-21-820	E21-3 E21-4	1.5"	6	2/CS-#16		1	#14	XHHW-2	FR: MAU-21.820 TO: CONDUIT TEE 4 2/CS-#16 >> MAU-21.820 SIGNAL 1 2/CS-#16 >> TIT-21.821 SIGNAL 1 2/CS-#16 >> TIT-21.820 SIGNAL	S-21-821 S-21-802
S-21-821	E21-3	2"	12	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 4 2/CS-#16 >> MAU-21.810 SIGNAL 1 2/CS-#16 >> TIT-21.811 SIGNAL 1 2/CS-#16 >> TIT-21.810 SIGNAL 4 2/CS-#16 >> MAU-21.820 SIGNAL 1 2/CS-#16 >> TIT-21.821 SIGNAL 1 2/CS-#16 >> TIT-21.820 SIGNAL	S-21-810 S-21-810 S-21-810 S-21-820 S-21-820 S-21-820
S-21-830	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: TIT-21.812 TO: CONDUIT TEE 1 2/CS-#16 >> TIT-21.812 SIGNAL	S-21-832
S-21-831	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PDIT-21.813 TO: CONDUIT TEE 1 2/CS-#16 >> PDIT-21.813 SIGNAL	S-21-832
S-21-832	E21-3	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 1 2/CS-#16 >> TIT-21.812 SIGNAL 1 2/CS-#16 >> PDIT-21.813 SIGNAL	S-21-830 S-21-831
S-21-833	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: TIT-21.842 TO: PCM-2100 1 2/CS-#16 >> TIT-21.842 SIGNAL	
S-21-834	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: TIT-21.832 TO: PCM-2100 1 2/CS-#16 >> TIT-21.832 SIGNAL	

CONDUIT SCHEDULE AREA 21									ENGINEER	CAH
PROJECT 5									REVISION	0
GRIT REMOVAL BUILDING									DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND				
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS
S-21-835	E21-4	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: TIT-21.822 TO: CONDUIT TEE 1 2/CS-#16 >> TIT-21.822 SIGNAL	S-21-837
S-21-836	E21-4	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: PDIT-21.823 TO: CONDUIT TEE 1 2/CS-#16 >> PDIT-21.823 SIGNAL	S-21-837
S-21-837	E21-4	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> TIT-21.822 SIGNAL 1 2/CS-#16 >> PDIT-21.823 SIGNAL	S-21-132 S-21-835 S-21-836
S-21-850	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-21.934 TO: CONDUIT TEE 1 2/CS-#16 >> AIT-21.934 SIGNAL	S-21-852
S-21-851	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-21.935 TO: CONDUIT TEE 1 2/CS-#16 >> AIT-21.935 SIGNAL	S-21-852
S-21-852	E21-3	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> AIT-21.934 SIGNAL 1 2/CS-#16 >> AIT-21.935 SIGNAL	S-21-856 S-21-850 S-21-851
S-21-853	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-21.931 TO: CONDUIT TEE 1 2/CS-#16 >> AIT-21.931 SIGNAL	S-21-855
S-21-854	E21-3	0.75"	1	2/CS-#16		1	#14	XHHW-2	FR: AIT-21.932 TO: CONDUIT TEE 1 2/CS-#16 >> AIT-21.932 SIGNAL	S-21-855
S-21-855	E21-3	0.75"	2	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: CONDUIT TEE 1 2/CS-#16 >> AIT-21.931 SIGNAL 1 2/CS-#16 >> AIT-21.932 SIGNAL	S-21-856 S-21-853 S-21-854
S-21-856	E21-3	1"	4	2/CS-#16		1	#14	XHHW-2	FR: CONDUIT TEE TO: PCM-2100 1 2/CS-#16 >> AIT-21.934 SIGNAL 1 2/CS-#16 >> AIT-21.935 SIGNAL 1 2/CS-#16 >> AIT-21.931 SIGNAL 1 2/CS-#16 >> AIT-21.932 SIGNAL	S-21-852 S-21-852 S-21-855 S-21-855
X-21-001	GE-SE-37 E21-1	3"	1	PULL	ROPE				FR: GRB-MCC-1 TO: EMH-1 1 PULL >> SPARE	
X-21-002	GE-SE-37 E21-1	3"	1	PULL	ROPE				FR: PCM-2100 TO: EMH-1 1 PULL >> SPARE	
X-21-050	GE-SE-37	3"	1	PULL	ROPE				FR: 4C-PB-7 TO: EMH-1 1 PULL >> SPARE	
X-21-051	GE-SE-37	3"	1	PULL	ROPE				FR: 4C-PB-7 TO: EMH-1 1 PULL >> SPARE	
X-21-060	GE-SE-37	3"	1	PULL	ROPE				FR: 4C-CB-3 TO: EMH-1 1 PULL >> SPARE	
X-21-061	GE-SE-37	3"	1	PULL	ROPE				FR: 4C-CB-3 TO: EMH-1 1 PULL >> SPARE	
L4702	GE-SE-37	4"	1		24/FO-SM	1	#14	XHHW-2	FR: PCM-605 TO: 4C-CB-3 1 24/FO-SM >> PCM-605>PCM-2100 NETWORK EXISTING CONDUIT, NEW CABLE	N-21-051 M4025
M4011	GE-SE-37	3"	1		24/FO-SM	1	#14	XHHW-2	FR: VCP-610 TO: 4C-CB-2 1 24/FO-SM >> VCP-610>PCM-600A EXISTING CONDUIT, NEW CABLE	

CONDUIT SCHEDULE AREA 21										ENGINEER	CAH
PROJECT 5										REVISION	0
GRIT REMOVAL BUILDING										DATE	3/1/19
CONDUIT			CONDUCTORS			GROUND					
NUMBER	DWG	SIZE	#	SIZE	TYPE	#	SIZE	TYPE	DESCRIPTION	CONNECTING SEGMENTS	
M4012	E13-1	3"	1		24/FO-SM	1	#14	XHHW-2	FR: VCP-610 TO: 4C-CB-2 1 24/FO-SM >> VCP-610>PCM-2100 NETWORK EXISTING CONDUIT, NEW CABLE	M4025	
M4025	GE-SE-37	3"	1		24/FO-SM	1	#14	XHHW-2	FR: 4C-CB-2 TO: 4C-CB-3 1 24/FO-SM >> VCP-610>PCM-2100 NETWORK EXISTING CONDUIT, NEW CABLE	N-21-050 M4012	
M1039	E13-1	4"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: ES-5 TO: 4C-PB-3 3 #4/0 >> GRB-MCC-1 POWER EXISTING CONDUIT, NEW CONDUCTOR	M1051	
M1040	E13-1	4"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: ES-5 TO: 4C-PB-3 3 #4/0 >> GRB-MCC-1 POWER EXISTING CONDUIT, NEW CONDUCTOR	M1056	
M1051	GE-SE-37	3"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: 4C-PB-3 TO: 4C-PB-7 3 #4/0 >> GRB-MCC-1 POWER EXISTING CONDUIT, NEW CONDUCTOR	P-21-050 M1039	
M1056	GE-SE-37	3"	3	#4/0	XHHW-2	1	#3	XHHW-2	FR: 4C-PB-3 TO: 4C-PB-7 3 #4/0 >> GRB-MCC-1 POWER EXISTING CONDUIT, NEW CONDUCTOR	P-21-051 M1040	

END OF CONDUIT SCHEDULE

END OF SECTION

SECTION 17050

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements applicable to all Process Control and Instrumentation Work.
 - 2. General requirements for process control and instrumentation submittals.
 - 3. As specified in this Section, some PLC programming and SCADA/HMI software configuration will be provided by the Owner.
- B. Interfaces to equipment, instruments, and other components:
 - 1. Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
 - 2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
 - a. Make all changes necessary to meet the manufacturer's wiring requirements.
 - 3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00700 - General Conditions.
 - 4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items indicated on the Drawings or in Specifications from another discipline in the scope of Work:
 - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
 - 5. Loop drawings:
 - a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
 - b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
 - c. The Owner and Engineer are not responsible for providing detailed loop diagrams for Contractor furnished equipment.

- C. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
 2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
 3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Instrumentation and Control Specifications' requirements.

Contract Documents:

4. General:
 - a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
5. Specifications:
 - a. Documents 00700 - General Conditions and 00800 - Supplementary Conditions of the Contract Documents govern the Work.
 - b. These requirements are in addition to all General Requirements.
6. Contract drawings:
 - a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire drawing set for construction purposes.
 - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
 - 1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
 - 2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
 - c. Installation details:
 - 1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.

- d. Schematic diagrams:
 - 1) All controls are shown de-energized.
 - 2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
 - 3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
 - 4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
 - 5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

D. Alternates/Alternatives:

- 1. Substitute item provisions as specified in Document 00700 - General Conditions.

E. Changes and change orders:

- 1. As specified in Section 01600 - Product Requirements.

1.02 REFERENCES

A. Code compliance:

- 1. As specified in Section 01410 - Regulatory Requirements:
 - a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
- 2. The following codes and standards are hereby incorporated into this Section:
 - a. American National Standards Institute (ANSI).
 - b. American Petroleum Institute (API):
 - 1) RP 550 - Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
 - 2) RP 551 - Process Measurement Instrumentation.
 - c. International Organization for Standardization (ISO):
 - 1) 9001 - Quality Management Systems - Requirements.
 - d. International Society of Automation (ISA):
 - 1) 5.1 - Instrumentation Symbols and Identification.
 - 2) 5.4 - Instrument Loop Diagrams.
 - 3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
 - e. National Electrical Manufacturers Association (NEMA):
 - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
 - f. National Fire Protection Association (NFPA).
 - g. National Institute of Standards and Technology (NIST).
 - h. Underwriters Laboratories, Inc. (UL):
 - 1) 508 - Standard of Safety for Industrial Control Equipment.
 - 2) 508A - Standard of Safety for Industrial Control Panels.

- B. Compliance with Laws and Regulations:
 - 1. As specified in Document 00700 - General Conditions.

1.03 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations in accordance with:
 - 1. Factory Mutual (FM).
 - 2. International Electrotechnical Commission (IEC).
 - 3. Institute of Electrical and Electronics Engineers (IEEE).
 - 4. International Society of Automation (ISA).
 - 5. International Organization for Standardization (ISO).
 - 6. National Electrical Code (NEC).
 - 7. National Electrical Manufacturers Association (NEMA).
 - 8. InterNational Electrical Testing Association (NETA).
 - 9. National Fire Protection Association (NFPA).
 - 10. National Institute of Standards and Technology (NIST).
 - 11. Underwriters Laboratories (UL).
- B. Specific definitions:
 - 1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
 - 2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems.
 - 3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
 - 4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
 - 5. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, 2-wire transmitter refers to a transmitter that provides a signal such as 4 to 20 mA 24VDC regulation of a signal in a series circuit with an external 24 VDC driving potential:
 - a. Fieldbus communications signal or both.
 - 6. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 mA 24VDC signal, a digital bus communications signal, or both.
 - 7. System supplier - As specified in ICSC Qualifications in the Quality Assurance article of this Section.
 - 8. Modifications: Changing, extending, interfacing to, removing, or altering an existing circuit.
- C. NEMA:
 - 1. Type 1 enclosure in accordance with NEMA 250.
 - 2. Type 2 enclosure in accordance with NEMA 250.
 - 3. Type 3 enclosure in accordance with NEMA 250.
 - 4. Type 3R enclosure in accordance with NEMA 250.

5. Type 3S enclosure in accordance with NEMA 250.
6. Type 3X enclosure in accordance with NEMA 250.
7. Type 3RX enclosure in accordance with NEMA 250.
8. Type 3SX enclosure in accordance with NEMA 250.
9. Type 4 enclosure in accordance with NEMA 250.
10. Type 4X enclosure in accordance with NEMA 250.
11. Type 5 enclosure in accordance with NEMA 250.
12. Type 6 enclosure in accordance with NEMA 250.
13. Type 6P enclosure in accordance with NEMA 250.
14. Type 12 enclosure in accordance with NEMA 250.
15. Type 12K enclosure in accordance with NEMA 250.
16. Type 13 enclosure in accordance with NEMA 250.

D. Acronym definitions:

1. ACB: Automatic current balance.
2. DPDT: Double-pole, double-throw.
3. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
4. FAT: Factory acceptance test also known as Source Test.
5. HART: Highway addressable remote transducer.
6. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
7. HMI: Human machine interface is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphical format.
8. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
9. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace, or relocate instrument signals.
10. I/O: Input/Output.
11. IP: Internet protocol or ingress protection.
12. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
13. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
14. LOI: Local Operator Interface is an operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The LOI is typically a flat panel type of display mounted on the front of an enclosure with either a touch screen or tactile button interface.
15. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits

completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.

16. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO, etc.
17. P&ID: Process and instrumentation diagram.
18. PC: Personal computer.
19. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings. This includes all the PCS and instruments and networking components as well as the various servers, workstations, thin clients, etc.
20. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
21. PCS: Process Control System: A general name for the computerized system that gathers and processes data from equipment and sensors and applies operational controls to the process equipment. It includes the PLCs and/or RIOs, LOIs, HMIs, both LCPs, VCPs and all data management systems accessible to staff.
22. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
23. PLC: Programmable logic controller.
24. PS: Power supply.
25. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
26. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
27. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and equipment located outside of the facility, such as wells, lift stations, metering stations, etc.
28. SPDT: Single-pole, double-throw.
29. SPST: Single-pole, single-throw.
30. UPS: Uninterruptible power supply.
31. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, LOI, HMI, etc.
32. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the instrumentation and control system work indicated on the Drawings and specified in the Specifications and reasonably inferable therefrom including but not limited to:
 - a. Preparing hardware submittals for field instrumentation.

- b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
 - c. Prepare the test plan, the training plan, and the spare parts submittals.
 - d. Procure all hardware.
 - e. Provide all PCS system hardware.
 - f. Fabricate panels.
 - g. Perform factory tests on panels.
 - h. Perform bench calibration and verify calibration after installation.
 - i. Oversee and certify installation of the PCS system.
 - j. Oversee, document, and certify loop testing.
 - k. Oversee, document, and certify system Installation Testing.
 - l. Oversee and document Functional Testing.
 - m. Conduct the Process Operational Period and the Instrumentation and Controls Process Performance Testing.
 - n. Prepare operation and maintenance manuals.
 - o. Conduct training classes.
 - p. Integrate the PCS with instrumentation and control devices provided under other sections.
 - q. Configure all VFD on-board logic for interlocks, inputs, and outputs.
 - r. Provide Record Drawings and Loop Drawings associated with Instruments and equipment:
 - 1) As specified in the Contract Documents.
 - 2) For Owner furnished items.
 - 3) For interfaces with existing equipment.
 - s. Resolve signal, power, or functional incompatibilities between the PCS and interfacing devices.
 - t. Perform all required corrective and preventative maintenance.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.
 3. Provide the complete operating PCS to perform the specified monitoring, communications, alarm, control, and display functions in accordance with the PCS requirements.
 4. The Owner will provide the configuration and programming for parts of the PLC and PC based control system, as described below.
 - a. The following PLCs will be programmed by the Owner:
 - 1) PLC-600A.
 - 2) PLC-2100.
 - b. The CCS consisting of personal computers and software that will be configured by the Owner.
 - c. All other PLCs and other programmable devices shall be programmed by the Contractor, either directly or through the services of other entities such as subcontractors, equipment suppliers, and packaged equipment suppliers (vendors).
 5. The Owner, will also supply miscellaneous hardware and software listed below. The software listed is for the exclusive use of the Owner, and will not be made available for use by the Contractor. The hardware listed is for

incorporation into the Plant PCS system, does not include all required PCS components, and will not be available for use in any other systems or equipment. The quantities being supplied by the Owner are limited to the quantities listed below. Additional hardware and software of similar make and model shall be provided by the Contractor, as needed to complete the PCS system and all other portions of the Work shown or specified. Owner will supply:

- a. 1 new panel-mounted operator workstation PCS system clients (hardware).
 - b. Microsoft and PCS application software for the Plant PCS system.
 - c. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors, or suppliers.
 - d. Coordinate all aspects of the Work relating to Owner-provided equipment during panel fabrication.
6. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, and all other documentation required to operate, modify, and maintain all parts of the PCS.
 7. Where demolition is indicated on the Drawings, the electrical subcontractor is responsible for disconnecting equipment electrical connections and rendering the equipment safe. The ICSC is responsible for physically removing all instrumentation to be demolished and return it either to the Owner or dispose of it as directed by the Owner's representative.
 8. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment.
 - a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before performing any Work.
 - b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.
 9. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
 10. Defective Work:
 - a. As specified in Document 00700 - General Conditions.
- B. Existing system:
1. The existing grit and phosphorous removal systems are being upgraded to meet the new Utah Department of Water Quality regulations regarding phosphorous removal.
 2. Currently, all five bioreactors utilize air from the fine bubble diffusers to adjust the dissolved oxygen (DO) concentration within the basins and achieve treatment goals. The diffusers are fed by a series of five single stage, centrifugal blowers manufactured by Turblex that are located in Blower Building No. 3. The existing fine bubble diffusers have been in service for approximately 10 years and have had issues with fouling.
 3. Bioreactors 1-4 are equipped with supplemental mechanical mixers within the four anoxic zones. Bioreactor 5 uses mechanical mixing in the first zones and

- a Tideflex jet bubble mixing in subsequent zones. Similar to Bioreactors 1-4, the aerated zones within Bioreactor 5 depend on aeration mixing only.
- 4. The existing aeration system for Bioreactors 1-4 is controlled by a single automated air control valve at each bioreactor while the individual zones are equipped with manual valves. As such, the individual zones must be manually adjusted in the field by operators. This method of operation does not allow for quick reactions or for adjustment between zones.
- 5. Control system:
 - a. The existing control system includes GE RX3i PLCs located throughout the treatment plant with GE iFIX HMI software.
 - b. Existing PLC control panel PCM-600 located at the Bioreactors includes a PLC, Ethernet switch, and GE Genius remote I/O modules. The remote I/O is monitored and controlled by PLC-610 in Blower Building 3.

C. New system:

- 1. Owner will provide PLC and SCADA programming and integration.
- 2. The existing Bioreactor Mixers' starters are being replaced as indicated on the Drawings, and new analytical instrumentation and actuated valves are provided to allow additional monitoring and control over the bioreactor system. New analytical instrumentation shall communicate via Modbus TCP Ethernet connection to the new PCM-600A. All actuated valves shall communicate over Profibus DP network as indicated on the Drawings.
- 3. Fiber optic installation including, but not limited to, new connections from Bioreactor No. 5 electrical room and Blower Building No. 3 and connections to new analyzer network junction boxes as indicated on the Drawings.
- 4. Installation of Owner-provided networking equipment as specified hereinafter and indicated on the Drawings.
- 5. New instrumentation shall be provided for the Grit Influent and Effluent Channels, as well as new actuated gates and valves. New Grit Pumps, Grit Washers, and an odor control system are provided as shown in the Drawings.
- 6. New PLC enclosure in new Grit Removal Building with the following:
 - a. PLC.
 - b. HMI node with keyboard and touch-screen monitor.
 - c. Rack-mounted Ethernet switch.
 - d. Fiber optic patch panel.
 - e. UPS.
- 7. New PLC enclosure in new prefabricated electrical building at the bioreactors with the following:
 - a. PLC.
 - b. Rack-mounted Ethernet switch.
 - c. Fiber optic patch panel.
 - d. UPS.

D. Operating facility:

- 1. As specified in Section 01140 - Work Restrictions.
- 2. Portions of this existing facility must remain fully functional throughout the entire construction period. In consideration of this requirement, comply with the following guidelines:
 - a. All outages must be of minimal duration and fully coordinated and agreed to by the Owner. Adjust the construction to meet the requirements of the Owner.

- b. As weather and facility demand conditions dictate, re-adjust the construction schedule to meet the demands placed upon Owner by its users.
 - c. Where portions of the Work are in existing facilities and require interface to existing circuits, power systems, controls and equipment, perform comprehensive and detailed field investigations of existing conditions. Determine all information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
- 3. According to individual circumstances and in compliance with the Drawings, extend or replace conduit and cable connections from existing locations.
- 4. Where shown or specified, replace existing field instruments with new.
- 5. Contractor is responsible for the integrity and measurement accuracy of all loops.
- 6. Any defect found in existing equipment is the responsibility of the Owner. Contractor is not responsible for defects on existing Owner components.
- 7. The standards of documentation, instrument tagging, cable and conductor termination, terminal identification and labeling that apply to the new installation apply equally to the existing installation.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures and this Section.
- B. General:
 - 1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
 - 2. Furnish the submittals required by each section in the Instrumentation Specifications.
 - 3. Adhere to the wiring numbering scheme specified in Section 16075 - Identification for Electrical Systems throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on all Equipment Drawings.
 - 4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
- C. Submittal preparation:
 - 1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.

2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
 - a. Employ the nomenclature and numbers designated in this Section and indicated on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
 - b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and indicated on the Drawings.

D. Specific submittal requirements:

1. Shop drawings:
 - a. Required for materials and equipment listed in this and other sections.
 - b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
 - c. Shop drawings requirements:
 - 1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
 - 2) Locations of conduit entrances and access plates.
 - 3) Component layout and identification.
 - 4) Schematic and wiring diagrams with wire numbers and terminal identification.
 - 5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
 - 6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
 - 7) Weight.
 - 8) Finish.
 - 9) Nameplates:
 - a) As specified in Section 16075 - Identification for Electrical Systems or as indicated on the Drawings.
 - 10) Temperature limitations, as applicable.
 - d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
 - e. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
 - 1) Uniquely number each wire per the Specifications.
 - f. Wire numbers must appear on all equipment drawings.
 - g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
 - 1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose-leaf, vinyl plastic, hard-cover binders suitable for bookshelf storage.
 - 2) Binder ring size: 2 inches.
 - h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
 - 1) The firm's registered business name.
 - 2) Firm's physical address, email address, and phone number.
 - 3) Owner's name.
 - 4) Project name and location.

- 5) Drawing name.
 - 6) Revision level.
 - 7) Personnel responsible for the content of the drawing.
 - 8) Date.
- i. The work includes modifications to existing circuits:
 - 1) Clearly show all modifications to existing circuits.
 - 2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.
2. Product data:
 - a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
 - b. Include:
 - 1) Catalog cuts.
 - 2) Bulletins.
 - 3) Brochures.
 - 4) Quality photocopies of applicable pages from these documents.
 - 5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
 - 6) Identify model number and options for the actual equipment being furnished.
 - 7) Neatly cross out options that do not apply or equipment not intended to be supplied.
 - c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
 - d. Adhere to wiring numbering scheme outlined in Section 16075 - Identification for Electrical Systems throughout the Project:
 - 1) Uniquely number each wire per the Specifications.
 - e. Wire numbers must appear on all equipment drawings.
3. Detailed sequence of operation for all equipment or systems.
4. Operation and maintenance manuals:
 - a. As specified in Section 01782 - Operation and Maintenance Data.
5. Material and equipment schedules:
 - a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
 - 1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
6. Itemized instrument summary:
 - a. Submit a hard copy of the instrument summary.
 - b. List all of the key attributes of each instrument including:
 - 1) Tag number.
 - 2) Manufacturer.
 - 3) Model number.
 - 4) Service.
 - 5) Area location.
 - 6) Calibrated range.
 - 7) Loop drawing number.
 - c. Associated LCP, VCP, PCM, or PLC.
7. Instrument data sheets and cut sheets:
 - a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hard copy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control

Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:

- 1) Component functional description specified in this Section and indicated on the Drawings.
 - 2) Manufacturers model number or other product designation.
 - 3) Tag number specified in this Section and indicated on the Drawings.
 - 4) System or loop of which the component is a part.
 - 5) Location or assembly at which the component is to be installed.
 - 6) Input and output characteristics.
 - 7) Scale range with units and multiplier.
 - 8) Requirements for electric supply.
 - 9) Requirements for air supply.
 - 10) Power consumption.
 - 11) Response timing.
 - 12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
 - 13) Special requirements or features, such as specifications for ambient operating conditions.
 - 14) Features and options that are furnished.
- b. Provide a technical brochure or bulletin ("cut sheet") for each instrument on the project. Submit with the corresponding data sheets:
- 1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
 - 2) Include a list of tag numbers for which it applies with each brochure or bulletin.
 - 3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
 - 4) Cross out models, features, options, or accessories that are not being provided.
 - 5) Clearly mark and identify special options and features.
- c. Organization: Index the data sheets and brochures in the submittal by systems or loops.
8. Control panel hardware submittal:
- a. Submit the following in 1 submittal package.
 - b. Complete and detailed bills of materials:
 - 1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
 - 2) Include all items within an enclosure.
 - c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and Control System equipment.
 - d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
 - e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.

- f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
 - 1) The manufacturer's model number or other identifying product designation.
 - 2) Tag and loop number.
 - 3) System to which it belongs.
 - 4) Site to which it applies.
 - 5) Input and output characteristics.
 - 6) Requirements for electric power.
 - 7) Device ambient operating requirements.
 - 8) Materials of construction.
- 9. Installation recommendations:
 - a. Submit the manufacturer's printed recommendations for installation of instrumentation equipment.
- 10. Training submittals:
 - a. Develop and submit for review a general training plan for approval by Owner within 14 calendar days from Notice to Proceed. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
 - b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
 - c. The general training plan and schedule shall be updated by the Contractor at the beginning of each Phase and approved by the Owner a minimum of 30 days prior to commencement of training.
 - d. Training course plan submittals:
 - 1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson as specified in Section 01756 - Commissioning.
 - 2) Describe any student pre-requisites for the course or training activity.
 - 3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
 - 4) Submit training materials.
 - e. Incorporate all submittal review comments into the course.
 - f. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.
- 11. Project Record documents:
 - a. Furnish as specified in Section 01770 - Closeout Procedures.
 - b. Record Drawing requirements:
 - 1) Provide Project Record Drawing of all Instrumentation Drawings.
 - 2) Update Record Drawings weekly.
 - 3) Record Drawings must be fully updated as a condition of the monthly progress payments.

- 4) Clearly and neatly show all changes including the following:
 - a) All existing pipe, conduit, wire, instruments or other structures encountered or uncovered during construction.
12. Loop Drawings:
 - a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
 - 1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
 - 2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
 - 3) Provide loop drawings in the format indicated in the contract drawings. Provide all tagging in accordance with the Owner's standard.
 - b. Show every instrument and I/O point on at least one loop diagram.
 - c. Provide a complete index in the front of each bound volume:
 - 1) Index the loop drawings by systems or process areas.
 - d. Provide drawings showing definitive diagrams for every instrumentation loop system:
 - 1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
 - 2) Furnish a separate drawing sheet for each system or loop diagram.
 - e. In addition to the ISA-5.4 requirements, show the following details:
 - 1) Functional name of each loop.
 - 2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
 - 3) Show all terminal numbers, regardless of the entity providing the equipment.
 - 4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
 - 5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
 - 6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
 - 7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.
 - f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.
13. Instrument Installation Drawings:
 - a. Submit instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
 - b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.

- c. For each detail, provide certification and the hard copies by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
 - d. For each detail, provide, as a minimum, the following contents:
 - 1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
 - 2) Ambient temperature and humidity where the instrument is to be installed.
 - 3) Corrosive qualities of the environment where the instrument is to be installed.
 - 4) Hazardous rating of the environment where the instrument is to be installed.
 - 5) Process line pipe or tank size, service and material.
 - 6) Process tap elevation and location.
 - 7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
 - 8) Routing of tubing and identification of supports.
 - 9) Mounting brackets, stands, anchoring devices, and sun shades.
 - 10) Conduit entry size, number, location, and delineation between power and signal.
 - 11) NEMA ratings of enclosures and all components.
 - 12) Clearances required for instrument servicing.
 - 13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.
14. Control Panel Drawings:
- a. Layout Drawings:
 - 1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
 - 2) As a minimum, include the following information:
 - a) To scale front, side, and plan views.
 - b) Dimensions.
 - c) Interior and exterior arrangements.
 - d) Mounting information, including conduit entrance location.
 - e) Finish data.
 - f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
 - g) Nameplate legend including text, letter size, materials, and colors.
 - b. Wiring and piping diagrams:
 - 1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.
 - 2) Include the following information:
 - a) Name of panel.
 - b) Wiring and piping sizes and types.
 - c) Terminal strip numbers.
 - d) Wire tags and labels.
 - e) Functional name and manufacturer's designation for items to which wiring and piping are connected.

- f) Electrical control schematics in accordance with ANSI standards.
- c. Installation drawings:
 - 1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
 - 2) Provide scaled drawings and show the position of the equipment at its intended installation location.
 - 3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
 - 4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.
- 15. Schematic Diagrams:
 - a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
 - b. Include device and field connection terminal numbers on all schematic diagrams.
 - c. Incorporate equipment manufacturer's shop drawing information into the schematic diagrams in order to document the entire control system.
- 16. Control System Diagram:
 - a. Submit a complete set of control system diagrams including the following information:
 - 1) All PLCs, workstations, printers, communication devices, and communication links:
 - a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
 - 2) All cables required for communication requirements.
 - 3) Show each component fully annotated with conduit size and number associated with the power source.
- 17. Instrumentation and Control System Contractor Statement of Qualifications:
 - a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.
- 18. Test Procedure Submittals:
 - a. Submit the proposed procedures to be followed during tests of the PCS and its components in 2 parts:
 - 1) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
 - 2) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.
- 19. Test reports:
 - a. As specified in Section 01330 - Submittal Procedures.
- 20. Calculations:
 - a. Where required by specific Instrumentation Specifications:
 - 1) Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.

1.06 QUALITY ASSURANCE

- A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.
- B. ICSC qualifications:
 - 1. General information on the proposing company:
 - a. Document that the ICSC company has been actively involved in the instrumentation, PLC-based control systems business for a minimum of five years and has adequate facilities, organization structure, manpower, and technical and managerial expertise to properly perform the Work as specified in these Specifications.
 - 2. Document that the ICSC has a qualified permanent service facility:
 - a. Said facility shall be staffed with permanent employees and equipped with the tools and test equipment necessary to calibrate, test, and process start-up all of the instrumentation, control, telemetry, SCADA and control systems hardware furnished under this Contract.
 - b. Document in-house resource of permanent personnel experienced in the design of equipment and systems as specified in these Specifications.
 - c. Document the existence of a training program staffed by qualified instructors, to provide proper training in the operation and maintenance of equipment as specified in these Specifications.
 - 3. Similar project experience of the company:
 - a. Provide a list of at least 3 successfully completed projects for a water and/or wastewater system of similar scope and complexity in which the proposing firm used components the same as those intended for use on this Project. The proposing firm must have performed, for each listed project, system engineering, system fabrication and installation, documentation (including schematic, wiring and panel assembly drawings), field testing, calibration and process start-up, operator instruction, and maintenance training. In addition, provide the following information for each project:
 - 1) Name of plant or system owner, contact name, and current telephone number. Design engineer's name, address, and telephone number. Failure to provide current contact information may result in the listed project being disqualified for use in meeting the minimum requirements for prequalification.
 - 2) Manufacturer and model number(s) of the PLC based control system.
 - 3) Brief description of the system.
 - 4) Approximate number of input and output signals: analog, digital, and fieldbus.
 - 5) Contracted cost of the system, separate by base amount and any change orders for the completed projects.
 - 6) Duration of the project and date of completion.
 - 4. Information on the proposed Project team members:
 - a. Provide the name and resume of the individual persons who will be responsible for each of the following:
 - 1) Office engineering and management of this Project.
 - 2) Individual who will be responsible for the hardware and hardware interface design.
 - 3) Individual who will be responsible for field testing, calibration, and process start-up.
 - 4) Individual who will be responsible for operator training.

- b. All of these individuals must be permanent employees of the proposing firm.
- 5. Determination of the proposed ICSC qualifications is at the sole discretion of the Engineer.
- C. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.
- D. The ICSC must have their own operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508/508A requirements.
- E. ICSC:
 - 1. Contractor, through the use of a qualified ICSC, is responsible for the implementation of the PCIS and the integration of the system with other required instrumentation, control devices, and software.
 - 2. The ICSC assumes full responsibility, through the Contractor, to perform all work to select, furnish, install, test, calibrate, and place into operation all instrumentation, controls, telemetry equipment, control panels, and control system, for a complete, integrated and functional PCIS system.
 - 3. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these Specifications that the ICSC be responsible for the integration of the PCIS with existing devices and devices provided under the Contract Documents with the objective of providing a completely integrated control system.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 01600 - Product Requirements.
- B. Special instructions:
 - 1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.
- C. Tagging:
 - 1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
 - 2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCS.
 - 3. Tag instruments immediately upon receipt in the field.
 - 4. Prominently display identification on the outside of the package.
 - 5. Utilize the Tag and Loop Number identifications shown on the P&IDs.
- D. Delivery and inspection:
 - 1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.08 PROJECT OR SITE CONDITIONS

- A. Site conditions:
 - 1. Provide all equipment, raceways, and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
 - 2. Seismic classification:
 - a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612 - Seismic Design Criteria.
 - 3. Wind:
 - a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01614 - Wind Design Criteria.
 - 4. Altitude, temperature and humidity:
 - a. As specified in Section 01610 - Project Design Criteria.
 - b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
 - c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
 - 1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
 - 5. Area classifications:
 - a. Furnish enclosures that match the area classifications as specified in Section 16050 - Common Work Results for Electrical.
 - 6. Site security:
 - a. Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01329 - Safety Plan.

1.09 SEQUENCING

- A. General:
 - 1. As specified in Sections 01312 - Project Meetings and 01756 - Commissioning.
 - 2. Testing requirements are specified in Sections 01756 - Commissioning, 17950 - Testing, Calibration, and Commissioning and other sections.
 - 3. General scheduling requirements are specified in Section 01324A - Progress Schedules and Reports - Large Projects.
 - 4. Work restrictions and other scheduling requirements are specified in Section 01140 - Work Restrictions.
 - 5. Commissioning requirements as specified in Section 01756 - Commissioning.
- B. Submit proposed ICSC statement of qualifications:
 - 1. The ICSC must be accepted by the Engineer and Owner before any other Work commences.

- C. Pre-submittal conferences:
 - 1. Before producing any submittals, schedule a pre-submittal conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.
 - 2. The Contractor, instrumentation and control subcontractor, electrical subcontractor, and all manufacturers furnishing major pieces of equipment must attend, including but not limited to:
 - a. Vendor control panels.
 - b. Motor control centers.
 - c. Variable frequency drives.
- D. Control logic meetings:
 - 1. Vendor Equipment Meetings: Facilitate a meeting with each equipment supplier (including HVAC) who is providing equipment with a PLC and/or LOI. Meeting discussion point will include the following at a minimum:
 - a. Tag Naming Conventions.
 - b. PLC to PLC global data mapping.
 - c. All PLCs to HMI tags mapping.
 - d. LOI screen colors and navigation.
 - e. Interlock and Permissive definitions.
 - f. Communication Methods.
 - g. Standard code blocks for common control functionality.
 - h. Alarms: Clearing, formats, colors, and status.
- E. Source testing:
 - 1. Before the delivery and installation of control panels, PLCs, control system equipment, and other PCS components at the job site, but after the procurement and assembly of components, perform Source Test.
 - 2. Schedule the Source Test after receiving approval of the Source Test procedures submittal.
 - 3. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
 - 4. Notify the Engineer of scheduled tests a minimum of 15 days before the date of the test.
- F. General Field Start-Up and testing procedures:
 - 1. As specified in Section 01756 - Commissioning.
- G. Installation testing:
 - 1. As specified in Section 01756 - Commissioning.
 - 2. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
 - 3. Acceptance of the PCIS Installation testing must be provided in writing by the Owner before the performance testing may begin.
- H. Training:
 - 1. As specified in Section 01756 - Commissioning.
- I. Functional testing:
 - 1. Representatives from each of the following groups shall be in attendance during the functional Testing: Owner, ICSC. Commence after acceptance of all

training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.

2. Loop validation test.
 3. As specified in Section 17950 - Testing, Calibration, and Commissioning.
 - a. Notify the Owner of scheduled tests a minimum of 21 days before the estimated completion date of installation and wiring of the PCIS.
 - b. Complete loop validation testing a minimum of 5 days before the pre-commissioning phase of the project.
 - c. Loop validation certifications:
 - 1) After the field device loop tests have been successfully completed as specified in Section 17950 - Testing, Calibration, and Commissioning for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, Vendor, and the Owner's representative with test data entered, together with a clear and unequivocal statement that all instrumentation, including all control and signal wiring, has been successfully calibrated, inspected, and tested.
 - a) Acceptance of the PCIS Installation Testing must be provided in writing by the Engineer before the Process Operational Period may begin.
 - d. The Owner will assist with Functional Testing for PLCs programmed by the Owner, as specified in Section 17950 - Testing, Calibration, and Commissioning.
 - e. The Owner shall not be required to supply application software, until the loop validation tests are complete for a PLC and all prerequisites for the Process Operational Period are completed.
- J. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before Process Operational Period commences, suitably wrapped, and identified.
- K. Process Operational Period:
 1. Upon completion of the Process Operational Period, conduct an Instrumentation and Controls Process Performance Test as a condition for Project final completion.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. Provide additional warranty as specified in the individual Instrumentation and Control Specifications that extends beyond the Correction Period, as specified in Documents 00700 - General Conditions and 00800 - Supplementary Conditions.

1.12 SYSTEM PROCESS START-UP

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:

1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE

- A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by the Contract Documents.
- C. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.
- D. Submit all special tools and spare parts, suitably wrapped and identified, before Process Operational Period commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.
- B. Allowable manufacturers are specified in individual instrument and equipment specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.

- B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.
- C. Signal transmission:
 - 1. Analog signals:
 - a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
 - b. Furnish electrical analog signals outside control panels that are 4 to 20 milliamperes 24 VDC, except as indicated.
 - c. Analog signals within enclosures may be 1 to 5 VDC.
 - d. Electrically or optically isolate all analog signals from other signals.
 - e. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
 - f. Maintain the total 4 to 20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
 - g. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
 - 2. Pneumatic signals:
 - a. All pneumatic signals: 3 to 15 pounds per square inch gauge.
 - 3. Discrete input signals:
 - a. As indicated in the controller hardware specification.
 - 4. Discrete output signals:
 - a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
 - b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
 - c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
 - d. Provide interposing relays as required for functionality of the control circuit.
 - 5. Signal performance and design criteria:
 - a. Stability:
 - 1) After Controls have taken corrective action, oscillation of the final control element shall not exceed 2 cycles per minute or a magnitude of motion of 0.5 percent of full travel.
 - b. Response:
 - 1) Any change in setpoint or controlled variable shall produce a corrective change in position of the final control element and stabilized within 30 seconds.
 - c. Agreement:
 - 1) Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
 - d. Repeatability:
 - 1) For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position the final element.
 - e. Sensitivity:
 - 1) Controls shall respond to a setpoint deviations and measured variable deviations within 1.0 percent of full scale.

f. Performance:

- 1) All instruments and control devices shall perform in accordance with the manufacturers' specifications.

D. Discrete circuit configuration:

1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
2. Alarm contacts: Fail to the alarm condition.
3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.

E. Grounding:

1. Provide control panels with a signal ground bus, isolated from the power ground bus:
 - a. Provide multiple panels in one location with a common point for signal ground bus connection to ground.
2. Ground single-point ground shields and measurement loops at the source panel external terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
3. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

2.07 ACCESSORIES

- A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.

B. Nameplates:

1. Provide a nameplate for each controller, instrument transducer, instrument power supply, solenoid, or any other control device located either in the field or within panels.
2. All nameplates shall be of identical style, color, and material throughout the facility.
3. Device nameplates shall include:
 - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
 - 1) Device tag and loop number ID (e.g., FIT-60.011).
 - 2) PLC ID (e.g., PLC-11).
 - 3) Power information (e.g., PCM-11, 120VAC).
 - b. White lettering on a black background, laminated plastic.
4. All instruments shall be equipped with Type 316 stainless steel nameplate with the instrument tag stamped in 3/8-inch letters and connected to the instrument using Type 316 stainless steel wire.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products that bear all approvals and labels as required by the Specifications.
- B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
 - 1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.
- C. Source Test is specified in Section 17950 - Testing, Calibration, and Commissioning.

PART 3 EXECUTION

3.01 EXAMINATION

- A. The ICSC is encouraged to attend a pre-bid conference and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.
- B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.
- C. Provide a complete instrumentation and control system:
 - 1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
 - 1. Verify all dimensions as indicated on the Drawings:
 - a. Actual field conditions govern all final installed locations, distances, and levels.
 - 2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
 - 3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
- B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.

- C. The PCIS configurations are diagrammatic:
 - 1. The locations of equipment are approximate unless dimensioned.
 - 2. Where Project conditions require, make reasonable changes in locations and arrangements.
- D. Field instruments installation:
 - 1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
 - 2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
 - a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
 - b. Provide sun shields for all field electronic instruments exposed to direct sunlight.
 - 3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
 - a. Type of flexible conduit required for the area classification:
 - 1) Area classification as specified in Section 16050 - Common Work Results for Electrical.
 - b. Maximum length of 18 inches.
 - 4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
 - a. Special cable applications shall be in accordance with the NEC.
 - 5. Verify the correctness of each installation:
 - a. Polarity of electric power and signal connections.
 - 6. Ensure all process connections are free of leaks.
- E. Process sensing lines and air tubing:
 - 1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
 - 2. Provide supports for rigid tubing at intervals of not more than 3 feet.
 - 3. Slope horizontal runs of instrument tubing at a minimum of 1/16-inch per foot to allow for draining of any condensate.
 - 4. Bends:
 - a. Use proper tool.
 - b. Make bends for parallel lines symmetrical.
 - c. Make bends without deforming or thinning the walls of the tubing.
 - 5. Square-cut and clean all ends of tubing before being inserted in the fittings.
 - 6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
 - 7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
 - a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.
- F. Conduit, cables, and field wiring:
 - 1. Provide all PCS equipment cables, and process LAN communication networks under the Instrumentation and Control Specifications.

2. Provide terminations and wire identification as specified in the Electrical Specifications.
 3. Protect all wiring from sharp edges and corners.
 4. Provide all conduits, fittings, boxes, etc. in accordance with all the requirements of the Electrical Specifications.
- G. Equipment tie-downs:
1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
 2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.
- H. Existing instrumentation:
1. Clean, recondition and re-calibrate each existing instrument to be reused, removed, or reinstalled using an authorized service facility of the instrument manufacturer.
 2. Provide certification of this Work before reinstallation of each instrument.
- I. Instrument tagging:
1. As specified in Section 16075 - Identification for Electrical Systems.
 2. Provide all field-mounted instruments with nameplates:
 - a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
 - 1) Affix tags with stainless steel wire fasteners.
 3. Provide all back of panel instruments with nameplates:
 - a. Engraved with the instrument's full tag number as indicated on the Drawings:
 4. Provide all front of panel instruments with a nameplate:
 - a. Engraving to include the following:
 - 1) Instrument's full tag number.
 - 2) Service description.
 - b. Nameplates:
 - 1) Secure nameplates to the panel with stainless steel screws.
 - 2) Use an accepted adhesive if screws would violate the NEMA or other ratings of the enclosure.
- J. Cable and conductor termination:
1. Terminate all cables and conductors on terminal blocks.
 2. Terminal block enclosures:
 - a. Suitable for the area classification as specified in Section 16050 - Common Work Results for Electrical.
- K. Surge protection:
1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments and the panel.
 2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.
 3. Provide voltage surge protection for 4 wire transmitters and analyzers:
 - a. Protect both power source and signal loop.

L. Scope and responsibilities:

1. Refer to the following table for procurement and installation scope and responsibilities for the owner, design engineer, contractor, and integrator.

Item No.	Task	Responsible Parties				Service or Equipment Supplied By
		Owner (O)	Design Engineer (DE)	Contractor (C)	Integrator (I)	
1.00	I&C Design Update					
1.01	Owner furnished equipment procurement.	L	A			O
1.02	Equipment and package system procurement.			L		C
1.03	Equipment and package system submittal preparation.			L		C
1.04	Equipment and package system submittal review.	A	L			DE/ O
1.05	Update I&C design to incorporate any changes, if changes approved by Owner during the submittal processes, for equipment and/or package systems.	A	L		A	DE
2.00	HMI Application Programming					
2.01	HMI software application programming.	L		A		O
2.02	Develop PLC/DCS interfaces to Vendor package systems (Vendor package system programmed by Vendor).	L		A		O
2.03	Digital field network interface and network configuration (ownership including calibration and setup).	L		A		O
2.04	HMI Graphical User Interface.	L		A		O
3.00	Vendor Package and Auxiliary System Application Programming					
3.01	Vendor Package PLC software application programming (procured by Contractor).	S		L		C
4.00	Integration					
4.01	Instrumentation specifications and procurement.			A	L	I

Item No.	Task	Responsible Parties				Service or Equipment Supplied By
		Owner (O)	Design Engineer (DE)	Contractor (C)	Integrator (I)	
4.02	Vendor supplied package and Auxiliary system coordination with plant PLC/DCS (communications, submittals, software development).	S		A	L	I
4.03	Vendor package systems and Auxiliary system interface demonstration at FAT, where required.	S		S	L	I
4.04	Control system equipment, Vendor package system, and Auxiliary system interface submittal review and preparation for formal Owner review.			S	L	I
4.05	I&C Design update to reflect approved vendor submittals (if required).		L	S	S	DE
5.00	Equipment and Panels					
5.01	PLC/DCS Process Control System					
5.02	PLC/DCS control panels and associated panel equipment procurement.			A	L	I
5.03	PLC/DCS panels and associated panel equipment fabrication.			A	L	I
5.04	PLC/DCS panels factory testing.	S	W	A	L	I
5.05	PLC/DCS installation.	W		A	L	I
5.06	PLC/DCS field testing OAT, SAT.	W	W	A	L	I
5.07	Operator Interface Stations (both in panel and desktop) related setup and configuration.	L		A	A	O
5.08	Field PLC/DCS interfaces (HMIs).	L		A		O
5.09	Communications					
5.10	Fiber patch panel procurement and installation.			A	L	I
5.11	Ethernet switch procurement and installation.			A	L	I
5.13	Uninterruptible power supply procurement and installation.			A	L	I

Item No.	Task	Responsible Parties				Service or Equipment Supplied By
		Owner (O)	Design Engineer (DE)	Contractor (C)	Integrator (I)	
5.14	Field Local Control Panels (LCPs)					
5.15	LCP procurement and fabrication.			A	L	I
5.16	LCP installation.			L	A	I
6.00	Instruments and Control Valves					
6.01	Submittal & Datasheets.			A	L	I
6.02	Procurement.			A	L	I
6.03	Installation.			A	L	I
6.04	Setup and/or Calibration.			A	L	I
7.00	Electrical and Mechanical for Process Control System					
7.01	Building electrical provision and installation - cable / conduit / wire.			L	A	C
7.02	Building mechanical provision and install - including process instruments related tubing			L	A	C
7.03	Building wiring racks and supports (cable and/or conduit) - coordinated w/DIV 16 power contractor where applicable.			L	A	C
7.04	Building internal Fiber Optic backbone conduit installation (from building entrance / duct bank).			L	A	C
7.05	Building internal communication wiring - DeviceNet, Modbus, Ethernet, etc. from PLC/DCS and/or patch panel.			L	A	C
7.06	Electrical and mechanical installation inspection.	W	A	L	A	C
7.07	Vendor Package - On/Off Skid related electrical controls installation.			L	A	C

Item No.	Task	Responsible Parties				Service or Equipment Supplied By
		Owner (O)	Design Engineer (DE)	Contractor (C)	Integrator (I)	
7.08	Vendor Package - On/Off Skid related mechanical controls installation.			L	A	C
7.09	Vendor Package Electrical and Mechanical installation inspection.	W	A	L	A	C
7.10	Site Fiber Optic backbone cable installation, termination, and certification testing.			A	L	I
7.11	Network testing.	W	A	A	L	I
8.00	Process Start-up					
8.01	Pre-operation and component test.	W	A	A	L	I
8.02	Loop checkout.	W	A	A	L	I
8.03	System Acceptance Test (SAT).	W	A	A	L	I
8.04	Operational Testing.	W	A	A	L	I
8.05	Commissioning Testing.	L	A	A	A	O
9.00	Process Closeout					
9.01	Redline Drawings and/or Electronic files submit to Owner.			A	L	I
9.02	As-builts (record set) - Update All Drawings.			A	L	I
9.03	Operation and Maintenance Manuals.			A	L	I
9.04	Operational Testing and Commissioning Sign Off Forms.	W	W	A	L	I
9.05	Training.	W		A	L	I
9.06	Commissioning (process performance testing).	L	A	A	A	O
Key: L – Lead, A – Assist, S – Support, W – Witness						

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. As specified in Section 01756 - Commissioning.
- B. Owner Training:
 - 1. Demonstration requirements are specified in Section 17950 - Testing, Calibration, and Commissioning.
 - 2. General:
 - a. Provide system maintenance and operator training courses for all the instrumentation and control systems furnished.
 - b. Provide system maintenance and operator training courses for all the instrumentation and control equipment and systems furnished, as described below.
 - 1) All training described below shall be provided by the Contractor.
 - c. Conduct all training at the Project Site unless another location is accepted by the Engineer and Owner:
 - 1) Include instruction on the use of all maintenance equipment and special tools provided under the Contract.
 - d. Tailor training classes to the specific needs of the class participants:
 - 1) Develop separate courses for operators, maintenance staff, and supervisors:
 - a) The specific categories and number of personnel in each category are identified below.
 - 2) Furnish training courses that are a combination of classroom and hands-on training:
 - a) To the greatest extent possible, utilize components from the Owner's PCS system.
 - b) Limit classes that include extensive hands-on activities to a maximum of 5 students per class.
 - 3) Present the minimum number of sessions, specified in Table 1, for each course in order to satisfy class size restrictions and limitations scheduling Owner staff.
 - 4) Furnish additional sessions if required to accommodate the total number of personnel identified for each course.
 - e. Schedule individual training classes:
 - 1) Coordinate with the Owner at least 3 weeks before the start of the class:
 - 2) Schedule training classes Monday - Thursday.
 - 3) Each individual daily training session, travel time excluded:
 - a) Minimum duration of 4 hours.
 - b) Maximum duration of 7 hours.
 - c) Breaks scheduled at least every 90 minutes and 1 hour for lunch.
 - 4) Complete training for maintenance personnel 90 days before Process Operational Period.
 - 5) Complete operator training classes before process start-up of the control system software, or any part of it:
 - a) As specified in the Sequencing article of this Section.
 - 6) Schedule follow-up training classes after the PCS start-up on a schedule determined by the Owner.

- f. Instructor qualifications:
 - 1) Highly qualified training instructors for technical training with demonstrated expertise in not only control system functionality but also professional training techniques:
 - a) Instructor qualifications are subject to the approval of the Engineer.
 - 2) Furnish training instructors thoroughly familiar with the PCIS system, who are members of the implementation team.
3. Training manuals and materials:
 - a. Furnish training manuals and other materials for training courses.
 - b. Manuals are to be professionally written to present the course material in a format that is easy to comprehend.
 - c. The manuals are to serve as teaching aids during presentation of the training classes.
 - d. Manuals are to serve as reference material after the training has been completed.

Table 1			
Course Title	Minimum Course Length (hours per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	4	5	1
Instrument Training	8	3	1
Analytical Instrument Training	8	3	3

4. Training course requirements:
 - a. System overview training:
 - 1) Furnish training courses that give the Owner's supervisory level personnel an overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
 - b. Instrumentation training:
 - 1) Furnish training covering all instruments and control panels.
 - 2) Furnish the specified quantity of training, allocated to cover new instruments and hardwired controls as specified in this Section and specifically determined in the accepted training plan.
 - 3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the instruments furnished within this Project.
 - 4) Furnish training on the operation of new hardwired controls.
 - c. Analytical instrument training:
 - 1) Furnish training covering all analytical instruments.
 - 2) Furnish the specified quantity of training, allocated to cover new analytical instruments as specified in this Section and specifically determined in the accepted training plan.
 - 3) Train maintenance staff in the use, cleaning, calibration, maintenance, and troubleshooting of all the analytical instruments furnished within this Project.
 - 4) Provide training by manufacturer.

5. Recording training sessions:
 - a. Record all training.
 - b. Produce audio-visual presentations by recording the actual training sessions of the Owner's personnel.
 - c. Furnish digital video disk (DVD) format.
 - d. These disks become the property of the Owner and cover, in detail, the training for the specific hardware and software of all the systems provided for the Project.
6. Provide all the necessary cameras and recording equipment.

3.08 FIELD QUALITY CONTROL

- A. Inspection:
 1. Allow for inspection of PCIS installation as specified in Section 01450 - Quality Control.
 2. Provide any assistance necessary to support inspection activities.
 3. Engineer inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect installation for compliance with Drawings and Specifications.
 - c. Inspect installation for obstructions and adequate clearances around equipment.
 - d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - e. Inspect equipment nameplate data to verify compliance with design requirements.
 - f. Inspect cable terminations.
 - g. Inspect/witness instrument calibrations/verifications.
 4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Testing, Calibration, and Commissioning.
- B. Instrument Installation Inspection:
 1. Provide any assistance necessary to support inspection activities.
 2. Inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect the installed arrangement, lay lengths, orientation, piping obstructions, etc., that could affect the instruments accuracy or repeatability.
 - c. Inspect installation for compliance with Drawings and Specifications.
 - d. Inspect installation for obstructions and adequate clearances around equipment.
 - e. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - f. Inspect equipment nameplate data to verify compliance with design requirements.
 - g. Inspect cable terminations.
 - h. Inspect/witness instrument calibrations/verifications.
 3. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950 - Testing, Calibration, and Commissioning.
 4. Field acceptance testing: (Functional Testing) is specified in Section 17950 - Testing, Calibration, and Commissioning. Additional general requirements are specified in Section 01756 - Commissioning.

- C. Installation supervision:
 - 1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
 - a. Installation resources:
 - 1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
 - b. Provide technical assistance to installation personnel by telephone:
 - 1) Furnish installation personnel with at least 1 copy of the accepted submittals, including all installation details.
 - c. Periodic inspections during the construction period.
 - d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
 - e. Field verify accuracy and calibration of all instruments.

3.09 ADJUSTING

- A. Control valves:
 - 1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
 - 2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.

3.10 CLEANING

- A. As specified in Section 01770 - Closeout Procedures.
- B. Vacuum clean all control panels and enclosures before process start-up and again after final completion of the project.
- C. Clean all panel surfaces.
- D. Return to new condition any scratches and/or defects.
- E. Wipe all instrument faces and enclosures clean.
- F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
 - 1. Neatly coil and label all spare wiring lengths.
 - 2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.
- G. As specified in other sections of the Contract Documents.

3.11 PROTECTION

- A. Protect all Work from damage or degradation until date of Substantial Completion.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17206

LEVEL MEASUREMENT: ULTRASONIC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Ultrasonic level instruments.
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

- D. Manufacture instruments facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Ultrasonic level sensor with 4-wire remote transmitter:
 - a. Endress+Hauser, Prosonic S FDU Series Sensor with FMU Series Transmitter.
 - b. Siemens, Echomax Series sensor with HydroRanger 200 Series Transmitter.
 - c. Pulsar, dB Series Sensor with Ultra 3 transmitter.

2.02 MANUFACTURED UNITS

- A. Ultrasonic level measurement with 4-wire remote transmitter:
 - 1. General:
 - a. Continuous non-contact level measurement device with remote transmitter using ultrasonic echo sensing. The transducer generates an ultrasonic pulse in the range of 12 to 50 kHz and measures the time required for the pulse to travel to the process surface and return. The distance is calculated from the send and receive times. Each 4-wire level transmitter system includes, but is not limited to:
 - 1) Ultrasonic transducer.
 - 2) Signal cable.

- 3) Transmitter.
2. Performance requirements:
 - a. Accuracy:
 - 1) 0.25 percent of range.
 - b. Repeatability:
 - 1) 0.1 percent of range.
3. Ultrasonic transducer:
 - a. Encapsulated in chemical- and corrosion-resistant material as indicated on the Instrument Data Sheet or Instrument Index.
 - b. Class 1 Division 1
 - c. Operating temperature range: -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius).
 - d. Operating relative humidity range: 5 to 95 percent.
 - e. Functions:
 - 1) Temperature compensation.
 - f. Mounting: As indicated in the Contract Documents.
 - g. Sensors shall be rated for NEMA 6P submergence. Sensors shall have mechanical decoupling between sensor membrane and outer housing. Sensors shall be provided with automatic build up compensation to provide self-cleaning when condensation may occur. Sensors shall be provided with internal heating elements and separate power supplies for these elements when freezing condensation may occur.
4. Transmitter:
 - a. Level-indicating transmitter:
 - 1) Indicator: Liquid crystal display with approximately 0.50-inch display scaled to read in engineering units.
 - 2) Sensitivity: Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
 - 3) Ability to allow for signal profiles and echo mapping:
 - a) Provide manufacturer's software for re-mapping the signal.
 - b. Functions:
 - 1) Level measurement.
 - 2) Tank volume.
 - 3) Flow measurement.
 - c. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 36 VA maximum.
 - d. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC.
 - 2) Relay outputs:
 - a) Minimum 3 Form A or Form C contacts.
 - b) Rated 4 amps at 250 VAC.
 - c) Programmable.
 - 3) Enclosure: NEMA Type 4X.
 - 4) Mounting: As indicated in the Contract Documents.
 - 5) Operating temperature range from -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius); relative humidity of 10 to 100 percent.
 - 6) Power supply shall be 120 VAC.
 - 7) The transmitter shall have automatic volume calculation for horizontal or vertical tanks with 32 point linearization; pre-programmed linearization tables for flumes and weirs; back water detection for

- submerged flow conditions; sludge detection; synchronization of pulses between two ultrasonic units used in same tank; automatic sensor detection; alternating pump control; rake/screen control.
- 8) There shall be at least 3 integral totalizers and 3 daily counters with the ability for simultaneous measurement of level and flow in storm water overflow basin with only 1 sensor; EE prom memory backup; temperature compensation; average, difference and sum calculations.

2.03 ACCESSORIES

- A. Mounting brackets: As indicated on the Drawings.
- B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. As specified in Section 17950 - Testing, Calibration, and Commissioning.

- B. Turn on turbulent surface software feature for all installations measuring surfaces lacking a placid surface. This would include but not be limited to level measurements in mixed media filters and potentially wet wells.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be as indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ULTRASONIC LEVEL INSTRUMENTS					
							Spec. No.	Rev.
			No	By	Date	Revision	17206	
							Contract	Date
							Req.	P.O.
							By	Chk
G	1	Instrument Tag Number	LE/LIT-21.112	LE/LIT-21.122	LE/LIT-21.132			
	2	Service	GRIT EFFLUENT CHANNEL	GRIT EFFLUENT CHANNEL	GRIT EFFLUENT CHANNEL			
	3	P&ID	PI21-01	PI21-02	PI21-03			
	4	Other						
P R O B E	5	Type	Ultrasonic	Ultrasonic	Ultrasonic			
	6	Housing Material						
	7	Measurement Range	0-25 FT	0-25 FT	0-25 FT			
	8	Op. Temp. Range						
	9	Manufacturer						
	10	Model						
	11	Model Number						
C A B L E	12	Style	Mfg. Recommended	Mfg. Recommended	Mfg. Recommended			
	13	Length						
	14	Other						
	15	Other						
	16	Other						
T R A N S M I T T E R	17	Type						
	18	Operating Mode						
	19	Enclosure	NEMA 4X	NEMA 4X	NEMA 4X			
	20	Mounting	REMOTE	REMOTE	REMOTE			
	21	Temperature Range						
	22	Voltage Requirements	115 VAC, 60 Hz	115 VAC, 60 Hz	115 VAC, 60 Hz			
	23	Power						
	24	Accuracy						
	25	Display	YES	YES	YES			
	26	Output	4-20 mA	4-20 mA	4-20 mA			
	27	Calibration						
	28	Status Relay						
	29	Manufacturer						
	30	Model No.						
	31	Elect. Entry						
	32	Other						
O P T S	33							
	34							
	35							
	36							
Notes: LE/LIT-21.132 IS INCLUDED UNDER ADDITIVE BID ITEM NO. 3.								

SECTION 17301

FLOW MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Thermal dispersion flow switches.
- B. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Thermal dispersion type:
 - a. Fluid Components International LLC, FLT93.
 - b. Kayden.

2.02 MANUFACTURED UNITS

- A. Thermal dispersion type:
 - 1. General:
 - a. Instrument uses a heated probe and a reference probe.
 - 1) Deviation in the amount of heat measured by the reference probe deviates beyond the setpoint an adjustable relay closes.
 - 2) Switch:
 - a) Micro-processor based with continuous self-diagnostics, "Smart Heater" to prevent sensor failure, no mechanical jumpers or trim pots, and a 3-year warranty.
 - 2. Performance requirements:
 - a. Accuracy: Within 2 degrees Fahrenheit.
 - b. Repeatability: Within 1 percent of setpoint range.
 - c. Response time: 0.5 to 2.5 seconds.
 - d. Adjustable Bypass Delay Timer.
 - e. Adjustable range.
 - 3. Switch characteristics:
 - a. Exposed parts: Powder coated aluminum housing.

- b. Wetted parts:
 - 1) Materials as recommended by the manufacturer and approved by the Engineer.
- c. Power supply:
 - 1) 115 VAC.
 - 2) Power consumption: 13 VA maximum.
- d. Operating temperature range: -40 degrees Fahrenheit to 140 degrees Fahrenheit.
- e. Enclosure:
 - 1) NEMA Type 4X
- f. Approvals:
 - 1) FM Class 1 Division 2.

2.03 ACCESSORIES

- A. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. As specified in Section 17950 - Testing, Calibration, and Commissioning.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 17306

FLOW MEASUREMENT: ULTRASONIC DOPPLER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Ultrasonic Doppler flow meters.
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 01330 – Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Ultrasonic strap-on:
 - a. Siemens SITRANS FUS1010.
 - b. Polysonics.
 - c. TN Technologies.

2.02 MANUFACTURED UNITS

- A. Ultrasonic Doppler: strap-on:
 - 1. General:
 - a. Ultrasonic Doppler system shall consist of strap-on sensor to produce 4 to 20 milliamperes DC signal that is directly proportional to the liquid flow rate.
 - b. Ultrasonic Doppler system shall also provide programmable relay outputs for pump control, fault indication power down alarming or remote totalizer driving.
 - c. Each ultrasonic Doppler system shall include:
 - 1) Clamp-on sensor.
 - 2) Signal cable.
 - 3) Remote mount transmitter.
 - 4) Sensor compound kit and sensor mounting clamps.
 - 2. Performance requirements:
 - a. Accuracy:
 - 1) 1 percent of flow rate.

- b. Repeatability:
 - 1) 0.25 percent of full-scale.
 - 3. Element:
 - a. 2 encapsulated single or dual-frequency sensor heads suitable for submersible/underground service.
 - b. Type 316 stainless steel mounting clamp assembly.
 - 4. Transmitter:
 - a. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 60 VA maximum.
 - b. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC.
 - 2) Relay outputs:
 - a) 2 Form C contact.
 - c. Microprocessor-based signal converter/transmitter.
 - d. Type 316 stainless steel or flame retardant fiberglass-reinforced polyester NEMA Type 4X (IP65) enclosure.
 - e. Operator interface consisting of keypads that respond to English text entry.
 - f. Ambient operating temperature limits of -29 to 60 degrees Celsius (-20 to 140 degrees Fahrenheit)

2.03 ACCESSORIES

- A. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.05 ADJUSTING

- A. As specified in Section 17950 - Testing, Calibration, and Commissioning.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers				ULTRASONIC DOPPLER FLOWMETERS											
Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:				No		By		Date		Revision		Spec. No.		Rev.	
												17306			
												Contract		Date	
												Req.		P.O.	
										By		Chk		App	
1	Instrument Tag No.			FE/FIT-21.215				FE/FIT-21.235				FE/FIT-21.255			
2	Service			GRIT PUMPS DISCHARGE				GRIT PUMPS DISCHARGE				GRIT PUMPS DISCHARGE			
3	P&ID			PI21-04				PI21-05				PI21-06			
4	C	Line Size / Schedule		4"				4"				4"			
5	O	Line Material													
6	N	Line Thickness													
7	N	Connection Type													
8	S	Type		Spool Piece: Strap-On: X				Spool Piece: Strap-On: X				Spool Piece: Strap-On: X			
9	E	Sensor Material													
10	N	Number of Sensors													
11	S	Enclosure Class		NEMA 4X				NEMA 4X				NEMA 4X			
12	O	Retract Mechanism													
13	R	Other													
14	N	Other													
15	T	Fluid		GRIT				GRIT				GRIT			
16	F	Max Flow Units		400 GPM				400 GPM				400 GPM			
17	L	Max Velocity Units													
18	U	Norm Flow	Min Flow	0	300 GPM		300 GPM		300 GPM		300 GPM		300 GPM		
19	I	Max Temp	Min Temp	0	90 DEG. F		90 DEG. F		90 DEG. F		90 DEG. F		90 DEG. F		
20	D	Max Press	Min Press												
21		Other													
22		Other													
23	T	Function													
24	R	Mounting		REMOTE				REMOTE				REMOTE			
25	A	Enclosure Class		NEMA 4X				NEMA 4X				NEMA 4X			
26	N	Length Signal Cable													
27	S	Type Span Adjustment		Mfr. Std.				Mfr. Std.				Mfr. Std.			
28	M	Power Supply		115VAC, 60Hz				115VAC, 60Hz				115VAC, 60Hz			
29	I	Transmitter Output		4-20mA				4-20mA				4-20mA			
30	T	Calibrated Range		0-400 GPM				0-400 GPM				0-400 GPM			
31	T	Accuracy		1.0% OF FLOW				1.0% OF FLOW				1.0% OF FLOW			
32	E	Other													
33	R	Display Scale Size	Range	16 Char. LCD	Adjustable	16 Char. LCD	Adjustable	16 Char. LCD	Adjustable	16 Char. LCD	Adjustable	16 Char. LCD	Adjustable		
34		Alarm Contact No.	Form	Mfr. Std.	Mfr. Std.	Mfr. Std.	Mfr. Std.	Mfr. Std.	Mfr. Std.	Mfr. Std.	Mfr. Std.	Mfr. Std.			
35		Manufacturer													
36		Model No.													
Notes: FE/FIT-21.255 IS INCLUDED UNDER ADDITIVE BID ITEM NO. 3.															

SECTION 17316

FLOW MEASUREMENT: ROTAMETERS (VARIABLE AREA FLOWMETERS)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Rotameters (variable area flowmeters).
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.05 QUALITY ASSURANCE

- A. As specified in Section 01330 – Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. ABB.
 - 2. Brooks.
 - 3. King Instrument Co.

2.02 MANUFACTURED UNITS

- A. Rotameters:
 - 1. General:
 - a. Variable area type flowmeters with local flow indication.
 - b. Glass tube type.
 - c. Metal tube type:
 - 1) For applications above 100 pounds per square inch gauge, with hazardous fluids, or with opaque liquids, provide a metal meter tube.
 - 2. Performance requirements:
 - a. Flow range:
 - 1) As specified in instrument data sheets or instrument index.
 - b. Accuracy:
 - 1) Glass tube: Within 2.0 percent of range.
 - 2) Metal tube: Within 5.0 percent of range.
 - 3) Repeatability: 0.50 percent of range.
 - 3. Element:
 - a. Flow tube:
 - 1) Glass tube: Borosilicate glass, or as required to be compatible with the process conditions.
 - b. Metal tube with magnetic follower: Type 316 stainless steel.
 - c. Turndown: 10 to 1.
 - d. Process temperature:
 - 1) Glass tube: 32 to 200 degrees Fahrenheit.
 - 2) Metal tube: -20 to 320 degrees Fahrenheit.
 - e. Maximum process pressure:
 - 1) Glass tube: 100 pounds per square inch gauge.
 - 2) Metal tube: 450 pounds per square inch gauge.

- 3) Size tube for the largest of the following:
 - a) 2.0 times the normal flow rate.
 - b) 1.2 times the maximum flow rate.
 - c) 4.0 times the minimum flow rate.
 - f. Float:
 - 1) Design to provide the widest possible immunity band change in viscosity.
 - 2) Metal tube rotameters: Float with encapsulated magnet.
- 4. Components:
 - a. Seals: O-rings or packing glands fully compatible with process fluid.
 - b. Integral needle valve for flow control.
- 5. Scale:
 - a. Metal tube: Dial indicator with rotatable magnet coupled to magnet encapsulated in rotameter float.
- 6. Other:
 - a. Process connection:
 - 1) As indicated on the Mechanical Drawings.
 - b. Mounting:
 - 1) As indicated on the Drawings.
 - 2) Provide all necessary hardware for rotameter mounting.

2.03 ACCESSORIES (NOT USED)

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers				VARIABLE AREA FLOWMETERS (ROTAMETERS)									
Contractor: Project: Project 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: SVWRF Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:				No		By		Date		Revision			
												17316	
												Contract	
												Req.	
												P.O.	
								By		Chk			
										App			

G E N E R A L	1	Instrument Tag Number		FI-21.118		FI-21.128		FI-21.138	
	2	Service		UTILITY WATER		UTILITY WATER		UTILITY WATER	
	3	P&ID		PI21-01		PI21-02		PI21-03	
	4	Function		Local indicator		Local indicator		Local indicator	
	5	Mounting		Line		Line		Line	
	6	Power Supply		N/A		N/A		N/A	
	7	Conn. Size	Type						
	8	Inlet Dir.	Outlet Dir.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
	9	Fitting Material							
	10	Packing or O-ring Mat'l.							
	11	Enclosure Type		N/A					
M E T E R F A C T O R S	12	Size	Float Guide	1"		1"		1"	
	13	Tube Mat'l.	Float Mat'l.	Metal	Mfr. Std.	Metal	Mfr. Std.	Metal	Mfr. Std.
	14	Meter Scale: Lgth. & Type							
	15	Meter Scale Range		0-50 GPM		0-50 GPM		0-50 GPM	
	16	Meter Factor							
	17	Rated Accuracy							
	18	Hyd. Calib. Required							
	19	Fluid							
	20	Color or Transparency							
	21	Max. Flow Rate		50 GPM		50 GPM		50 GPM	
	22	Norm Flow	Min Flow						
D I S T R I B U T I O N	23	Oper. Sp. Gr. (Liq.)							
	24	Max. Oper. Viscosity							
	25	Oper. Press.	Oper. Temp.						
	26	Oper. Density (Gas)							
	27	Std. Dens.	Mol. Wgt.						
	28	Max. Allow. Press. Drop							
	29	Other							
	30	Extension Well Mat'l.		N/A		N/A		N/A	
	31	Gasket Mat'l.		N/A		N/A		N/A	
	32	Other		N/A		N/A		N/A	
	X M T R A C T I O N	33	Xmtr Output		N/A		N/A		N/A
34		Xmtr Enclosure Class		N/A		N/A		N/A	
35		Scale Range		N/A		N/A		N/A	
36		Other		N/A		N/A		N/A	
37		# Contacts	Form	N/A	N/A	N/A	N/A	N/A	N/A
38		Rating	Housing	N/A	N/A	N/A	N/A	N/A	N/A
39		Action		N/A		N/A		N/A	
40		Other		N/A		N/A		N/A	
41		Valve Size & Material		N/A		N/A		N/A	
42		Valve Location		N/A		N/A		N/A	
43		Cnst. Diff. Relay Mat'l.		N/A		N/A		N/A	
S P E C I F I C A T I O N	44	Purge Meter Tubing		N/A		N/A		N/A	
	45	Airset		N/A		N/A		N/A	
	46	Other		N/A		N/A		N/A	

47	Manufacturer			
48	Model Number			
49	Tube Number			
50	Float Number			
Notes: FI-21.138 IS INCLUDED UNDER ADDITIVE BID ITEM NO. 3				

A/E: Carollo Engineers				VARIABLE AREA FLOWMETERS (ROTAMETERS)											
Contractor: Project: Project 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: SVWRF Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:				No		By		Date		Revision		Spec. No.		Rev.	
												17316			
												Contract		Date	
												Req.		P.O.	
										By		Chk		App	

G E N E R A L	1	Instrument Tag Number		FI-21.217		FI-21.227		FI-21.237		FI-21.247	
	2	Service		SEAL WATER		SEAL WATER		SEAL WATER		SEAL WATER	
	3	P&ID		PI21-04		PI21-04		PI21-05		PI21-05	
	4	Function		Local indicator		Local indicator		Local indicator		Local indicator	
	5	Mounting		Line		Line		Line		Line	
	6	Power Supply		N/A		N/A		N/A		N/A	
	7	Conn. Size	Type								
	8	Inlet Dir.	Outlet Dir.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.	Vert.
	9	Fitting Material									
	10	Packing or O-ring Mat'l.									
	11	Enclosure Type		N/A				N/A		N/A	
M E T E R F L U I D D I A G N O S T I C S	12	Size	Float Guide	½"		½"		½"		½"	
	13	Tube Mat'l.	Float Mat'l.	Metal	Mfr. Std.	Metal	Mfr. Std.	Metal	Mfr. Std.	Metal	Mfr. Std.
	14	Meter Scale: Lgth. & Type									
	15	Meter Scale Range		0-10 GPM		0-10 GPM		0-10 GPM		0-10 GPM	
	16	Meter Factor									
	17	Rated Accuracy									
	18	Hyd. Calib. Required									
	19	Fluid									
	20	Color or Transparency									
	21	Max. Flow Rate		10 GPM		10 GPM		10 GPM		10 GPM	
	22	Norm Flow	Min Flow								
D I A G N O S T I C S	23	Oper. Sp. Gr. (Liq.)									
	24	Max. Oper. Viscosity									
	25	Oper. Press.	Oper. Temp.								
	26	Oper. Density (Gas)									
	27	Std. Dens.	Mol. Wgt.								
	28	Max. Allow. Press. Drop									
	29	Other									
	30	Extension Well Mat'l.		N/A		N/A		N/A		N/A	
	31	Gasket Mat'l.		N/A		N/A		N/A		N/A	
	32	Other		N/A		N/A		N/A		N/A	
	X M T R A C T I O N S	33	Xmtr Output		N/A		N/A		N/A		N/A
34		Xmtr Enclosure Class		N/A		N/A		N/A		N/A	
35		Scale Range		N/A		N/A		N/A		N/A	
36		Other		N/A		N/A		N/A		N/A	
37		# Contacts	Form	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
38		Rating	Housing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
39		Action		N/A		N/A		N/A		N/A	
40		Other		N/A		N/A		N/A		N/A	
41		Valve Size & Material		N/A		N/A		N/A		N/A	
42		Valve Location		N/A		N/A		N/A		N/A	
43		Cnst. Diff. Relay Mat'l.		N/A		N/A		N/A		N/A	
S	44	Purge Meter Tubing		N/A		N/A		N/A		N/A	
	45	Airset		N/A		N/A		N/A		N/A	
	46	Other		N/A		N/A		N/A		N/A	

47	Manufacturer				
48	Model Number				
49	Tube Number				
50	Float Number				
Notes:					

A/E: Carollo Engineers Contractor: Project: Project 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: SVWRF Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:			VARIABLE AREA FLOWMETERS (ROTAMETERS)							
							Spec. No.		Rev.	
			No	By	Date	Revision	17316			
							Contract		Date	
							Req.		P.O.	
							By	Chk	App	
GENERAL	1	Instrument Tag Number		FI-21.257			FI-21.267			
	2	Service		SEAL WATER			SEAL WATER			
	3	P&ID		PI21-06			PI21-06			
	4	Function		Local indicator			Local indicator			
	5	Mounting		Line			Line			
	6	Power Supply		N/A			N/A			
	7	Conn. Size	Type							
	8	Inlet Dir.	Outlet Dir.	Vert.	Vert.	Vert.	Vert.			
	9	Fitting Material								
	10	Packing or O-ring Mat'l.								
	11	Enclosure Type		N/A						
METER	12	Size	Float Guide	½"		½"				
	13	Tube Mat'l.	Float Mat'l.	Metal	Mfr. Std.	Metal	Mfr. Std.			
	14	Meter Scale: Lgth. & Type								
	15	Meter Scale Range		0-10 GPM			0-10 GPM			
	16	Meter Factor								
	17	Rated Accuracy								
	18	Hyd. Calib. Required								
	19	Fluid								
	20	Color or Transparency								
	21	Max. Flow Rate		10 GPM			10 GPM			
	22	Norm Flow	Min Flow							
DETAILS	23	Oper. Sp. Gr. (Liq.)								
	24	Max. Oper. Viscosity								
	25	Oper. Press.	Oper. Temp.							
	26	Oper. Density (Gas)								
	27	Std. Dens.	Mol. Wgt.							
	28	Max. Allow. Press. Drop								
	29	Other								
	30	Extension Well Mat'l.		N/A			N/A			
	31	Gasket Mat'l.		N/A			N/A			
	32	Other		N/A			N/A			
	MOUNTING	33	Xmtr Output		N/A			N/A		
34		Xmtr Enclosure Class		N/A			N/A			
35		Scale Range		N/A			N/A			
36		Other		N/A			N/A			
37		# Contacts	Form	N/A	N/A	N/A	N/A			
38		Rating	Housing	N/A	N/A	N/A	N/A			
39		Action		N/A			N/A			
40		Other		N/A			N/A			
41		Valve Size & Material		N/A			N/A			
42		Valve Location		N/A			N/A			
43		Cnst. Diff. Relay Mat'l.		N/A			N/A			
PURGE	44	Purge Meter Tubing		N/A			N/A			
	45	Airset		N/A			N/A			
	46	Other		N/A			N/A			

47	Manufacturer		
48	Model Number		
49	Tube Number		
50	Float Number		
Notes: FI-21.257 AND FI-21.267 ARE INCLUDED UNDER ADDITIVE BID ITEM NO. 3			

SECTION 17401

PRESSURE/VACUUM MEASUREMENT: DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Diaphragm seals.
- B. Provide all seals identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
 - 1. Product data:
 - a. Manufacturer's installation instructions.
 - b. Seal type.
 - c. Body materials.
 - d. Diaphragm material.
 - e. Fill fluid type.
 - f. Seal size.
 - g. Options.
 - h. Process connection.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify the compatibility with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.

- c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Diaphragm seals:
 - 1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
 - a. Ashcroft:
 - 1) Flushing connection: Type 741.
 - 2) Without flushing connection: Type 740.
 - b. Mansfield and Green:
 - 1) Flushing connection: Type SGT.
 - 2) Without flushing connection: Type SBT.
 - c. Wika, Type L990.40.
 - d. Emerson, Rosemount.
 - 2. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
 - a. Ashcroft:
 - 1) Flushing connection: Type 201.
 - 2) Without flushing connection: Type 200.
 - 3) Saddle mount: Type 205.
 - b. Mansfield and Green:
 - 1) Flushing connection: Type SG.
 - 2) Without flushing connection: Type SB.

- 3) Saddle mount: Type SJ.
- c. Wika:
 - 1) Type L990.10.
 - 2) Saddle mount: L910.ZA.

2.02 MANUFACTURED UNITS

- A. Diaphragm seals:
 - 1. General:
 - a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
 - 2. Requirements:
 - a. Seal type:
 - 1) Metallic diaphragm: Welded to upper housing.
 - 2) Elastomer diaphragm: Bonded to upper housing.
 - b. Process connection: 1 inch NPT or Saddle flange, as indicated on the Drawings.
 - c. Instrument connection: 1/2 inch NPT.
 - d. Material Construction: Type 316 Stainless Steel
 - e. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
 - f. Flush port plug: Same material of construction as diaphragm lower housing.
 - g. Provide fill/bleed connection.
 - h. Mounting: As indicated in the Contract Documents.
 - i. Provide Type 316 stainless steel armored capillary for all remote installations.
 - j. Nuts and bolts: Type 316 stainless steel.
 - k. Materials of construction:
 - 1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
 - a) Diaphragm: Type 316 stainless steel.
 - b) Lower housing: Type 316 stainless steel.
 - c) Upper housing: Type 316 stainless steel.
 - d) Fill fluid: Silicon oil.
 - 2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
 - a) Diaphragm: Type 316 stainless steel.
 - b) Lower housing: Type 316 stainless steel.
 - c) Upper housing: Type 316 stainless steel.
 - d) Fill fluid: Silicon oil.
 - 3) Engineer's approval.

2.03 ACCESSORIES(NOT USED)

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation System.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
- C. Do not use Teflon thread seal tape on pressure instruments with silicon oil fill fluid.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING (NOT USED)

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17402

PRESSURE/VACUUM MEASUREMENT: INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Valve manifolds and instrument valves.
- B. Provide all valves identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
 - 1. Product data:
 - a. Valve type.
 - b. Body material.
 - c. Size.
 - d. Options.
 - 2. Shop drawings:
 - a. Mounting details for all manifold valves.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the valves are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the valve manufacturer's recommendations or specifications.
- D. Provide valves manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide valves suitable for the installed site conditions including, but not limited to, material compatibility, process, and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Valve manifold:
 - 1. One of the following or equal:
 - a. Anderson Greenwood.
 - b. Hex Valve.
 - c. Noshok.
 - d. Emerson, Rosemount.
- B. Block and bleed valve:
 - 1. One of the following or equal:
 - a. Anderson Greenwood.
 - b. Hex Valve.

- C. Gauge valve:
 - 1. One of the following or equal:
 - a. Anderson Greenwood.
 - b. Hex Valve.

2.02 MANUFACTURED UNITS

- A. Valve manifolds:
 - 1. General:
 - a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds as indicated on the Drawings.
 - b. Valve manifolds shall have one piece bonnet with a metal to metal seal to the valve body below the bonnet threads.
 - 2. Requirements:
 - a. Bonnet lock pin to prevent accidental loosening.
 - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
 - e. Manifold valves shall allow for direct or remote instrument mounting.
 - f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
 - g. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-Ring: Teflon.
 - h. 2-Valve manifolds:
 - 1) 1 isolation valve and 1 drain/vent and calibration valve.
 - i. 3-Valve manifolds:
 - 1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
 - 2) Plugged vent connections used for vent/drain or calibration.
 - j. Blowdown 5-valve manifold:
 - 1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.
 - k. Metering 5-valve manifold:
 - 1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.
- B. Block and bleed valves:
 - 1. General:
 - a. Valve shall provide process isolation and venting/draining capabilities.
 - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - d. Valve shall not be used with fluids with high solids content, such as raw wastewater or sludge.
 - 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-Ring: Teflon.

- C. Gauge valves:
 - 1. General:
 - a. Valve shall provide process isolation from pressure instrument.
 - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-Ring: Teflon.

2.03 ACCESSORIES

- A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.
- B. Provide stainless steel concentric or eccentric pipe nipples when necessary.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location and verify it will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of all valves.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. As specified in Section 17950 - Testing, Calibration, and Commissioning.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Demonstrate performance of all valves to the Engineer before commissioning.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17403

PRESSURE/VACUUM MEASUREMENT: SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure/vacuum switches.
- B. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
 - 1. Product data:
 - a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Mechanical type pressure switch: One of the following or equal:
 - 1. Ashcroft, B Series Type 400.
 - 2. United Electric Controls Series 400.
 - 3. ASCO, S-Series.

2.02 MANUFACTURED UNITS

- A. Mechanical type pressure switches:
 - 1. General:
 - a. Pressure switch shall be diaphragm or diaphragm-sealed piston type.
 - 2. Performance requirements:
 - a. Pressure range:
 - 1) As shown on the P&IDs.
 - b. Accuracy:
 - 1) Within 1.0 percent of range.
 - c. Repeatability:
 - 1) Within 1.0 percent of range.
 - 3. Element:
 - a. Type: Diaphragm, diaphragm-sealed piston, or bourdon tube.
 - b. Overpressure:
 - 1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
 - 2) Minimum 400 percent of nominal range without leakage or rupture.
 - c. Sensing element shall not require ambient temperature compensation.

- d. Wetted materials: Stainless steel.
- e. Setpoint:
 - 1) Single.
 - 2) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
- f. Adjustable deadband.
- g. Switch elements:
 - 1) Snap acting.
 - 2) Single-pole double-throw (SPDT).
 - 3) Hermetically sealed.
 - 4) Rated at 5 A, 125/250 VAC.
 - 5) Automatic reset type.
- h. Enclosure: Epoxy coated:
 - 1) NEMA Type 4X.
- i. Switch mounting:
 - 1) Process connection: 1/2-inch NPT.
- 4. Components:
 - a. Provide all necessary hardware for pressure switch mounting.

2.03 ACCESSORIES

- A. Provide diaphragm seals as specified in data sheets or as indicated on the Drawings and as specified in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
 - 1. Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.
- B. Furnish block and bleed valves as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves.
- C. Furnish gauge valves as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves.
- D. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments specified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E: Carollo Engineers				PRESSURE/VACUUM SWITCHES					
Contractor: Project: Project 5 Customer: SVWRF Plant: SVWRF Location: 7495 South 1300 West West Jordan, UT 84084 BOM No.: File:								Spec. No.	Rev.
				No	By	Date	Revision	17403	
								Contract	Date
								Req.	P.O.
								By	Chk
D E V I C E	1	Type			Press: X Vacuum: Comp.: Diff.Press: Other				
	2	Setting			Set in Field: X Factory Set: Internal: External: Dial:				
	3	Dead Band			Fixed: Adj.: X Min.: Other:				
	4	Mtl :	Body	Seat	Tube				
	5	Element Type			Diaphragm: X Bourdon: Bellows: Other				
	6	Material			Bronze: SS: Alloy St.: Other				
	7	Connection			½ in NPT √ Bottom: Back:				
	8	Mounting			Local: X Surface: Flush:				
	9	Accuracy							
	10	Other							
S W I T C H	11	Type			Mercury: Snap: X Other				
	12	Quantity			Single: X Dual: Other				
	13	Form			SPST: SPDT: X DPDT: Other				
	14	Rating:	Amps	Volts	Hertz	5	120	60	
	15	Other							
	16	Load			Inductive: Non-Inductive: √				
	17	Enclosure			General Purpose: Weatherproof: X None: Explosion proof:				
	18	Enclosure Class							
	19	Conduit Connection			MFR STD: X Other				
	20	Other							
	21	Manufacturer							
	22	Model No.							
Rev	Tag Number	Adj. Range	SP Process	Signal SP	Op. Temp.	P&ID	Service	Notes	
	PSL-21.212	0-30 PSIG	15 PSIG		90 DEG. F.	PI21-04	GRIT PUMP SUCTION		
	PSL-21.216	0-60 PSIG	40 PSIG		90 DEG. F.	PI21-04	SEAL WATER		
	PSL-21.222	0-30 PSIG	15 PSIG		90 DEG. F.	PI21-04	GRIT PUMP SUCTION		
	PSL-21.226	0-60 PSIG	40 PSIG		90 DEG. F.	PI21-04	SEAL WATER		
	PSL-21.232	0-30 PSIG	15 PSIG		90 DEG. F.	PI21-05	GRIT PUMP SUCTION		
	PSL-21.236	0-60 PSIG	40 PSIG		90 DEG. F.	PI21-05	SEAL WATER		
	PSL-21.242	0-30 PSIG	15 PSIG		90 DEG. F.	PI21-05	GRIT PUMP SUCTION		
	PSL-21.246	0-60 PSIG	40 PSIG		90 DEG. F.	PI21-05	SEAL WATER		
	PSL-21.252	0-30 PSIG	15 PSIG		90 DEG. F.	PI21-06	GRIT PUMP SUCTION	BID ADD	
	PSL-21.256	0-60 PSIG	40 PSIG		90 DEG. F.	PI21-06	SEAL WATER	BID ADD	

	PSL-21.262	0-30 PSIG	15 PSIG		90 DEG. F.	PI21-06	GRIT PUMP SUCTION	BID ADD
	PSL-21.266	0-60 PSIG	40 PSIG		90 DEG. F.	PI21-06	SEAL WATER	BID ADD
Notes: Refer to Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals for additional diaphragm seal requirements. Refer to Section 17402 - Pressure/Vacuum Measurement: Instrument Valves for additional instrument valve requirements. BID ADD = Associated with and Additive Bid Item. Refer to Section 01230 for Additive Bid Items.								

SECTION 17404

PRESSURE/VACUUM MEASUREMENT: GAUGES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure/vacuum gauges.
- B. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B40.100 - Pressure Gauges and Gauge Attachments.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Additional requirements:
 - 1. Product data:
 - a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Ashcroft:
 - a. Maximum pressure less than 10 pounds per square inch:
 - 1) Model 1188
 - 2) If a stainless steel dial casing is required:
 - a) Model 1009.
 - b. Maximum pressure greater than or equal to 10 pounds per square inch:
 - 1) Model 1279.
 - 2) If a stainless steel dial casing is required:
 - a) Model 1009.
 - 2. Wika.
 - 3. Ametek U.S. Gauge.

2.02 MANUFACTURED UNITS

- A. General:
 - 1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.
- B. Performance requirements:
 - 1. Pressure range:
 - a. As specified in the Contract Documents.
 - 2. Accuracy:
 - a. Grade 2A, as defined by ASME B40.100.

- b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
 - c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
- 3. Element:
 - a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon® tube.
 - b. Socket tips for bellows and Bourdon® tube:
 - 1) Materials: Type 316 stainless steel.
 - c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
 - d. Wetted materials: Type 316 stainless steel.
- 4. Dial gauge:
 - a. Dial size: 4-1/2 inches.
 - b. Dial case material:
 - 1) Maximum pressure less than 10 pounds per square inch:
 - a) Phenolic.
 - 2) Maximum pressure greater than or equal to 10 pounds per square inch:
 - a) Stainless steel
 - c. Provide safety gauge with safety blow out through the back or top of the unit.
 - d. Dial face: Gasketed shatterproof glass or polycarbonate.
 - e. Provide gauge locks on all pressure gauges directly connected to diaphragm seals.
 - f. Provide gauge locks where possible.
 - g. Hermetically sealed.
 - h. Connection and mounting:
 - 1) Direct mounted and suitable for outdoor installation.
 - 2) 1/2-inch NPT.
 - 3) Connection material: Stainless steel.
 - i. Pointer: Externally adjustable.

2.03 ACCESSORIES

- A. Pulsation dampeners and snubbers:
 - 1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
 - 2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
 - 3. Materials: Type 316 stainless steel.
 - 4. Mount pulsation dampener or snubber integrally to the pressure gauge.
 - 5. Connection: 1/2-inch NPT.
- B. Provide diaphragm seals as specified in the Contract Documents and in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
 - 1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.
- C. Provide means for gauge isolation as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves:
 - 1. Mount valve manifold integrally to the gauge.

2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.
- D. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: Project 5 Customer: SVWRF Plant: SVWRF Location: 7495 South 1300 West West Jordan, UT 84084 BOM No.: File:			PRESSURE GAUGES					
							Spec. No.	Rev.
			No	By	Date	Revision	17404	
							Contract	Date
							Req.	P.O.
				By	Chk	App		

1	Type	Direct Rdg.: ☒	Receiver:	Other:
2	Mounting	Surface: Local: ☒	Flush:	
3	Dial	Diameter: 4.5"	Color:	
4	Case	Cast Iron: ☐	Aluminum: ☐	Phenolic: ☐
5	Ring	Screwed: ☐	Hinged: ☐	Slip: ☐
6	Blowout Protection	None: ☐	Disc: ☐	Front: ☐
7	Lens	Glass: ☒	Plastic: ☐	
8	Options	Siphon: N/A	Material:	
9	Other	Snubber: N/A		
10	Other	Pressure Limit Valve: N/A		
11	Other	Movement Damping: N/A		
12	Nominal Accuracy Required			
13	Pressure Element	Bourdon®: ☒	Bellows: ☐	Other: ☐
14	Element Material	Bronze: ☐	Steel: ☐	Type SS: 316 ☒
15	Socket Material	Bronze: ☐	Steel: ☐	SS: 316 ☐
16	Connection	1/4 in.: ☐	1/2 in.: ☒	Bottom: ☐
17	Movement	Dampened: ☐	Standard: ☒	Other: ☐
18	Diaphragm Seal	Mfr.: ☐	Wetted Part Mat'l: SS ☐	Type: ☐
19	Other	Other Mat'l: ☐	Fill Fluid: Mfr. Std ☐	Model: ☐
20	Manufacturer			
21	Model No.			

Rev	Tag Number	Range	P&ID	Service	Notes
	PI-21.213	0-60 PSIG	PI21-04	GRIT PUMP NO. 1 DISCHARGE	
	PI-21.218	0-160 PSIG	PI21-04	GRIT PUMP NO. 1 SEAL WATER	
	PI-21.219	0-60 PSIG	PI21-04	GRIT PUMP NO. 1 SUCTION	
	PI-21.223	0-60 PSIG	PI21-04	GRIT PUMP NO. 2 DISCHARGE	
	PI-21.228	0-160 PSIG	PI21-04	GRIT PUMP NO. 2 SEAL WATER	
	PI-21.229	0-60 PSIG	PI21-04	GRIT PUMP NO. 2 SUCTION	
	PI-21.233	0-60 PSIG	PI21-05	GRIT PUMP NO. 3 DISCHARGE	
	PI-21.238	0-160 PSIG	PI21-05	GRIT PUMP NO. 3 SEAL WATER	
	PI-21.239	0-60 PSIG	PI21-05	GRIT PUMP NO. 3 SUCTION	
	PI-21.243	0-60 PSIG	PI21-05	GRIT PUMP NO. 4 DISCHARGE	
	PI-21.248	0-160 PSIG	PI21-05	GRIT PUMP NO. 4 SEAL WATER	
	PI-21.249	0-60 PSIG	PI21-05	GRIT PUMP NO. 4 SUCTION	
	PI-21.253	0-60 PSIG	PI21-06	GRIT PUMP NO. 5 DISCHARGE	BID ADD
	PI-21.258	0-160 PSIG	PI21-06	GRIT PUMP NO. 5 SEAL WATER	BID ADD
	PI-21.259	0-60 PSIG	PI21-06	GRIT PUMP NO. 5 SUCTION	BID ADD
	PI-21.263	0-60 PSIG	PI21-06	GRIT PUMP NO. 6 DISCHARGE	BID ADD
	PI-21.268	0-160 PSIG	PI21-06	GRIT PUMP NO. 6 SEAL WATER	BID ADD
	PI-21.269	0-60 PSIG	PI21-06	GRIT PUMP NO. 6 SUCTION	BID ADD

Notes:
Refer to Section 17402 - Pressure/Vacuum Measurement: Instrument Valves for additional instrument valve requirements.
BID ADD = Associated with Additive Bid Item. Refer to Section 01230 for all Additive Bid Items.

SECTION 17405

PRESSURE/VACUUM MEASUREMENT: DIRECT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure transmitters and indicators.
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
 - 2. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.
 - 3. Calibrated range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than or equal to the URV. The calibrated range corresponds to the flow signal sent from the transmitter.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.

2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 1. Emerson, Rosemount 3051 Series.
 2. Emerson, Rosemount 2051 Series with High performance option
 3. Yokogawa, EJA Series.
 4. ABB, 266 Series.
 5. Endress & Hauser, Cerabar S Series.

2.02 MANUFACTURED UNITS

A. Pressure transmitters - direct:

1. General:
 - a. Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor based transmitter for measurement of gauge, vacuum, or absolute pressure.
2. Performance requirements:
 - a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
 - b. Accuracy:
 - 1) Reference accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
 - 2) Total performance accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
 - 3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
3. Element:
 - a. Diaphragm type transducer integral to pressure transmitter.
 - b. Diaphragm material: Stainless steel or ceramic.
 - c. Process material compatibility:
 - 1) Verify all material compatibilities with the instrument manufacturer.
 - d. Process connection: As specified in the Instrument Data Sheets.
4. Transmitter:
 - a. Power supply:
 - 1) 24 VDC - 2 wire loop powered.
 - 2) Power consumption: 3 VA maximum.
 - b. Outputs:
 - 1) Isolated 4-20mA DC with HART communication protocol.
 - c. Provided with electronic microprocessor.
 - d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
 - e. Local display:
 - 1) None.
 - f. Enclosure:
 - 1) NEMA Type 4X.
 - g. Over range protection: To maximum process line pressure.
 - h. Conduit: 1/2-inch male NPT.
5. Components:
 - a. Transmitter mounting:
 - 1) Mounted to stainless steel duct. Provide threaded connection.
 - 2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

A. Provide valve manifolds as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves:

1. Mount valve manifold integrally to the transmitter.
2. Valve manifold and transmitter shall be assembled by Manufacturer and shipped as an assembly.

3. Provide remote or integral diaphragm seals as specified in the Instrument Data Sheets and in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals.
- B. Provide sunshades for outdoor installations.
- C. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. As specified in Section 17950 - Testing, Calibration, and Commissioning.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:		PRESSURE TRANSMITTERS						
						Spec. No.		Rev.
		No	By	Date	Revision	17405		
						Contract		Date
						Req.		P.O.
					By	Chk	App	
GENERAL	1	Instrument Tag No.	PIT-21.511			PIT-21.512		
	2	Service	FOUL AIR			FOUL AIR		
	3	P&ID	PI21-10			PI21-10		
SERVICE	4	Pressure						
	5	Process Temperature	35-70 Deg. F			35-70 Deg. F		
	6	Ambient Temperature						
TRANSMITTER	7	Manufacturer						
	8	Model No.						
	9	Pressure Transmitter Type	Direct			Direct		
	10	Calibrated Span	-20 IN. W.C. – 20 IN. W.C.			-20 IN. W.C. – 20 IN. W.C.		
	11	Accuracy						
	12	Adjustable Range						
	13	Output Signal	4-20 mA			4-20 mA		
	14	Body Rating	NEMA 4X			NEMA 4X		
BODY	15	Process Flange Type						
	16	Drain/Vent						
	17	Process Flange						
	18	Adapters						
	19	Wetted O-Ring						
	20	Housing						
	21	Bolts						
	22	Mounting Brackets						
ELEMENT	23	Conduit Entry Size						
	24	Isolating Diaphragm	Not Required			Not Required		
OPTIONS	25	Fill Fluid	Not Required			Not Required		
	26	Certification / Approval Type	FM Class I Division 2			FM Class I Division 2		
	27	Meter						
	28	Zero Span & Adjustment						
	29	Surge Protection						
MANIFOLD	30	Custom Configuration						
	31	Manufacturer						
	32	Model Number						
	33	Manifold Style						
	34	Manifold Type						
Notes: Refer to Section 17402 - Pressure/Vacuum Measurement: Instrument Valves for additional instrument valve requirements.								

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:		PRESSURE TRANSMITTERS					
						Spec. No.	Rev.
		No	By	Date	Revision	17405	
						Contract	Date
						Req.	P.O.
					By	Chk	
						App	
GENERAL	1	Instrument Tag No.	PIT-21.513		PIT-21.514		
	2	Service	FOUL AIR		FOUL AIR		
	3	P&ID	PI21-10		PI21-10		
SERVICE	4	Pressure					
	5	Process Temperature	35-70 Deg. F		35-70 Deg. F		
	6	Ambient Temperature					
TRANSMITTER	7	Manufacture					
	8	Model No.					
	9	Pressure Transmitter Type	Direct		Direct		
	10	Calibrated Span	-20 IN. W.C. – 20 IN. W.C.		-20 IN. W.C. – 20 IN. W.C.		
	11	Accuracy					
	12	Adjustable Range					
	13	Output Signal	4-20 mA		4-20 mA		
	14	Body Rating	NEMA 4X		NEMA 4X		
BODY	15	Process Flange Type					
	16	Drain/Vent					
	17	Process Flange					
	18	Adapters					
	19	Wetted O-Ring					
	20	Housing					
	21	Bolts					
	22	Mounting Brackets					
ELEMENT	23	Conduit Entry Size					
	24	Isolating Diaphragm	Not Required		Not Required		
OPTIONS	25	Fill Fluid	Not Required		Not Required		
	26	Certification / Approval Type	FM Class I Division 2		FM Class I Division 2		
	27	Meter					
	28	Zero Span & Adjustment					
	29	Surge Protection					
MANIFOLD	30	Custom Configuration					
	31	Manufacturer					
	32	Model Number					
	33	Manifold Style					
	34	Manifold Type					
Notes: Refer to Section 17402 - Pressure/Vacuum Measurement: Instrument Valves for additional instrument valve requirements.							

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:		PRESSURE TRANSMITTERS						
						Spec. No.		Rev.
		No	By	Date	Revision	17405		
						Contract		Date
						Req.		P.O.
						By	Chk	App
GENERAL	1	Instrument Tag No.	PIT-21.515			PIT-21.521		
	2	Service	FOUL AIR			FOUL AIR		
	3	P&ID	PI21-10			PI21-11		
SERVICE	4	Pressure						
	5	Process Temperature	35-70 Deg. F			35-70 Deg. F		
	6	Ambient Temperature						
TRANSMITTER	7	Manufacture						
	8	Model No.						
	9	Pressure Transmitter Type	Direct			Direct		
	10	Calibrated Span	-20 IN. W.C. – 20 IN. W.C.			0-10.00 in. w.c.		
	11	Accuracy						
	12	Adjustable Range						
	13	Output Signal	4-20 mA			4-20 mA		
	14	Body Rating	NEMA 4X			NEMA 4X		
BODY	15	Process Flange Type						
	16	Drain/Vent						
	17	Process Flange						
	18	Adapters						
	19	Wetted O-Ring						
	20	Housing						
	21	Bolts						
	22	Mounting Brackets						
	23	Conduit Entry Size						
ELEMENT	24	Isolating Diaphragm	Not Required			Not Required		
	25	Fill Fluid	Not Required			Not Required		
OPTIONS	26	Certification / Approval Type	FM Class I Division 2			FM Class I Division 2		
	27	Meter						
	28	Zero Span & Adjustment						
	29	Surge Protection						
	30	Custom Configuration						
MANIFOLD	31	Manufacturer						
	32	Model Number						
	33	Manifold Style						
	34	Manifold Type						
Notes: Refer to Section 17402 - Pressure/Vacuum Measurement: Instrument Valves for additional instrument valve requirements. PIT-21.521 is included as part of Additive Bid Item No. 4.								

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:		PRESSURE TRANSMITTERS					
						Spec. No.	Rev.
		No	By	Date	Revision	17405	
						Contract	Date
						Req.	P.O.
					By	Chk	
						App	
GENERAL	1	Instrument Tag No.	PIT-21.522				
	2	Service	FOUL AIR				
	3	P&ID	PI21-11				
SERVICE	4	Pressure					
	5	Process Temperature	35-70 Deg. F				
	6	Ambient Temperature					
TRANSMITTER	7	Manufacture					
	8	Model No.					
	9	Pressure Transmitter Type	Direct				
	10	Calibrated Span	0-10.00 in. w.c.				
	11	Accuracy					
	12	Adjustable Range					
	13	Output Signal	4-20 mA				
	14	Body Rating	NEMA 4X				
BODY	15	Process Flange Type					
	16	Drain/Vent					
	17	Process Flange					
	18	Adapters					
	19	Wetted O-Ring					
	20	Housing					
	21	Bolts					
	22	Mounting Brackets					
	23	Conduit Entry Size					
ELEMENT	24	Isolating Diaphragm	Not Required				
	25	Fill Fluid	Not Required				
OPTIONS	26	Certification / Approval Type	FM Class I Division 2				
	27	Meter					
	28	Zero Span & Adjustment					
	29	Surge Protection					
	30	Custom Configuration					
MANIFOLD	31	Manufacturer					
	32	Model Number					
	33	Manifold Style					
	34	Manifold Type					
Notes: Refer to Section 17402 - Pressure/Vacuum Measurement: Instrument Valves for additional instrument valve requirements. Included as part of Additive Bid Item No. 4.							

SECTION 17406

PRESSURE/VACUUM MEASUREMENT: DIFFERENTIAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Differential pressure transmitters and indicators.
- B. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
 - 2. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.
 - 3. Calibrated range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than the URV. The calibrated range corresponds to the pressure signal sent from the transmitter. When a Low-Flow Cut-Off is considered, the calibration set points need to be 10 percent, 25 percent, 50 percent, 75 percent, and 100 percent of the output flow-rate rather than starting from 0 percent.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.
- C. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following, no equal:
 - 1. Emerson, Rosemount.
 - 2. Yokogawa, EJA Series.
 - 3. ABB, 264 Series.
 - 4. Endress + Hauser, Deltabar S Series.
 - 5. SMAR, LD300 Series.

2.02 MANUFACTURED UNITS

A. Pressure transmitters - differential:

1. General:
 - a. Differential pressure transmitter assembly shall include a diaphragm-type pressure transducer and microprocessor-based transmitter for measurement of differential pressure.
 - b. Differential pressure transmitters shall be used for differential pressure, flow, or liquid level measurement as indicated on the Drawings.
2. Performance requirements:
 - a. As specified in data sheets or instrument index.
 - b. Maximum ratio of total instrument range to calibrated span: 10 to 1.
 - c. Accuracy:
 - 1) Reference accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
 - 2) Total performance accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
 - 3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
3. Element:
 - a. Diaphragm-type transducer integral to differential pressure transmitter.
 - b. Diaphragm material: Stainless steel or ceramic.
 - c. Wetted materials: Stainless steel
 - 1) Process material compatibility:
 - a) Verify all material compatibilities with the instrument manufacturer.
 - d. Diaphragm fill fluid: Silicon Oil.
 - e. Process connection: 1/2 inch NPT.
4. Transmitter:
 - a. Power supply:
 - 1) 24 VDC - loop powered.
 - b. Outputs
 - 1) Isolated 4-20 mA DC.
 - c. Provided with electronic microprocessor.
 - d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
 - e. Square root extraction for flow calculation.
 - f. Local display:
 - 1) 5-digit LCD.
 - 2) Scaled in engineering units.
 - g. Enclosure: NEMA Type 4X
 - h. Overrange protection: To maximum process line pressure.
 - i. Conduit connection: 1/2 inch male NPT.
5. Components:
 - a. Transmitter mounting:
 - 1) As specified in the data sheets or instrument index.
 - 2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

- A. Provide valve manifold as specified in Section 17402 - Pressure/Vacuum Measurement: Instrument Valves and as indicated in the Drawings:
 - 1. Mount valve manifold integrally to the transmitter.
 - 2. Valve manifold and transmitter shall be assembled by manufacturer and shipped as an assembly.
- B. Provide sunshades for outdoor installations.
- C. Provide stainless steel tags for each instrument. Tags shall be labeled as specified in the Contract Documents.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Each differential pressure transmitter shall be factory calibrated with 5-point calibration at a facility that is traceable to the NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:			DIFFERENTIAL PRESSURE TRANSMITTERS					
							Spec. No.	Rev.
			No	By	Date	Revision	17406	
							Contract	Date
							Req.	P.O.
					By	Chk	App	
GENERAL	1	Instrument Tag No.	PDIT-21.503					
	2	Service	Grease Mist Eliminator					
	3	P&ID	PI21-10					
SERVICE	4	Pressure						
	5	Process Temperature						
	6	Ambient Temperature						
TRANSMITTER	7	Manufacturer						
	8	Model No.						
	9	Pressure Transmitter Type						
	10	Calibrated Span	0-3.00 IN. W.C.					
	11	Accuracy						
	12	Adjustable Range						
	13	Output Signal	4-20 mA					
	14	Body Rating	NEMA 4X					
BODY	15	Process Flange Type						
	16	Drain/Vent						
	17	Process Flange						
	18	Adapters						
	19	Wetted O-Ring						
	20	Housing						
	21	Bolts						
	22	Mounting Brackets						
	23	Conduit Entry Size						
ELEMENT	24	Isolating Diaphragm	NO					
	25	Fill Fluid						
OPTIONS	26	Certification / Approval Type	Class 1 Division 2					
	27	Meter						
	28	Zero Span & Adjustment						
	29	Surge Protection						
	30	Custom Configuration						
MANIFOLD	31	Manufacturer						
	32	Model Number						
	33	Manifold Style						
	34	Manifold Type						
Notes: Refer to Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals for additional diaphragm seal requirements. Refer to Section 17402 - Pressure/Vacuum Measurement: Instrument Valves for additional instrument valve requirements.								

SECTION 17407

PRESSURE MEASUREMENT: SUBMERSIBLE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Submersible pressure transmitters.
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures, and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Submersible level measurement with 2-wire integral transmitter:
 - 1. One of the following or equal:
 - a. Endress+Hauser, Waterpilot FMX21 with 1.65-inch outer diameter probe.
 - b. GE Druck, PTX-1290.
 - c. Siemens, A1000i.
 - d. Measurement Specialties, KPSI 700 Series.

2.02 MANUFACTURED UNITS

- A. Submersible level measurement with 2-wire integral transmitter:
 - 1. General:
 - a. Pressure is measured through a diaphragm-type measuring cell and converted to linear pressure measurement.
 - b. Each submersible pressure transmitter system shall include:
 - 1) Signal cable, including pressure compensation tube.
 - 2) Transducer probe with integral transmitter.
 - 3) Transmitter cable termination box.
 - 2. Performance requirements:
 - a. Accuracy:
 - 1) 0.3 percent of range.
 - b. Repeatability:
 - 1) 0.25 percent of full scale.
 - c. Rangeability:
 - 1) 3:1.

- d. Range:
 - 1) As indicated on the contract documents.
- 3. Element:
 - a. Sensor housing shall be Type 316L stainless steel or titanium with ceramic, teflon-coated, or titanium diaphragm.
 - b. Protective cap shall be manufacturer's recommended material, chemically resistant to process fluid.
 - c. Slip resistant extension cable with pressure compensation tube with Teflon filter.
 - d. Enclosure for probe and transmitter assembly shall be NEMA Type 6P.
- 4. Transmitter:
 - a. Power supply:
 - 1) 24 VDC: 2 wire loop powered.
 - 2) Power consumption: 18 VA maximum.
 - b. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC.
 - c. Without display.
 - d. Ambient operating temperature limits of -10 to 70 degrees Celsius (-14 to 158 degrees Fahrenheit).
 - e. Transmitter shall be integral to probe housing.
- 5. Transmitter cable termination box:
 - a. NEMA Type 4X.
 - b. Equipped with filter or desiccant chamber to eliminate moisture from the pressure compensation tube.
 - c. Termination for signal wires and pressure compensation tube.
- 6. Approvals: Element must be approved for use in a Class 1 Division 1 environment.

2.03 ACCESSORIES

- A. Type 316L stainless steel mounting clamp with Type 304 stainless steel mounting screws.
- B. Provide guide tube for stillwell mounting.
- C. Provide additional anchor to prevent movement.
- D. Provide cable clamp and strain relief.
- E. Provide computer cable adapter with Windows® software.
- F. Provide remote display with backlight or loop indicator with backlight as indicated on the Drawings and as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.
- G. Provide sunshade for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: Project 5 Customer: South Valley Water Reclamation Facility Plant: SVWRF Location: West Jordan, UT BOM No.: File:			SUBMERSIBLE PRESSURE INSTRUMENTS							
							Spec. No.		Rev.	
			No	By	Date	Revision	17407			
							Contract		Date	
							Req.		P.O.	
						By	Chk	App		

G E N	1	Instrument Tag Number	LT-21.001		
	2	Service	Grit Influent Channel		
	3	P&ID	PI21-01		
	4	Fluid Type			
	5	Fluid Specific Gravity			
P R O B E	6	Type	Submersible		
	7	Measuring Cell Material	Diaphragm		
	8	Probe Body Material			
	9	Op. Temp. Range	40-80 deg F		
	10	Op. Pressure Range	0-10 ft		
	11	Other			
	12	Other			
C A B L E	13	Style	Mfg. Recommended		
	14	Signal Cable Length	As Required		
	15	Other			
	16	Other			
	17	Other			
T R A N S M I T T E R	18	Type			
	19	Operating Mode	Continuous		
	20	Enclosure	NEMA 4X		
	21	Mounting			
	22	Temperature Range			
	23	Measurement Range			
	24	Power Supply	24 VDC		
	25	Accuracy	0.3 % of range		
	26	Display			
	27	Output	4-20 mA		
	28	Calibration			
	29	Status Relay			
	30	Manufacturer			
	31	Model No.			
	32	Elect. Entry			
	33	Other			
O P T S	33				
	34				
	35				
	36				

Notes:

SECTION 17502

ANALYZERS: ORP

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. ORP instruments.
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. CSA International (CSA).

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following, no equal:
 - 1. Hach:
 - a. Differential ORP.
 - b. Controller Model: SC1000.
 - 2. YSI:
 - a. Sensor Model: SensoLyt 700 IQ.
 - b. Controller Model: IQ Sensornet 284.
- B. All analyzer elements connected to a common transmitter must be furnished by the same manufacturer.

2.02 MANUFACTURED UNITS

- A. ORP analyzer:
 - 1. General:
 - a. The oxidizing reducing potential (ORP) is a unit of measurement for the state of equilibrium between oxidizing and reducing components of a media. A platinum or gold electrode shall be used with integrated noble metal reference system. The measuring electrode shall generate a voltage output relative to the oxidizing or reducing reactions.

2. Performance requirements:
 - a. Accuracy: Within 5.0 millivolts.
 - b. Stability: Within 2.0 mV per 24 hours, non-cumulative
 - c. Repeatability: Within 2.0 millivolt.
3. Element:
 - a. Sensor material:
 - 1) Gold ring ORP electrode.
 - 2) Rated for continuous submersion
 - 3) 316 Stainless steel body.
 - 4) Steady reference signal from the reference electrode junction by resisting plugging in dirty applications.
 - b. ORP measuring range: -1,500 to 1,500 millivolts.
 - c. Temperature measuring range: 0 to 100 degrees Celsius.
 - d. Operating temperature range: -5 to 105 degrees Celsius.
 - e. Operating pressure range: 0 to 100 pounds per square inch.
 - f. Process connection:
 - 1) Submersion.
4. Transmitter:
 - a. As specified in Section 17506 - Analyzers: Dissolved Oxygen.
5. Components:
 - a. Sensor cable:
 - 1) Provided watertight sensor-to-cable connector that prevents cable twisting and eliminates rewiring when replacing the sensor.
 - 2) Cable length: As required to connect sensor to transmitter plus 10 percent.

2.03 ACCESSORIES

- A. Provide sunshades for outdoor applications.
- B. Calibration equipment:
 1. Provide components recommended by the manufacturer to verify calibration.
- C. Provide manufacturer's hand rail swivel mounting hardware with all stainless steel components.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.

1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.05 ADJUSTING

- A. As specified in Section 17950 - Testing, Calibration, and Commissioning.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Contractor: Project: Customer: Plant: Location: BOM No.: File:		PROJECT 5 SOUTH VALLEY WATER RECLAMATION FACILITY 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084			ORP ANALYZERS					
									Spec. No.	Rev.
					No	By	Date	Revision	17502	
									Contract	Date
									Req.	P.O.
									By	Chk
G E N	1	Tag No.	Element	Transmitter	AE-16.251		AE-16.253			
	2	Service			ZONE AN-3		ZONE AX-3			
	3	P&ID			PI16-02		PI16-04			
E L E M E N T	4	Type			IMMERSION		IMMERSION			
	5	Body Style								
	6	Enclosure								
	7	Electrodes			GOLD		GOLD			
	8	Ambient Conditions								
	9	Connection								
	10	Sample Flow Required								
	11	ORP Measuring Range			-1000-1000 mV		-1000-1000 mV			
	12	Temperature Measuring Range			-5 - 70°C		-5 - 70°C			
	13	Manufacturer								
C A B L E	14	Model No.								
	15	Length								
	16	Other								
	17	Style								
	18	Length								
T R A N S M I T T E R	19	Model No.								
	20	Pre-Amplifier								
	21	Other								
	22	Type					Control Unit and Display			
	23	Enclosure					NEMA 4X			
	24	Mounting					REMOTE			
	25									
	26	Power Requirements					115 VAC, 60 Hz			
	27	Resolution								
	28	Accuracy								
	29	Calibrated Range								
	30									
O P T S	31	Outputs					MODBUS TCP			
	32	Contacts								
	33	Manufacturer								
	34	Model No.								
	35	Display								
	36	Other								
	37	Other								
	38	Other								
	38	Cleaning								
	39	Low Flow Cell								
	38	Process Assembly								
	38	Other								
	39									
Notes: INCLUDED UNDER ADDITIVE BID ITEM NO. 2										

A/E: Contractor: Project: Customer: Plant: Location: BOM No.: File:		PROJECT 5 SOUTH VALLEY WATER RECLAMATION FACILITY 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084			ORP ANALYZERS					
					Spec. No.		Rev.			
					No	By	Date	Revision	17502	
									Contract	Date
									Req.	P.O.
									By	Chk
G E N	1	Tag No.	Element	Transmitter	AE-16.351		AE-16.353			
	2	Service			ZONE AN-3		ZONE AX-3			
	3	P&ID			PI16-15		PI16-17			
E L E M E N T	4	Type			IMMERSION		IMMERSION			
	5	Body Style								
	6	Enclosure								
	7	Electrodes			GOLD		GOLD			
	8	Ambient Conditions								
	9	Connection								
	10	Sample Flow Required								
	11	ORP Measuring Range			-1000-1000 mV		-1000-1000 mV			
	12	Temperature Measuring Range			-5 - 70°C		-5 - 70°C			
	13	Manufacturer								
C A B L E	14	Model No.								
	15	Length								
	16	Other								
	17	Style								
T R A N S M I T T E R	18	Length								
	19	Model No.								
	20	Pre-Amplifier								
	21	Other								
	22	Type					Control Unit and Display			
	23	Enclosure					NEMA 4X			
	24	Mounting					REMOTE			
	25									
	26	Power Requirements					115 VAC, 60 Hz			
	27	Resolution								
	28	Accuracy								
	29	Calibrated Range								
O P T S	30									
	31	Outputs					MODBUS TCP			
	32	Contacts								
	33	Manufacturer								
	34	Model No.								
	35	Display								
	36	Other								
	37	Other								
	38	Other								
O P T S	38	Cleaning								
	39	Low Flow Cell								
	38	Process Assembly								
	38	Other								
	39									
Notes: INCLUDED UNDER ADDITIVE BID ITEM NO. 2										

A/E: Contractor: Project: Customer: Plant: Location: BOM No.: File:		PROJECT 5 SOUTH VALLEY WATER RECLAMATION FACILITY 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084			ORP ANALYZERS					
									Spec. No.	Rev.
					No	By	Date	Revision	17502	
									Contract	Date
									Req.	P.O.
									By	Chk
G E N	1	Tag No.	Element	Transmitter	AE-16.451		AE-16.453			
	2	Service			ZONE AN-3		ZONE AX-3			
	3	P&ID			PI16-28		PI16-30			
E L E M E N T	4	Type			IMMERSION		IMMERSION			
	5	Body Style								
	6	Enclosure								
	7	Electrodes			GOLD		GOLD			
	8	Ambient Conditions								
	9	Connection								
	10	Sample Flow Required								
	11	ORP Measuring Range			-1000-1000 mV		-1000-1000 mV			
	12	Temperature Measuring Range			-5 - 70°C		-5 - 70°C			
	13	Manufacturer								
C A B L E	14	Model No.								
	15	Length								
	16	Other								
	17	Style								
	18	Length								
T R A N S M I T T E R	19	Model No.								
	20	Pre-Amplifier								
	21	Other								
	22	Type					Control Unit and Display			
	23	Enclosure					NEMA 4X			
	24	Mounting					REMOTE			
	25									
	26	Power Requirements					115 VAC, 60 Hz			
	27	Resolution								
	28	Accuracy								
	29	Calibrated Range								
	30									
O P T S	31	Outputs					MODBUS TCP			
	32	Contacts								
	33	Manufacturer								
	34	Model No.								
	35	Display								
	36	Other								
	37	Other								
	38	Other								
O P T S	38	Cleaning								
	39	Low Flow Cell								
	38	Process Assembly								
	38	Other								
Notes: INCLUDED UNDER ADDITIVE BID ITEM NO. 2										

SECTION 17504

ANALYZERS: GAS MONITORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Combustible and toxic gas monitors.
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. LEL: Lower explosive limit is the lowest concentration of vapor in air, which will burn or explode upon contact with a source of ignition.
 - 2. Multi-channel gas monitor: A multi-channel gas monitor facilitates monitoring of 2 or more sensor modules.
 - 3. Sensor module: A module formed using the combination of a sensor and a transmitter is called a sensor module.
 - 4. Single-channel gas monitor: A single-channel gas monitor is used to monitor a single type of gas.
 - 5. STEL: Short-term exposure limit is the maximum permissible concentration of a material for duration of 15 minutes.
 - 6. TWA: Time-weighted-average concentration is the average concentration of a chemical to which it is permissible to expose a worker for a period of 8 hours.
 - 7. Wet stack sensor: A sensor designed for monitoring reactive gas concentrations in moisture saturated air streams.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems:
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.
- B. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Single-channel gas monitor:
 - a. ATI, Series 12 Gas Transmitter.
 - b. MSA, Ultima X Series Single Channel Gas Monitors.
 - c. Sensidyne, SensAlert Plus Single Channel Gas Monitor.

- d. SMC, Series 4000/5100 Gas Sensor-Transmitter Modules/Single Channel Monitor.

2.02 MANUFACTURED UNITS

- A. Single-channel gas monitor:
 - 1. General:
 - a. Monitor a single type of gas and produce an analog output, which is directly proportional to the gas concentration.
 - b. A single-channel gas monitoring system consists of:
 - 1) A gas sensor module (integral or remote to the gas transmitter).
 - 2) A gas transmitter.
 - 3) Cable between gas sensor and gas transmitter (for remote applications).
 - 2. Performance requirements:
 - a. Repeatability: Within 1 percent full-scale.
 - b. Accuracy: Within- 5 percent of full-scale.
 - c. Calibrated range: As indicated on the Instrument Data Sheets.
 - 3. Sensor module:
 - a. Gas type: Toxic or Combustible as indicated on the individual Instrument Data Sheets.
 - b. Sensor type:
 - 1) Toxic gases: Electrochemical sensors.
 - 2) Combustible gases: Infrared or Catalytic bead sensors as indicated on the individual Instrument Data Sheets.
 - c. Enclosure rating: As indicated on the Instrument Data Sheets.
 - d. Integral or remote as indicated on the Drawings.
 - e. Corrosion resistant.
 - 4. Transmitter:
 - a. Microprocessor-based transmitter.
 - b. Programming and setup: Non-intrusive.
 - c. Enclosure rating: As indicated on the Instrument Data Sheets.
 - d. Mounting: As indicated on the Instrument Data Sheets.
 - e. Power requirements: As indicated on the Instrument Data Sheets.
 - f. LCD or LED display.
 - g. Outputs: As indicated on the Instrument Data Sheets.
 - h. Operating temperature range: As indicated on the Instrument Data Sheets.
 - 5. Cable between sensor and transmitter for remote applications: Manufacturer's standard for the intended application.

2.03 ACCESSORIES

- A. Calibration equipment:
 - 1. Provide calibration kit including appropriate gas with all necessary hardware to calibrate the gas monitoring/indication units for a 2-year period.
 - 2. Furnish carrying case.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

- B. Factory-calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.05 ADJUSTING

- A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers				ANALYZERS - GAS MONITORS								
Contractor: Project: Project 5 Customer: South Valley Water Reclamation Facility Plant: SVWRF Location: West Jordan, UT BOM No.: File:				No				By		Rev.		
				Date				Revision		Spec. No.		Rev.
										17504		
										Contract		Date
										Req.		P.O.
										By		App
						Chk						
G	1	Tag No.	Sample Unit	Transmitter	AE/AIT-21.931				AE/AIT-21.932			
E	2	Service			Odor Control Fan Room				Odor Control Fan Room			
N	3	P&ID			PI21-13				PI21-13			
S	4	Gas Type			Toxic: Combustible: X				Toxic: X Combustible:			
E	5	Sensor Type			Electrochemical: Infra-Red:				Electrochemical: Infra-Red:			
N	6	Operating Temperature Range										
S	7	Operating Humidity Range										
O	8	Operating Pressure Range										
R	9	Enclosure Rating			NEMA TYPE 4X				NEMA TYPE 4X			
	10	Sensor Mounting to Transmitter			Integral: X Remote:				Integral: X Remote:			
	10	Repeatability										
	11	Accuracy										
	12	Calibrated Range			0-100% LEL				0 - 100 ppm			
	13	Other			Alarm at 10% LEL				Alarm at 10 ppm			
	14	Other										
	15	Manufacturer										
	16	Model No.										
C	17	Style										
A	18	Length										
B	19	Model No.										
L	20	Other										
E												
T	21	Type			Control Unit and Display				Control Unit and Display			
R	22	Enclosure Rating			NEMA TYPE 4X				NEMA TYPE 4X			
A	23	Mounting			Wall: X Panel: Other:				Wall: X Panel: Other:			
N	24	Power Requirements			2-wire 24 VDC: 3-wire 24 VDC:				2-wire 24 VDC: 3-wire 24 VDC:			
					120 VAC: X				120 VAC: X			
S	25	Display			LED or LCD				LED or LCD			
M	26	Output			4-20 mA DC				4-20 mA DC			
I	27	Calibration Type			Factory: Custom:				Factory: Custom:			
T	28	Operating Temperature Range										
T	29	SPDT Relay outputs										
E	30	Other										
R	31	Other										
	32	Manufacturer										
	33	Model No.										
C	34	Input type (from transmitter)										
N	35	Number of channels (transmitter inputs)										
T	36	Output										
R	37	Power Requirements										
L	38	Enclosure Rating										
E	39	Operating Temperature Range										
R	40	Mounting										
O	41	Mfr's flow cell and sampling system										
P	42											
T	43											
Notes:												

A/E: Carollo Engineers				ANALYZERS - GAS MONITORS							
Contractor: Project: Project 5 Customer: South Valley Water Reclamation Facility Plant: SVWRF Location: West Jordan, UT BOM No.: File:				No				By		Rev.	
										Spec. No.	
										Contract	Date
										Req.	P.O.
										By	Chk
										App	
G	1	Tag No.	Sample Unit	Transmitter	AE/AIT-21.934				AE/AIT-21.935		
E	2	Service			Odor Control Fan Room				Odor Control Fan Room		
N	3	P&ID			PI21-13				PI21-13		
S	4	Gas Type			Toxic: Combustible: X				Toxic: X Combustible:		
E	5	Sensor Type			Electrochemical: Infra-Red:				Electrochemical: Infra-Red:		
N	6	Operating Temperature Range									
S	7	Operating Humidity Range									
O	8	Operating Pressure Range									
R	9	Enclosure Rating			NEMA TYPE 4X				NEMA TYPE 4X		
	10	Sensor Mounting to Transmitter			Integral: X Remote:				Integral: X Remote:		
	10	Repeatability									
	11	Accuracy									
	12	Calibrated Range			0-100% LEL				0 - 100 ppm		
	13	Other			Alarm at 10% LEL				Alarm at 10 ppm		
	14	Other									
	15	Manufacturer									
	16	Model No.									
C	17	Style									
A	18	Length									
B	19	Model No.									
L	20	Other									
E											
T	21	Type			Control Unit and Display				Control Unit and Display		
R	22	Enclosure Rating			NEMA TYPE 4X				NEMA TYPE 4X		
A	23	Mounting			Wall: X Panel: Other:				Wall: X Panel: Other:		
N	24	Power Requirements			2-wire 24 VDC: 3-wire 24 VDC:				2-wire 24 VDC: 3-wire 24 VDC:		
S	25	Display			120 VAC: X				120 VAC: X		
M	26	Output			LED or LCD				LED or LCD		
I	27	Calibration Type			4-20 mA DC				4-20 mA DC		
T	28	Operating Temperature Range			Factory: Custom:				Factory: Custom:		
T	29	SPDT Relay outputs									
E	30	Other									
R	31	Other									
	32	Manufacturer									
	33	Model No.									
C	34	Input type (from transmitter)									
N	35	Number of channels (transmitter inputs)									
T	36	Output									
R	37	Power Requirements									
L	38	Enclosure Rating									
E	39	Operating Temperature Range									
R	40	Mounting									
O	41	Mfr's flow cell and sampling system									
P	42										
T	43										
Notes:											

SECTION 17506

ANALYZERS: DISSOLVED OXYGEN (DO)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Dissolved oxygen (DO) analyzer.
- B. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. NEMA:
 - 1. Type 6P enclosure in accordance with NEMA 250.
- C. Specific definitions:
 - 1. DO - Dissolved oxygen.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following, no equal:
 - 1. Optical:
 - a. Hach LDO 2 probe with Hach sc1000 controller.
 - b. YSI IQ SensorNet FDO with Model IQ Sensornet 284 controller.
- B. All analyzer elements connected to a common transmitter must be furnished by the same manufacturer.

2.02 MANUFACTURED UNITS

- A. Optical Dissolved oxygen analyzer:
 - 1. General:
 - a. Dissolved oxygen analyzer for continuous monitoring of dissolved oxygen in liquid.
 - 2. Performance requirements:
 - a. Measuring range: 0 to 20 parts per million.
 - b. Sensor accuracy:
 - 1) Within 0.2 parts per million for values above 5 parts per million.
 - 2) Within 0.1 parts per million for values below 5 parts per million.
 - c. Repeatability: Within 0.1 parts per million.

- d. Response time:
 - 1) 90 percent value: Less than 40 seconds.
 - 2) 95 percent value: Less than 60 seconds.
- 3. Element:
 - a. Optical type that measures the fluorescence or luminescence of a ruthenium or platinum coated sensor.
 - b. Using no membrane, electrodes, or electrolyte.
 - c. Drift: less than 1 percent per year.
 - d. Automatic self-diagnostics.
 - e. Integral temperature sensor.
 - f. Maximum pressure: 50 pounds per square inch.
 - g. Power supply: From transmitter through the sensor cable.
 - h. Enclosure: NEMA Type 6P.
- 4. Transmitter:
 - a. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 75 VA maximum.
 - b. Outputs:
 - 1) Modbus TCP.
 - c. Microprocessor based with features resident in non-volatile memory.
 - d. Display dissolved oxygen content with 0.01 parts per million resolution over a range of 0.00 to 9.99 parts per million and 0.1 parts per million resolution over a range of 10.0 to 20.0 parts per million.
 - e. Display temperature with 0.2 degree Celsius accuracy.
 - f. Enclosure rating: NEMA Type 4X.
 - g. Automatic temperature compensation.
- 5. Components:
 - a. Manufacturer's cable for sensor to transmitter connection.

2.03 ACCESSORIES

- A. Calibration equipment:
 - 1. Provide components recommended by the manufacturer to verify calibration.
- B. Provide sunshade for outdoor installations.
- C. Provide manufacturer's hand rail swivel mounting hardware with all stainless steel components and float type sensor housing.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.05 ADJUSTING

- A. As specified in Section 17950 - Testing, Calibration, and Commissioning.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.	P.O.		
							By	Chk	App	
G	1	Tag No.	AE/AIT-16.241				AE/AIT-16.242			
E	2	Service	ZONE OX-4				ZONE OX-5B			
N	3	P&ID	PI16-05				PI16-06			
S	4	Type	Luminescent, Immersion type				Luminescent, Immersion type			
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit				32 to 122 degrees Fahrenheit			
N	6	Resolution	0.01 ppm				0.01 ppm			
S	7	Sensitivity	±0.5% of span				±0.5% of span			
O	8	Repeatability	±0.1 ppm				±0.1 ppm			
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm				± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm			
	10	Manufacturer								
	11	Model No.								
C	12	Style	Mfr Recommended				Mfr Recommended			
A	13	Length	As required				As required			
B	14	Model No.								
L	15	Other								
E	16	Other								
	17	Type	Microprocessor-based				Microprocessor-based			
T	18	Enclosure	NEMA 4X				NEMA 4X			
R	19	Mounting	Remote				Remote			
A	20	Range	0-5 mg/l				0-5 mg/l			
N	21	Repeatability	±0.05% of range				±0.05% of range			
S	22	Power Requirements	120 VAC				120 VAC			
M	23	Display								
I	24	Resolution								
T	25	Number of sensor input channels								
T	26	Outputs	Modbus TCP				Modbus TCP			
E	27	Manufacturer								
R	28	Model No.								
	29	Ambient Operating Temperature	-4 to 140 degrees Fahrenheit				-4 to 140 degrees Fahrenheit			
	30	Relays	4 SPDT type				4 SPDT type			
O	31	Mounting Kit								
P	32	Cleaning								
T	33	Power cord								
Notes: AIT-16.241: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.										

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.	P.O.		
							By	Chk	App	
G	1	Tag No.	AE-16.243				AE/AIT-16.244			
E	2	Service	ZONE OX-6C				ZONE OX-7C			
N	3	P&ID	PI16-07				PI16-08			
S	4	Type	Luminescent, Immersion type				Luminescent, Immersion type			
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit				32 to 122 degrees Fahrenheit			
N	6	Resolution	0.01 ppm				0.01 ppm			
S	7	Sensitivity	±0.5% of span				±0.5% of span			
O	8	Repeatability	±0.1 ppm				±0.1 ppm			
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm				± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm			
	10	Manufacturer								
	11	Model No.								
C	12	Style	Mfr Recommended				Mfr Recommended			
A	13	Length	As required				As required			
B	14	Model No.								
L	15	Other								
E	16	Other								
	17	Type					Microprocessor-based			
T	18	Enclosure					NEMA 4X			
R	19	Mounting					Remote			
A	20	Range					0-5 mg/l			
N	21	Repeatability					±0.05% of range			
S	22	Power Requirements					120 VAC			
M	23	Display								
I	24	Resolution								
T	25	Number of sensor input channels								
T	26	Outputs					Modbus TCP			
E	27	Manufacturer								
R	28	Model No.								
	29	Ambient Operating Temperature					-4 to 140 degrees Fahrenheit			
	30	Relays					4 SPDT type			
O	31	Mounting Kit								
P	32	Cleaning								
T	33	Power cord								
Notes: AE-16.243: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.										

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.	P.O.		
							By	Chk	App	
G	1	Tag No.	AE/AIT-16.245				AE/AIT-16.246			
E	2	Service	ZONE OX-8C				ZONE OX-9B			
N	3	P&ID	PI16-09				PI16-10			
S	4	Type	Luminescent, Immersion type				Luminescent, Immersion type			
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit				32 to 122 degrees Fahrenheit			
N	6	Resolution	0.01 ppm				0.01 ppm			
S	7	Sensitivity	±0.5% of span				±0.5% of span			
O	8	Repeatability	±0.1 ppm				±0.1 ppm			
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm				± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm			
	10	Manufacturer								
	11	Model No.								
C	12	Style	Mfr Recommended				Mfr Recommended			
A	13	Length	As required				As required			
B	14	Model No.								
L	15	Other								
E	16	Other								
	17	Type	Microprocessor-based				Microprocessor-based			
T	18	Enclosure	NEMA 4X				NEMA 4X			
R	19	Mounting	Remote				Remote			
A	20	Range	0-5 mg/l				0-5 mg/l			
N	21	Repeatability	±0.05% of range				±0.05% of range			
S	22	Power Requirements	120 VAC				120 VAC			
M	23	Display								
I	24	Resolution								
T	25	Number of sensor input channels								
T	26	Outputs	Modbus TCP				Modbus TCP			
E	27	Manufacturer								
R	28	Model No.								
	29	Ambient Operating Temperature	-4 to 140 degrees Fahrenheit				-4 to 140 degrees Fahrenheit			
	30	Relays	4 SPDT type				4 SPDT type			
O	31	Mounting Kit								
P	32	Cleaning								
T	33	Power cord								
Notes: AIT-16.246: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.										

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.		P.O.	
							By	Chk	App	

G	1	Tag No.	AE/AIT-16.247	AE/AIT-16.341
E	2	Service	ZONE OX-10	ZONE OX-1
N	3	P&ID	PI16-12	PI16-18
S	4	Type	Luminescent, Immersion type	Luminescent, Immersion type
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit	32 to 122 degrees Fahrenheit
N	6	Resolution	0.01 ppm	0.01 ppm
S	7	Sensitivity	±0.5% of span	±0.5% of span
O	8	Repeatability	±0.1 ppm	±0.1 ppm
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm
	10	Manufacturer		
	11	Model No.		
C	12	Style	Mfr Recommended	Mfr Recommended
A	13	Length	As required	As required
B	14	Model No.		
L	15	Other		
E	16	Other		
	17	Type	Microprocessor-based	Microprocessor-based
T	18	Enclosure	NEMA 4X	NEMA 4X
R	19	Mounting	Remote	Remote
A	20	Range	0-5 mg/l	0-5 mg/l
N	21	Repeatability	±0.05% of range	±0.05% of range
S	22	Power Requirements	120 VAC	120 VAC
M	23	Display		
I	24	Resolution		
T	25	Number of sensor input channels		
T	26	Outputs	Modbus TCP	Modbus TCP
E	27	Manufacturer		
R	28	Model No.		
	29	Ambient Operating Temperature	-4 to 140 degrees Fahrenheit	-4 to 140 degrees Fahrenheit
	30	Relays	4 SPDT type	4 SPDT type
O	31	Mounting Kit		
P	32	Cleaning		
T	33	Power cord		

Notes:
 AIT-16.247: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.
 AIT-16.341: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.		P.O.	
							By	Chk	App	
G	1	Tag No.	AE/AIT-16.342				AE-16.343			
E	2	Service	ZONE OX-5B				ZONE OX-6C			
N	3	P&ID	PI16-19				PI16-20			
S	4	Type	Luminescent, Immersion type				Luminescent, Immersion type			
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit				32 to 122 degrees Fahrenheit			
N	6	Resolution	0.01 ppm				0.01 ppm			
S	7	Sensitivity	±0.5% of span				±0.5% of span			
O	8	Repeatability	±0.1 ppm				±0.1 ppm			
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm				± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm			
	10	Manufacturer								
	11	Model No.								
C	12	Style	Mfr Recommended				Mfr Recommended			
A	13	Length	As required				As required			
B	14	Model No.								
L	15	Other								
E	16	Other								
	17	Type	Microprocessor-based							
T	18	Enclosure	NEMA 4X							
R	19	Mounting	Remote							
A	20	Range	0-5 mg/l							
N	21	Repeatability	±0.05% of range							
S	22	Power Requirements	120 VAC							
M	23	Display								
I	24	Resolution								
T	25	Number of sensor input channels								
T	26	Outputs	Modbus TCP							
E	27	Manufacturer								
R	28	Model No.								
	29	Ambient Operating Temperature	-4 to 140 degrees Fahrenheit							
	30	Relays	4 SPDT type							
O	31	Mounting Kit								
P	32	Cleaning								
T	33	Power cord								
Notes: AE-16.343: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.										

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.		P.O.	
							By	Chk	App	
G	1	Tag No.	AE/AIT-16.344				AE/AIT-16.345			
E	2	Service	ZONE OX-7C				ZONE OX-8C			
N	3	P&ID	PI16-21				PI16-22			
S	4	Type	Luminescent, Immersion type				Luminescent, Immersion type			
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit				32 to 122 degrees Fahrenheit			
N	6	Resolution	0.01 ppm				0.01 ppm			
S	7	Sensitivity	±0.5% of span				±0.5% of span			
O	8	Repeatability	±0.1 ppm				±0.1 ppm			
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm				± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm			
	10	Manufacturer								
	11	Model No.								
C	12	Style	Mfr Recommended				Mfr Recommended			
A	13	Length	As required				As required			
B	14	Model No.								
L	15	Other								
E	16	Other								
	17	Type	Microprocessor-based				Microprocessor-based			
T	18	Enclosure	NEMA 4X				NEMA 4X			
R	19	Mounting	Remote				Remote			
A	20	Range	0-5 mg/l				0-5 mg/l			
N	21	Repeatability	±0.05% of range				±0.05% of range			
S	22	Power Requirements	120 VAC				120 VAC			
M	23	Display								
I	24	Resolution								
T	25	Number of sensor input channels								
T	26	Outputs	Modbus TCP				Modbus TCP			
E	27	Manufacturer								
R	28	Model No.								
	29	Ambient Operating Temperature	-4 to 140 degrees Fahrenheit				-4 to 140 degrees Fahrenheit			
	30	Relays	4 SPDT type				4 SPDT type			
O	31	Mounting Kit								
P	32	Cleaning								
T	33	Power cord								
Notes:										

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.		P.O.	
							By	Chk	App	

G	1	Tag No.	AE/AIT-16.346	AE/AIT-16.347
E	2	Service	ZONE OX-9B	ZONE OX-10
N	3	P&ID	PI16-23	PI16-25
S	4	Type	Luminescent, Immersion type	Luminescent, Immersion type
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit	32 to 122 degrees Fahrenheit
N	6	Resolution	0.01 ppm	0.01 ppm
S	7	Sensitivity	±0.5% of span	±0.5% of span
O	8	Repeatability	±0.1 ppm	±0.1 ppm
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm
	10	Manufacturer		
	11	Model No.		
C	12	Style	Mfr Recommended	Mfr Recommended
A	13	Length	As required	As required
B	14	Model No.		
L	15	Other		
E	16	Other		
	17	Type	Microprocessor-based	Microprocessor-based
T	18	Enclosure	NEMA 4X	NEMA 4X
R	19	Mounting	Remote	Remote
A	20	Range	0-5 mg/l	0-5 mg/l
N	21	Repeatability	±0.05% of range	±0.05% of range
S	22	Power Requirements	120 VAC	120 VAC
M	23	Display		
I	24	Resolution		
T	25	Number of sensor input channels		
T	26	Outputs	Modbus TCP	Modbus TCP
E	27	Manufacturer		
R	28	Model No.		
	29	Ambient Operating Temperature	-4 to 140 degrees Fahrenheit	-4 to 140 degrees Fahrenheit
	30	Relays	4 SPDT type	4 SPDT type
O	31	Mounting Kit		
P	32	Cleaning		
T	33	Power cord		

Notes:
 AIT-16.346: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.
 AIT-16.347: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.	P.O.		
							By	Chk	App	

G	1	Tag No.	AE/AIT-16.441	AE/AIT-16.442
E	2	Service	ZONE OX-4	ZONE OX-5B
N	3	P&ID	PI16-31	PI16-32
S	4	Type	Luminescent, Immersion type	Luminescent, Immersion type
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit	32 to 122 degrees Fahrenheit
N	6	Resolution	0.01 ppm	0.01 ppm
S	7	Sensitivity	±0.5% of span	±0.5% of span
O	8	Repeatability	±0.1 ppm	±0.1 ppm
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm
	10	Manufacturer		
	11	Model No.		
C	12	Style	Mfr Recommended	Mfr Recommended
A	13	Length	As required	As required
B	14	Model No.		
L	15	Other		
E	16	Other		
	17	Type	Microprocessor-based	Microprocessor-based
T	18	Enclosure	NEMA 4X	NEMA 4X
R	19	Mounting	Remote	Remote
A	20	Range	0-5 mg/l	0-5 mg/l
N	21	Repeatability	±0.05% of range	±0.05% of range
S	22	Power Requirements	120 VAC	120 VAC
M	23	Display		
I	24	Resolution		
T	25	Number of sensor input channels		
T	26	Outputs	Modbus TCP	Modbus TCP
E	27	Manufacturer		
R	28	Model No.		
	29	Ambient Operating Temperature	-4 to 140 degrees Fahrenheit	-4 to 140 degrees Fahrenheit
	30	Relays	4 SPDT type	4 SPDT type
O	31	Mounting Kit		
P	32	Cleaning		
T	33	Power cord		

Notes:
 AIT-16.441: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.	P.O.		
							By	Chk	App	
G	1	Tag No.	AE-16.443				AE/AIT-16.444			
E	2	Service	ZONE OX-6C				ZONE OX-7C			
N	3	P&ID	PI16-33				PI16-34			
S	4	Type	Luminescent, Immersion type				Luminescent, Immersion type			
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit				32 to 122 degrees Fahrenheit			
N	6	Resolution	0.01 ppm				0.01 ppm			
S	7	Sensitivity	±0.5% of span				±0.5% of span			
O	8	Repeatability	±0.1 ppm				±0.1 ppm			
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm				± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm			
	10	Manufacturer								
	11	Model No.								
C	12	Style	Mfr Recommended				Mfr Recommended			
A	13	Length	As required				As required			
B	14	Model No.								
L	15	Other								
E	16	Other								
	17	Type					Microprocessor-based			
T	18	Enclosure					NEMA 4X			
R	19	Mounting					Remote			
A	20	Range					0-5 mg/l			
N	21	Repeatability					±0.05% of range			
S	22	Power Requirements					120 VAC			
M	23	Display								
I	24	Resolution								
T	25	Number of sensor input channels								
T	26	Outputs					Modbus TCP			
E	27	Manufacturer								
R	28	Model No.								
	29	Ambient Operating Temperature					-4 to 140 degrees Fahrenheit			
	30	Relays					4 SPDT type			
O	31	Mounting Kit								
P	32	Cleaning								
T	33	Power cord								
Notes: AE-16.443: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.										

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.	P.O.		
							By	Chk	App	
G	1	Tag No.	AE/AIT-16.445			AE/AIT-16.446				
E	2	Service	ZONE OX-8C			ZONE OX-9B				
N	3	P&ID	PI16-35			PI16-36				
S	4	Type	Luminescent, Immersion type			Luminescent, Immersion type				
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit			32 to 122 degrees Fahrenheit				
N	6	Resolution	0.01 ppm			0.01 ppm				
S	7	Sensitivity	±0.5% of span			±0.5% of span				
O	8	Repeatability	±0.1 ppm			±0.1 ppm				
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm			± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm				
	10	Manufacturer								
	11	Model No.								
C	12	Style	Mfr Recommended			Mfr Recommended				
A	13	Length	As required			As required				
B	14	Model No.								
L	15	Other								
E	16	Other								
	17	Type	Microprocessor-based			Microprocessor-based				
T	18	Enclosure	NEMA 4X			NEMA 4X				
R	19	Mounting	Remote			Remote				
A	20	Range	0-5 mg/l			0-5 mg/l				
N	21	Repeatability	±0.05% of range			±0.05% of range				
S	22	Power Requirements	120 VAC			120 VAC				
M	23	Display								
I	24	Resolution								
T	25	Number of sensor input channels								
T	26	Outputs	Modbus TCP			Modbus TCP				
E	27	Manufacturer								
R	28	Model No.								
	29	Ambient Operating Temperature	-4 to 140 degrees Fahrenheit			-4 to 140 degrees Fahrenheit				
	30	Relays	4 SPDT type			4 SPDT type				
O	31	Mounting Kit								
P	32	Cleaning								
T	33	Power cord								
Notes: AIT-16.446: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.										

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST, WEST JORDAN, UT 84084 BOM No.: File:			ANALYZERS - DISSOLVED OXYGEN (DO)				Spec. No. 17506		Rev.	
			No	By	Date	Revision	Contract		Date	
							Req.	P.O.		
							By	Chk	App	
G	1	Tag No.	AE/AIT-16.447							
E	2	Service	ZONE OX-10							
N	3	P&ID	PI16-38							
S	4	Type	Luminescent, Immersion type							
E	5	Operating Temperature Range	32 to 122 degrees Fahrenheit							
N	6	Resolution	0.01 ppm							
S	7	Sensitivity	±0.5% of span							
O	8	Repeatability	±0.1 ppm							
R	9	Accuracy	± 0.1 ppm Below 5 ppm; ± 0.2 ppm Above 5 ppm							
	10	Manufacturer								
	11	Model No.								
C	12	Style	Mfr Recommended							
A	13	Length	As required							
B	14	Model No.								
L	15	Other								
E	16	Other								
	17	Type	Microprocessor-based							
T	18	Enclosure	NEMA 4X							
R	19	Mounting	Remote							
A	20	Range	0-5 mg/l							
N	21	Repeatability	±0.05% of range							
S	22	Power Requirements	120 VAC							
M	23	Display								
I	24	Resolution								
T	25	Number of sensor input channels								
T	26	Outputs	Modbus TCP							
E	27	Manufacturer								
R	28	Model No.								
	29	Ambient Operating Temperature	-4 to 140 degrees Fahrenheit							
	30	Relays	4 SPDT type							
O	31	Mounting Kit								
P	32	Cleaning								
T	33	Power cord								
Notes: AIT-16.447: Multiple elements connected to a single transmitter as shown on the Drawings. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.										

SECTION 17518

ANALYZERS: MIXED LIQUOR SUSPENDED SOLIDS (MLSS)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Mixed liquor suspended solids (MLSS) analyzer.
- B. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. MLSS - Mixed liquor suspended solids.
 - 2. NIR - Near infrared.
 - 3. SS - Suspended solids.
 - 4. DO - Dissolved oxygen.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Hach, SOLITAX sensor with SC1000 controller.
 - 2. YSI, ViSolid 700 IQ with IQ Sensornet 284 controller.
- B. All analyzer elements connected to a common transmitter must be furnished by the same manufacturer.

2.02 MANUFACTURED UNITS

- A. MLSS analyzer.
 - 1. MLSS Sensor:
 - a. Based on NIR light technology.
 - b. Sensor drift: less than 1 percent per year.
 - c. Automatic self-diagnostics sensor check.
 - d. Maximum pressure: 87 pounds per square inch.
 - e. Sensor installation: Immersible
 - f. Wetted material: Epoxy, polyurethane, and PVC or Type 316 stainless steel.

- g. Environmental requirements:
 - 1) Temperature range: 0 degrees Celsius to 40 degrees Celsius.
 - a) Humidity range: 15 percent to 95 percent relative humidity
- 2. Performance:
 - a. Measuring ranges: 0 to 30,000 milligrams per liter.
 - b. Response time: 90 percent value in less than 60 seconds.
 - c. Accuracy: 3 percent of reading.
 - d. Sensitivity/resolution:
 - 1) 1 milligrams per liter below 1,000 milligrams per liter.
 - 2) 10 milligrams per liter between 1,000 milligrams per liter and 9,999 milligrams per liter.
 - 3) 100 milligrams per liter above 10,000 milligrams per liter.
 - e. Repeatability: Within 3 percent.
- 3. Element:
 - a. Operation modes: Run mode, setup mode, and test mode.
- 4. Transmitter: As specified in Section 17506 - Pressure/Vacuum Measurement: Differential.

2.03 ACCESSORIES

- A. Provide calibration kit.
- B. Provide sunshades for outdoor installations.
- C. Provide manufacturer's hand rail swivel mounting hardware with all stainless steel components.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.05 ADJUSTING

- A. As specified in Section 17950 - Testing, Calibration, and Commissioning.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:			ANALYZER - MIXED LIQUOR SUSPENDED SOLIDS (MLSS)				Spec. No. 17518		Rev.	
			No	By	Date	Revision				
							Contract		Date	
							Req.		P.O.	
							By	Chk	App	
G	1	Tag No.	AE-16.252				AE-16.352			
E	2	Service	ZONE AX-1				ZONE AX-1			
N	3	P&ID	PI16-03				PI16-16			
S	4	Type	IMMERSIBLE				IMMERSIBLE			
E	5	Operating Temperature Range	0-40 °C				0-40 °C			
N	6	Resolution								
S	7	Calibrated Range	0-4000 mg/L				0-4000 mg/L			
O	8	Repeatability								
R	9	Accuracy								
	10	Manufacturer								
	11	Model No.								
C	12	Style	Mfr Recommended				Mfr Recommended			
A	13	Length	As required				As required			
B	14	Model No.								
L	15	Other								
E	16	Other								
	17	Type								
T	18	Enclosure								
R	19	Mounting								
A	20	Range								
N	21	Repeatability								
S	22	Power Requirements								
M	23	Display								
I	24	Resolution								
T	25	Number of sensor input channels								
T	26	Outputs								
E	27	Manufacturer								
R	28	Model No.								
	29	Ambient Operating Temperature								
	30	Relays								
O	31	Mounting Kit								
P	32	Cleaning								
T	33	Power cord								
Notes: INCLUDED UNDER ADDITIVE BID ITEM NO. 2 TRANSMITTER ASSOCIATED WITH EACH ELEMENT IS SPECIFIED IN SECTION 17506. CONNECTIONS TO TRANSMITTER ARE INDICATED ON THE DRAWINGS.										

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:			ANALYZER - MIXED LIQUOR SUSPENDED SOLIDS (MLSS)				Spec. No. 17518		Rev.
			No	By	Date	Revision			
							Contract	Date	
							Req.	P.O.	
							By	Chk	
							App		
G	1	Tag No.	AE-16.452						
E	2	Service	ZONE AX-1						
N	3	P&ID	PI16-29						
S	4	Type	IMMERSIBLE						
E	5	Operating Temperature Range	0-40 °C						
N	6	Resolution							
S	7	Calibrated Range	0-4000 mg/L						
O	8	Repeatability							
R	9	Accuracy							
	10	Manufacturer							
	11	Model No.							
C	12	Style	Mfr Recommended						
A	13	Length	As required						
B	14	Model No.							
L	15	Other							
E	16	Other							
	17	Type							
T	18	Enclosure							
R	19	Mounting							
A	20	Range							
N	21	Repeatability							
S	22	Power Requirements							
M	23	Display							
I	24	Resolution							
T	25	Number of sensor input channels							
T	26	Outputs							
E	27	Manufacturer							
R	28	Model No.							
	29	Ambient Operating Temperature							
	30	Relays							
O	31	Mounting Kit							
P	32	Cleaning							
T	33	Power cord							
Notes: INCLUDED UNDER ADDITIVE BID ITEM NO. 2 TRANSMITTER ASSOCIATED WITH EACH ELEMENT IS SPECIFIED IN SECTION 17506. CONNECTIONS TO TRANSMITTER ARE INDICATED ON THE DRAWINGS.									

DELETE THIS SECTION
BECAUSE THE ELECTRODE LIFE
OF THESE PROBES IS 2-3
WEEKS IN MIXED LIQUOR.

SECTION 17519

ANALYZERS: AMMONIA

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Ammonia analyzers.
- B. Provide all instruments as identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Hach:
 - a. Sensor Probe: AISE
 - 2. YSI:
 - a. Sensor Probe: AmmoLyt Plus 700 IQ.

2.02 MANUFACTURED UNITS

- A. Ammonia analyzers:
 - 1. General:
 - a. Ammonia monitors shall be supplied for continuous monitoring of ammonia in solution:
 - 1) The ammonia monitoring system shall include:
 - a) A sensor for ammonium ion selective measurement as described below.
 - b) Associated accessories described below.
 - 2. Performance requirements:
 - a. Accuracy: Within 2 percent of full scale.
 - b. Repeatability: Within 2 percent of full scale.
 - c. Range:
 - 1) 0.1 to 129 milligrams per liter.
 - 3. Sensor:
 - a. Ammonium ion selective measurement with automatic potassium compensation.

- b. Operating temperature range: 0 degrees Celsius to 40 degrees Celsius.
 - c. Calibration free for the service life of the electrode with capability of matrix adjustment.
- 4. Transmitter: As specified in Section 17506.

- B. All analyzer elements connected to a common transmitter must be furnished by the same manufacturer.

2.03 ACCESSORIES

- A. Provide sunshades for outdoor installations.
- B. Provide all required mounting accessories.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide manufacturer's services to perform installation inspection, start-up and calibration/verification.

3.05 ADJUSTING

- A. As specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:				AMMONIA ANALYZER				Spec. No.		Rev.	
								17519			
				No	By	Date	Revision	Contract		Date	
								Req.		P.O.	
				By	Chk	App					
G E N	1	Tag No.	Sample Unit	Transmitter	AE-16.254		AE-16.354				
	2	Service			ZONE OX-10		ZONE OX-10				
	3	P&ID			PI16-12		PI16-25				
S M P L U N I T	4	Type									
	5	Enclosure									
	6	Calibrated Range			0-2 mg/L		0-2 mg/L				
	7	Operating Temperature Range									
	8	Sample Temperature Range									
	9	Sample Flow Required									
	10	Manufacturer									
	11	Model No.									
12	Other										
C A B L E	13	Style									
	14	Length			As required		As required				
	15	Model No.									
	16	Other									
T R A N S M I T T E R	17	Other									
	18	Type									
	19	Enclosure									
	20	Mounting									
	21	Accuracy									
	22	Range									
	23	Power Requirements									
	24	Display									
	25	Resolution									
	26	Output									
	27	Calibration									
	28	Manufacturer									
	29	Model No.									
	30	Other									
	31	Other									
	O P T S	32	Other								
33		Buffer									
34											
35											
36											
37											
38											
Notes: Included under Additive Bid Item No. 2. Transmitter associated with each element is specified in Section 17506. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.											

A/E: Carollo Engineers Contractor: Project: PROJECT 5 Customer: SOUTH VALLEY WATER RECLAMATION FACILITY Plant: Location: 7495 SOUTH 1300 WEST WEST JORDAN, UT 84084 BOM No.: File:				AMMONIA ANALYZER						
								Spec. No.		Rev.
				No	By	Date	Revision	17519		
								Contract		Date
								Req.		P.O.
								By	Chk	App
G E N	1	Tag No.	Sample Unit	Transmitter	AE-16.454					
	2	Service			ZONE OX-10					
	3	P&ID			PI16-25					
S M P L U N I T	4	Type								
	5	Enclosure								
	6	Calibrated Range			0-2 mg/L					
	7	Operating Temperature Range								
	8	Sample Temperature Range								
	9	Sample Flow Required								
	10	Manufacturer								
	11	Model No.								
	12	Other								
C A B L E	13	Style								
	14	Length			As required					
	15	Model No.								
	16	Other								
	17	Other								
T R A N S M I T T E R	18	Type								
	19	Enclosure								
	20	Mounting								
	21	Accuracy								
	22	Range								
	23	Power Requirements								
	24	Display								
	25	Resolution								
	26	Output								
	27	Calibration								
	28	Manufacturer								
	29	Model No.								
	30	Other								
	31	Other								
	32	Other								
O P T S	33	Buffer								
	34									
	35									
	36									
	37									
	38									
Notes: Included under Additive Bid Item No. 2. Transmitter associated with each element is specified in Section 17506. It is the Contractor's responsibility to ensure that the transmitter has correct functionality for all analyzer elements. Refer to P&IDs for detailed analyzer element connections.										

SECTION 17710

CONTROL SYSTEMS: PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:
 - a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
 - b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
 - c. Control components.
 - d. Control panel installation.
- B. Provide all control panels identified in Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41.1 - Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
- C. Underwriters Laboratories Inc. (UL):
 - 1. 508 - Standard for Industrial Control Equipment.
 - 2. 508A - Standard for Industrial Control Panel.
 - 3. 913 - Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.
 - 4. 1283 - Standard for Electromagnetic Interference Filters.
 - 5. 1449 - Standard for Surge Protective Devices.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. The term "panel" in this Section is interchangeable with the term "enclosure."

1.04 SYSTEM DESCRIPTION

- A. Panel dimensions:
 - 1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
 - a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
 - b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
 - c. Maximum panel depth: 30 inches, unless otherwise indicated.
- B. Structural design:
 - 1. Completed and installed panel work shall safely withstand seismic requirements at the project site as specified in Section 16050 - Common Work Results for Electrical. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

- A. Provide submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide a control panel hardware submittal for each control panel and enclosure being provided on this project, including but not limited to:
 - 1. Product data:
 - a. Enclosure construction details and NEMA type.
 - b. Manufacturer's literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
 - 2. Shop drawings:
 - a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
 - 1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
 - b. Complete nameplate engraving schedule.
 - c. Structural details of fabricated panels.
 - 3. Calculations:
 - a. Provide installation details based on calculated shear and tension forces:
 - 1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
 - b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
 - 1) Weight including panel internal components.
 - 2) Seismic forces and overturning moments.
 - 3) Shear and tension forces in connections.
 - c. Cooling calculations, including but not limited to:
 - 1) Highest expected ambient temperature for the enclosure's location.
 - 2) Internal heat load.
 - 3) Exposure to direct sunlight.
 - 4) Dimensions of the enclosure in inches.

- 5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Seismic design:

1. Seismic panel construction:

- a. Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612 - Seismic Design Criteria:
 - 1) Stamped by a Professional Engineer registered in the state where the project is being constructed.
- b. For floor-mounted freestanding panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01612 - Seismic Design Criteria. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
 1. Provide all components and equipment with UL 508 listing.
 2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
 - a. Non-listed, complex, and unique equipment may be evaluated and approved by a third-party testing agency, with prior approval by the Owner. Provide report documenting the testing standard, specification, method of testing, and that the equipment and materials meet appropriate designated standards or have been tested and found suitable for use in a specified manner.
 3. Provide fuses for all equipment that is not UL or UR listed.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. As listed below in the individual component paragraphs.
- B. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.

2.02 EXISTING PRODUCTS

- A. Provide labor and materials for complete modifications to existing panels as required.

2.03 MATERIALS

- A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
 - 1. Enclosures shall have the following properties:
 - a. NEMA Type 1: Steel.
 - b. NEMA Type 4: Steel with gasketed door, raintight.
 - c. NEMA Type 4X: Type 316 stainless steel (unless Type 304 is indicated on the Drawings).
 - d. NEMA Type 12: Steel with gasketed door, dusttight.
 - e. NEMA Type 7: Cast aluminum.
- B. Bolting material:
 - 1. Commercial quality 1/2-inch diameter, stainless steel hex-head Grade 5 bolts, nuts, and washers, with unified coarse (UNC) threads.
 - 2. Carriage bolts for attaching end plates.
 - 3. All other bolted joints shall have S.A.E. standard lock washers.

2.04 MANUFACTURED UNITS

A. Panels/enclosures:

1. Manufacturers: One of the following or equal:
 - a. Rittal.
 - b. Pentair (formerly Hoffman Engineering).
 - c. Saginaw Control & Engineering.
2. Panel assembly:
 - a. General guidelines for panel fabrication include:
 - 1) Continuous welds ground smooth.
 - 2) Exposed surfaces free of burrs and sharp edges.
 - 3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2-inch holes at 12-inch spacing to accommodate anchoring of freestanding enclosures to floor.
 - b. Construct enclosure and mounting panel using stretcher-level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Wall-mounted up to 48	14	14
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10
82 or more	10	10

- 1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.
- c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
- d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.
- e. Door construction:
 - 1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
 - 2) Sufficient width to permit door opening without interference with rear projection of flush-mounted instruments.
 - 3) Heavy-gauge piano-type continuous stainless steel hinges.
 - 4) For NEMA Type 12, Type 4, and Type 4X, provide oil-resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
 - 5) Gasket installed to seal against roll lip on the enclosure opening.
- f. Latches:
 - 1) For panels, provide each door with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods shall be connected to a common door handle, hold doors securely,

- and form a compressed seal between door and gasket, at the top, side, and bottom.
 - a) Provide padlock for each enclosure with padlock provisions.
 - 2) Include an oiltight key-locking, 3-point latching mechanism on each door:
 - a) Provide 2 keys per panel.
 - b) All locks keyed alike.
 - 3) For large NEMA Type 4 and NEMA Type 4X cabinets not available with 3-point latching hardware, provide multiple clips and padlock hasps.
 - g. Panel cut-outs:
 - 1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
 - 2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
 - 3) Reinforce around cut-outs with steel angles or flat bars for the following:
 - a) Large panel cutouts; for example, openings for local operator interfaces.
 - b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.
 - 3. In addition to the requirements specified above, the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
 - a. Minimum 14-gauge, Type 304 stainless steel.
 - b. Captive stainless steel cover screws threaded into sealed wells.
 - c. Inside finish: White polyester powder coating.
 - d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
 - 4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
 - a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.
 - b. Door hardware: Stainless steel.
 - c. Provide factory installed rain canopy and sun shield for all enclosures with operator interface panels.
 - d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.
- B. Arrangement of components:
- 1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
 - 2. Arrange panel instruments and control devices in a logical configuration, associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
 - 3. Mount internal control components on an internal back panel. Devices may be mounted on the side panel only by special permission from the Engineer.
 - 4. All control-panel-mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.

- C. Overcurrent protection:
1. Main overcurrent device:
 - a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange-mounted disconnect handle operating a molded-case circuit breaker and provide a control power transformer for 120-VAC circuits:
 - 1) Door-mounted disconnect handles are not acceptable.
 - 2) Mechanically interlock the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
 - 3) Provide means to defeat the interlock.
 - 4) Lockable in the off position.
 - b. Control panels supplied with 120 VAC:
 - 1) Provide an internal breaker with the line side terminals covered by a barrier.
 - 2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
 2. Provide circuit breakers as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
 3. Selection and ratings of protective devices:
 - a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
 - b. Voltage rating: Not less than the voltage of the application.
 - c. Select current rating and trip characteristics to be suitable for:
 - 1) Maximum normal operating current.
 - 2) Inrush characteristics.
 - 3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
 4. Provide a separate protective device for each powered electrical device:
 - a. An individual circuit breaker for each 120-VAC instrument installed within its respective control panel and clearly identified for function.
 - b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
 - 1) Size external fuse to open before any I/O-card-mounted fuses.
 - 2) Individual discrete inputs shall use a 0.5-ampere fuse.
 - c. Control loops can use individual 5-ampere fuse for the loop.
 - d. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
 5. Fuses for 4 to 20 milliamperes signals:
 - a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
 - 1) Label shall not cover or interfere with equipment manufacturer's instructions.
 - b. An individual 1/2-ampere fuse for each 4 to 20 milliamperes analog loop powered from the control panel.
 - c. Provide fuses rated for the voltage and available short-circuit current at which they are applied.
 - d. Manufacturers: One of the following or equal:
 - 1) Ferraz Shawmut.

- 2) Littelfuse.
 - 3) Bussmann.
 - 6. Fuse holders:
 - a. Modular type:
 - 1) DIN rail mounting on 35-millimeter rail.
 - 2) Touch-safe design: All connection terminals to be protected against accidental touch.
 - 3) Incorporates blown-fuse indicator.
 - 4) Plug-in style fuse terminals and fuse plugs are not acceptable.
 - b. Provide nameplate identifying each fuse:
 - 1) As specified in Section 16075 - Identification for Electrical Systems.
 - c. Manufacturers: One of the following or equal:
 - 1) Phoenix Contact.
 - 2) Allen-Bradley, 1492-FB Series B.
 - 7. Control circuit breakers:
 - a. DIN rail mounting on 35-millimeter rail.
 - b. Manual OPEN-CLOSE toggle switch.
 - c. Rated for 250 VAC.
 - d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
 - e. Current ratings: As indicated on the Drawings or as required for the application.
 - f. Provide nameplate identifying each circuit breaker:
 - 1) As specified in Section 16075 - Identification for Electrical Systems.
 - g. Manufacturers: One of the following or equal:
 - 1) Phoenix Contact.
 - 2) ABB.
 - 3) Allen-Bradley.
 - 4) Square D.
- D. Conductors and cables:
- 1. Power and control wiring:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 volts type MTW.
 - c. Minimum sizes:
 - 1) Primary power distribution: 12 AWG.
 - 2) Secondary power distribution: 14 AWG.
 - 3) Control: 16 AWG.
 - d. Color:
 - 1) AC power (line and load): Black.
 - 2) AC power (neutral): White.
 - 3) AC control: Red.
 - 4) AC control: Orange for foreign voltages.
 - 5) DC power and control (ungrounded): Blue.
 - 6) DC power and control (grounded): White with Blue stripe.
 - 7) Ground: Green.
 - 2. Signal cables:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 volts, PVC outer jacket.
 - c. Minimum size: 18 AWG paired triad.
 - d. Overall aluminum shield (tape).
 - e. Copper drain wire.

- f. Color:
 - 1) 2-Conductor:
 - a) Positive (+): Black.
 - b) Negative (-): White and red.
 - 2) 3-Conductor:
 - a) Positive (+): Black.
 - b) Negative (-): Red.
 - c) Signal: White.
- g. Insulate the foil shielding and exposed drain wire for each signal cable with heat-shrink tubing.

E. Conductor identification:

- 1. Identify each conductor and cable with unique wire numbers as specified in Section 16075 - Identification for Electrical Systems.
- 2. Readily identified without twisting the conductor.

F. General wiring requirements:

- 1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
- 2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
- 3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
- 4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
- 5. Provide power surge protection for all control panels.
- 6. Provide signal surge protection within control panels for each analog I/O, discrete I/O, and data line (Copper Ethernet, Coax, Fieldbus signals) that originates from outdoor devices.
- 7. Provide non-metallic ducts for routing and organization of conductors and cables:
 - a. Provide wiring separation plan.
 - b. Size ducts for ultimate build-out of the panel, or for 20-percent spare, whichever is greater.
 - c. Provide separate ducts for signal and low-voltage wiring from power and 120-VAC control wiring:
 - 1) 120 VAC: Grey colored ducts.
 - 2) 24 VDC: White colored ducts.
- 8. Cables shall be fastened with cable-mounting clamps or with cable ties supported by any of the following methods:
 - a. Screw-on cable tie mounts.
 - b. Hammer-on cable-tie mounting clips.
 - c. Fingers of the nonmetallic duct.
- 9. Wire ties:
 - a. No wire ties inside wire duct.
 - b. Use Panduit Cable tie installation tool, with tension control/cutoff.
 - c. Verify cut ends are cut flush filed smooth after installed.
- 10. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
- 11. Support panel conductors where necessary to keep them in place.

12. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
 13. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
 - a. Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
- G. Provide power circuits for all Contractor and Vendor-furnished PLC cabinets in accordance with the PLC and Instrument Power wiring diagrams Indicated on the Drawings or as specified.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Thermal management:
1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050 - Common Work Results for Process Control and Instrumentation.
 2. Air conditioner:
 - a. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interface (LOI) units, panel instruments, programmable logic controllers, or remote I/O.
 - b. Provide filters on intake and exhaust openings.
 - c. Increase panel sizes as needed to accommodate cooling units.
 - d. Enclosure rating: NEMA Type 4X.
 - e. Closed-loop design.
 - f. Power supply: 120 VAC.
 - g. Utilize a CFC-free refrigerant.
 - h. Manufacturers: The following or equal:
 - 1) Kooltronic, Integrity Series Guardian/Guardian X.
 3. Heating:
 - a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters, except where all of the following conditions apply:
 - 1) The panel is not supplied with 120 VAC power.
 - 2) There are no electronics or moisture-sensitive devices in the enclosure.
 - 3) The panel is smaller than 38 inches high.
 4. Heat exchanger:
 - a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
 - b. Filterless design to facilitate easy cleaning of the core.
 - c. Mounting: As indicated on the Drawings.
 - d. Manufacturers: The following or equal:
 - 1) Noren, CC Series.

5. Enclosure temperature switch:
 - a. Provide wall-mounted bimetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
 - b. Sensor and electronic enclosure.
 - c. Accuracy: Within 2 degrees Fahrenheit.
 - d. Manufacturers: One of the following or equal:
 - 1) Hoffman ATEMNC.
 - 2) Pfannenberger FLZ.
6. Status relays and discrete inputs for switches, power supplies, and fieldbus devices (if applicable):
 - a. Provide as indicated on the Drawings or as specified.
7. Fan ventilation:
 - a. Provide Hoffman fan speed control:
 - 1) Provide 2 door/cabinet-mounted vent fans for every 72 inches of cabinet width.
 - 2) Provide finger-guard kit.
 - 3) Filter kit with 2 spare filters for each intake fan.
 - 4) Provide bezel and gasket kit.
 - 5) Provide fan shroud.
 - 6) Automatically adjust fan speed depending on remote temperature sensor input.
 - 7) 120 VAC, 60 hertz.
 - 8) NEMA Type 5-15R cord connections.

B. Panel meters:

1. Pointer type:
 - a. Suitable for panel mounting.
 - b. Minimum scale length: 3 inches.
 - c. Calibrated in engineering units.
 - d. Accuracy: Within 2 percent of span.
 - e. NEMA Type 4/IP65 sealed front metal bezel.
 - f. Manufacturers: One of the following or equal:
 - 1) Yokogawa.
 - 2) Red Lion.
2. Digital process indicators:
 - a. General:
 - 1) Integral provisions for scaling.
 - 2) Scale to process engineering units.
 - 3) Switch-programmable decimal points.
 - 4) NEMA Type 4/IP65 sealed front bezel.
 - b. Current and voltage indicators:
 - 1) 3-1/2-digit minimum.
 - 2) Minimum character height: 0.5 inches.
 - 3) Accuracy:
 - a) AC/DC volts: Within 0.1 percent of reading plus 2 digits.
 - b) DC current: 4 to 20 milliamperes; within 0.1 percent of reading plus 1 digit.
 - c) DC voltage: 0 to 10 volts; within 0.1 percent of reading plus 1 digit.
 - c. Operating voltage: 120 VAC.
 - d. Operating temperature: 0 to 60 degrees Celsius.

- 1) Manufacturers: One of the following or equal:
 - a) Red Lion.
 - b) Action Instruments, Visipak.
3. Digital bar graph meter:
 - a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.
 - b. Suitable for panel mounting.
 - c. LED display:
 - 1) Not less than 3 decimal digits.
 - 2) Not less than a 101-segment LED bar graph.
 - d. Input signal:
 - 1) All conventional current loops and voltage control signals.
 - e. Minimum sample rate of once per second.
 - f. Provisions for field-adjustable scaling and/or offset.
 - g. Accuracy shall be within 1 least-significant digit.
 - h. Manufacturers: One of the following or equal:
 - 1) Ametek Dixson.
 - 2) Yokogawa.
 - 3) Weschler Instruments.
4. Counters:
 - a. 6 digits.
 - b. Switch-selectable inputs:
 - 1) Switch contacts.
 - 2) CMOS.
 - 3) TTL.
 - 4) Magnetic pickup.
 - 5) RLC sensors.
 - c. Selectable up/down control via external signal.
 - d. Remote reset.
 - e. Remote inhibit to prevent accumulating counts.
 - f. Programmable to enable or disable front panel reset.
 - g. Non-volatile memory to retain all data upon loss of supply power.
 - h. Sunlight readable.
 - i. Operating temperature: 0 to 50 degrees Celsius.
 - j. Manufacturers: The following or equal:
 - 1) Red Lion, PAX Series.
- C. Pilot devices:
 1. General:
 - a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
 - b. Size:
 - 1) 30.5 millimeters.
 - c. Heavy duty.
 - d. Pushbuttons:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
 - e. Selector switches:
 - 1) Contacts rated:
 - a) NEMA Type A600.

- b) Knob type.
 - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
 - 3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
 - f. Pilot lights:
 - 1) Type:
 - a) LED for interior installations.
 - 2) Push to test.
 - 3) Lamp color:
 - a) On/Running/Start: Red.
 - b) Off/Stop: Green.
 - c) Power: White.
 - d) Alarm: Amber.
 - e) Status or normal condition: White.
 - f) Opened: Amber.
 - g) Closed: Blue.
 - h) Failure: Red.
 - 2. Indoor and outdoor areas:
 - a. NEMA Type 4/13.
 - b. Manufacturers: One of the following or equal:
 - 1) Allen-Bradley, Type 800T.
 - 2) Square D, Class 9001, Type K.
 - 3) General Electric, Type CR104P.
 - 4) IDEC, TWTD Series.
 - 3. Corrosive areas:
 - a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc.
 - d. Manufacturers: One of the following or equal:
 - 1) Cutler Hammer, Type E34.
 - 2) Square D, Class 9001, Type SK.
 - 3) Allen-Bradley Type 800H.
 - 4) IDEC, TWTD Series.
 - 4. Hazardous (Classified) Areas/Class I Division 2:
 - a. NEMA Type 4X.
 - b. Corrosion resistant.
 - c. Exterior parts of high-impact strength fiberglass-reinforced polyester or multiple-layer epoxy-coated zinc:
 - 1) All contacts contained within a hermetically sealed chamber:
 - a) Pushbuttons.
 - b) Selector switches.
 - c) Push-to-test contacts on pilot lights.
 - 2) UL listed and labeled for Class I Division 2 areas.
 - d. Manufacturers: One of the following or equal:
 - 1) Cutler Hammer, Type E34.
 - 2) Allen-Bradley, Type 800H.
- D. Potentiometer and slidewire transmitters:
- 1. Provide a DC output in proportion to a potentiometer input.

2. Potentiometer input:
 - a. 100 ohms to 100 K ohms.
 - b. Impedance Greater or equal to 1 M ohms.
 - c. Zero turn-up: 80 percent of full-scale input.
 - d. Span turn-down: 80 percent of full-scale input.
 3. Field-configurable output:
 - a. Voltage and current: All conventional current loops and voltage control signals.
 4. Accuracy including linearity and hysteresis within 0.1 percent maximum at 25 degrees Celsius.
 5. Operating temperature: 0 to 55 degrees Celsius.
 6. Supply power: 9 to 30 VDC.
 7. Manufacturers: The following or equal:
 - a. Phoenix Contact.
- E. Signal isolators and converters:
1. Furnish signal isolators that provide complete isolation of input, output, and power input:
 - a. Minimum isolation level: 1.5 kilovolts AC/50 hertz for at least 1 minute.
 - b. Adjustable span and zero.
 - c. Accuracy: Within 1.0 percent of span.
 - d. Ambient temperature range: -20 to +65 degrees Celsius.
 2. Manufacturers: One of the following or equal:
 - a. Phoenix Contact, MCR Series.
 - b. Acromag, 1500, 600T, 800T, Flat Pack, or ACR Series.
 - c. Action Instruments, Q500 Series or Ultra SlimPakII.
 - d. AGM Electronics, Model TA-4000.
- F. Relays:
1. General:
 - a. For all types of 120-VAC relays, provide surge protection across the coil of each relay.
 - b. For all types of 24-VDC relays, provide a free-wheeling diode across the coil of each relay.
 2. General purpose:
 - a. Magnetic control relays.
 - b. NEMA Type R300 rated:
 - 1) 300 volts.
 - 2) 8 Amps continuous (minimum).
 - 3) 7,200 volt-amperes make.
 - 4) 720 volt-amperes break.
 - c. Plug-in type.
 - d. LED indication for energization status.
 - e. Coil voltages: As required for the application.
 - f. Minimum poles: DPDT.
 - g. Touch-safe design: All connection terminals to be protected against accidental touch.
 - h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
 - i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
 - j. Relays with screw-type socket terminals.

- k. Provide additional (slave/interposing) relays when the following occurs:
 - 1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
 - 2) Higher contact rating is required in order to interface with starter circuits or other equipment.
 - l. DIN rail mounting on 35-millimeter rail.
 - m. Ice-cube-type relays with retainer clips to secure relay in socket.
 - n. Integrated label holder for device labeling.
 - o. Manufacturers: One of the following or equal:
 - 1) Phoenix Contact PLC Series.
 - 2) Potter and Brumfield Type KRP or KUP.
 - 3) IDEC R* Series (* = H, J, R, S, U).
 - 4) Allen-Bradley Type 700 HC.
 - 5) Square D Type K.
3. Latching:
- a. Magnetic-latching control relays.
 - b. NEMA ratings:
 - 1) 300 volts.
 - 2) 5 Amps continuous.
 - 3) 3,60 volt-amperes make.
 - 4) 320 volt-amperes break.
 - c. Plug-in type.
 - d. DIN rail mounting on 35-millimeter rail.
 - e. Coil voltage: As required for the application.
 - f. Minimum poles: 2 PDT; as required for the application. Plus 1 spare pole.
 - g. Touch-safe design: All connection terminals to be protected against accidental touch.
 - h. Clear cover for visual inspection.
 - i. Provide retainer clip to secure relay in socket.
 - j. Manufacturers: One of the following or equal:
 - 1) Square D, 8501, Type K.
 - 2) IDEC, RR2KP Series.
4. Time delay:
- a. Provide time-delay relays to control contact transition time.
 - b. Contact rating:
 - 1) 240 volts.
 - 2) 10 Amps continuous.
 - 3) 3,600 volt-amperes make.
 - 4) 360 volt-amperes break.
 - c. Coil voltage: As required for the application.
 - d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off-delay:
 - 1) For off-delay, use true power-off time-delay relays. Where the required timing range exceeds capability of the off-delay relay use, signal off-delay where power loss will not cause undesirable operation or pneumatic time-delay relays.
 - e. Minimum poles: 2 PDT.
 - f. Units include adjustable dial with graduated scale covering the time range in each case.
 - g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.

- h. Manufacturers: One of the following or equal:
 - 1) IDEC, RTE Series.
 - 2) Agastat, Series 7000 (pneumatic).
 - 3) Allen-Bradley, Type 700-HR.
- G. Terminal blocks:
 - 1. DIN rail mounting on 35-millimeter rail.
 - 2. Suitable for specified AWG wire.
 - 3. Rated for 15 amperes at 600 volts.
 - 4. Screw terminal type.
 - 5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
 - 6. Finger-safe protection for all terminals for conductors.
 - 7. Construction: Polyamide insulation material capable of withstanding temperature extremes from - 40 to 105 degrees Celsius.
 - 8. Terminals: Plainly identified to correspond with markings on the diagrams:
 - a. Permanent machine-printed terminal identification.
 - 9. Disconnect-type field signal conductor terminals with socket/screw for testing.
 - 10. Identify terminals suitable for use with more than 1 conductor.
 - 11. Position:
 - a. So that the internal and external wiring does not cross.
 - b. To provide unobstructed access to the terminals and their conductors.
 - 12. Provide minimum 25-percent spare terminals.
 - 13. Manufacturers: One of the following or equal:
 - a. Phoenix Contact, UT4 Series.
 - b. Allen-Bradley, 1492 Series.
- H. Wire duct:
 - 1. Provide flame retardant plastic wiring duct, slotted with dust cover.
 - 2. Type:
 - a. Wide slot.
 - b. Narrow slot.
 - c. Round hole.
 - 3. Manufacturers: The following or equal:
 - a. Panduit.
- I. Din rail:
 - 1. Perforated steel.
 - 2. 35 mm width.
 - 3. 15 mm deep.
 - 4. Provide 2-inch offset using one of the following:
 - a. Offset brackets.
 - b. Preformed standoff Din Rail Channel.
- J. Surge protection devices:
 - 1. 120-volt control power for panels:
 - a. Panels without a UPS:
 - 1) Provide surge protection device (SPD) for panel power entrances:
 - a) Nominal 120-VAC with a nominal clamping voltage of 200 volts.
 - b) Non-faulting and non-interrupting design.
 - c) A response time of not more than 5 nanoseconds.

- 2) Control panel power system level protection, non-UPS powered:
 - a) Designed to withstand a maximum 10-kA test current of an 8/20 μ s waveform according to IEEE C62.41.1 Category C Area.
 - b) For panels receiving power at 120 VAC, provide surge protection at secondary of main circuit breaker.
 - c) Provide both normal mode noise protection (line to neutral) and common mode (neutral to ground) surge protection.
 - d) DIN rail mounting.
 - e) Attach wiring to the SPD by means of a screw-type cable-clamping terminal block:
 - (1) Gastight connections.
 - (2) The terminal block: Fabricated of non-ferrous, non-corrosive materials.
 - f) Visual status indication of MOV status on the input and output circuits.
 - g) Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.
 - h) Meeting the following requirements:
 - (1) Response time: Less than or equal to 100 ns.
 - (2) Attenuation: Greater than or equal to -40 dB at 100 kilovolt-hertz as determined by a standard 50-ohm insertion test.
 - (3) Safety approvals:
 - (a) UL 1283 (EMI/RFI Filter).
 - (b) UL 1449 2nd Edition.
 - i) Manufacturers: One of the following or equal:
 - (1) Phoenix Contact, Type SFP Filter.
 - (2) Liebert, Accuvar Series.
 - (3) Islatrol.
 - b. Panels with a UPS:
 - 1) Provide surge protection on the control power source at each panel containing power supplies, or electronic components including PLCs, I/O, HMI, and digital meters.
 - 2) Location:
 - a) For panels with a UPS, install surge protection ahead of UPS and maintenance bypass switch.
 - (1) Surge protection is not required for 120-VAC circuits that are only used for panel lights and receptacles.
 - 3) MCOV: 150 VAC.
 - 4) Surge capability (8/20 μ s wave): 10 kA.
 - 5) Peak let-through: 620V L-N, 850V L-G.
 - 6) Manufacturers: One of the following or equal:
 - a) Phoenix Contact, Plugtrab PT Series.
 - b) MTL Surge Technologies, MA15 Series.
 - c. For panels receiving power at 480 VAC, provide surge protection on the 120-VAC control power transformer secondary.
2. Instrument, data, and signal line protectors (traditional I/O) - panel mounted:
 - a. Surge protection minimum requirements: Withstand a 10-kA test current of an 8/20 μ s waveform in accordance with IEEE C62.41.1 Category C Area.
 - b. DIN rail mounting on 35-millimeter rail (except field-mounted SPDs).

- c. SPDs consisting of 2 parts:
 - 1) A base terminal block.
 - 2) A plug protection module:
 - a) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
 - b) Base and plug coded to accept only the correct voltage plug.
 - d. SPD:
 - 1) Manufacturers: One of the following or equal:
 - a) Phoenix Contact, Plugtrab Series.
 - b) Bournes, Series 1800.
 - 3. Instrument, data, and signal line protectors (traditional I/O) - field mounted:
 - a. Surge protection minimum requirements: Withstand a minimum 10-kA test current of an 8/20 μ s waveform in accordance with IEEE C62.41.1 Category C Area.
 - b. Manufacturers: One of the following or equal:
 - 1) Plugtrab, PT Series.
 - 2) MTL, TP48 Series.
- K. Horns and beacons:
- 1. Beacons/horn combination units:
 - a. Manufacturers: The following or equal:
 - 1) Federal Signal Corp., Multi-Status LED 108i with tone module.
 - b. LED Colors: Red, Green, and Amber.
 - c. Power: 120VAC.
 - d. Provide accessories such as pipe mount flange, pipe extensions, corner mount brackets, or wall mount brackets as needed.
 - e. Horn rated 80 dB minimum at 10 feet.
 - 2. Dedicated beacon unit:
 - a. Manufacturers: One of the following or equal:
 - 1) Federal Signal Corp., Starfire Series.
 - 2) Allen-Bradley, 855 B *-* 10 Series.
 - 3) Edwards, 102 Series.
 - 3. Dedicated horn unit:
 - a. Electromechanical:
 - 1) Manufacturers: One of the following or equal:
 - a) Federal Signal, 350 or 31X Series.
 - b) Edwards, 878EX or 879EX Series.
 - b. Electronic:
 - 1) Manufacturers: One of the following or equal:
 - a) Federal Signal, 300GCX or 300X Series.
 - b) Allen-Bradley, 855H or 855XH Series.
 - c) Edwards, 5530M or 5533MD Series.
 - c. Rated for 80 dB minimum at 10 feet.
- L. Power supplies:
- 1. Design power supply system so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.
 - 2. Convert 120 VAC to 24-volt DC or other DC voltages required or as required for the application.
 - 3. Provide backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.

4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure:
 - a. Provide automatic switchover upon module failure.
 - b. Alarm contacts monitored by the PLC.
5. Sized to provide 40-percent excess rated capacity.
6. UL 508C listed to allow full-rated output without de-rating.
7. Provide fuse or short-circuit protection.
8. Provide a minimum of 1 set of dry contacts configured to change state on failure for monitoring and signaling purposes.
9. Output regulation: Within 0.05 percent for a 10-percent line change or a 50-percent load change:
 - a. With remote voltage sensing.
10. Operating temperature range: 0 to 50 degrees Celsius.
11. Touch-safe design: All connection terminals to be protected against accidental touch.
12. DIN rail mounting on 35-millimeter rail.
13. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
14. Manufacturers: One of the following or equal:
 - a. Fully redundant:
 - 1) Phoenix Contact, Quint Power Supply with SFB technology.
 - a) Phoenix Contact Quint - o-ring redundancy module.
 - 2) IDEC, PS5R Series:
 - a) Wit redundancy Diode.
 - b. Sola.
 - c. Acopian.
 - d. PULS.

M. Intrinsic safety barriers:

1. Transformer isolated barrier:
 - a. Containing a transformer to provide complete:
 - 1) Isolation between the safe and hazardous areas for loop-powered devices.
 - 2) 3-way isolation between the safe area, hazardous area, and power supply powered devices.
 - b. Resistor for current limitation.
 - c. Fuses for short-circuit protection.
 - d. Provide barriers with pluggable connectors that are coded for easy replacement.
 - e. Transmission error shall be less than or equal to 0.1 percent of full-scale.
 - f. DIN rail mounting on 35-millimeter rail.
 - g. Approvals:
 - 1) FM.
 - 2) UL 913.
2. Types:
 - a. Switch isolators:
 - 1) Designed and approved for use with discrete inputs.
 - 2) Supply power: 20 to 30 VDC.
 - 3) Output to track input.
 - 4) LED in the cover to indicate the status of the input.
 - 5) Selector switch to change the logic of the input.
 - 6) Input: Dry contact.

- 7) Output: SPDT relay.
- b. Transmitter and converters for use with 4- to 20-milliampere signals without Hart® communications capability:
 - 1) Designed and approved for use with 4- to 20-milliampere analog signals.
 - 2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
 - 3) Supply voltage: 20 to 30 VDC.
- c. Transmitter and converters for use with 4- to 20-milliampere signals with Hart® communications capability:
 - 1) Designed and approved for use with 4- to 20-milliampere analog signals.
 - 2) Designed for powering 2- and/or 3-wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.
 - 3) Transfer digital signals from the hazardous area to the safe area.
 - 4) Complete bi-directional communication between a smart transmitter located in the field and the suitable equipment located in the safe area.
 - 5) Supply voltage: 20 to 30 VDC.
- 3. Manufacturers: One of the following or equal:
 - a. Phoenix Contact, ME Series.
 - b. Pepperl + Fuchs.
- N. Limit switches:
 - 1. NEMA Type 4X.
 - 2. AC contact rating 120 volts, 10 A.
 - 3. DC contact rating 125 volts, 0.4 A.
 - 4. Provide robust actuation mechanism not prone to degradation.
 - 5. Provide complete actuator mechanism with all required hardware.
 - 6. Allows for contact opening even during contact weld condition.
 - 7. UL approved.
 - 8. Operating temperature range: -18 to +110 degrees Celsius (0 to 230 degrees Fahrenheit).
 - 9. Manufacturers: One of the following or equal:
 - a. Allen-Bradley, 802 Series.
 - b. Honeywell, HDLS Series.
 - c. Omron, D4 Series.
 - d. Eaton, E47, E49, E50.
 - e. ABB.
- O. Current switches:
 - 1. Operate from 120-VAC supply voltage.
 - 2. 1 normally open and normally closed contacts.
 - 3. Adjustable current setting.
 - 4. Manufacturers: The following or equal:
 - a. Zelio®, RM35.
- P. Current transmitters:
 - 1. Input current range: As indicated on Drawings.
 - 2. Output: 4-20 mA.

3. Operate from 24 VDC supply voltage.
4. Output overload protected.
5. Accuracy: Within 0.5 percent Full-Scale.
6. Ripple and Noise: 1 percent Max., peak to peak.
7. Frequency: 50/60 hertz.
8. Manufacturer:
 - a. CR Magnetics: CR4320 series.
 - b. American Aerospace: 1070 Series.
 - c. Phoenix Contact: MCR Series.

2.07 ACCESSORIES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide panels with an inside protective pocket to hold the panel drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.
- C. Provide 15-inch floor stands or legs where needed or as indicated on the Drawings.
- D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.
- E. Provide nameplate to each panel as indicated on the Drawings:
 1. Provide as specified in Section 16075 - Identification for Electrical Systems on all internal and external instruments and devices.
 2. Provide a nameplate with the following markings that is plainly visible after installation:
 - a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
 - b. Supply voltage, phase, frequency, and full-load current.
 - c. Power source or circuit ID.
 - d. Short-circuit current rating of the panel based on one of the following:
 - 1) Short-circuit current rating of a listed and labeled assembly.
 - 2) Short-circuit current rating established utilizing an approved method.
- F. Provide a window kit where indicated on the Drawings or where a transmitter with display is mounted inside a control panel. The window shall meet the following requirements:
 1. Safety plate glass.
 2. Secured by rubber locking seal.
 3. Allow full viewing of devices issuing visual process data or diagnostics.
- G. Lighting:
 1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
 - a. Covered or guarded.
 - b. Provide On-Off door-activated switches where indicated on the Drawings.
 - c. 120-volt, single-phase, 15-amp style plug.
 - d. Provide 4,000 K, 900 Lumens - LED fixture.

- 1) Provide additional fixtures for every 36 inches of width.

H. Receptacles:

1. Provide 1 duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
2. GFCI, 120-volt, single-phase, 15-amp style plug.
3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.

I. Grounding:

1. Provide the following:
 - a. Grounding strap between enclosure doors and the enclosure.
 - b. Equipment grounding conductor terminals.
 - c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
 - d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.
2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND," the letter "G," or the color green.
3. Signal (24 VDC) grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
5. Design so that removing a device does not interrupt the continuity of the equipment-grounding circuit.
6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.
7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment-grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
10. Bond together all remote and local control panels, processor racks, and conductive enclosures of power supplies and connect to the equipment-grounding circuit to provide a common ground reference.

J. Provide sunshades and insulation for all outdoor installations.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Finishes:

1. Metallic (non-stainless):
 - a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
 - b. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer's recommended dry-film thickness and allowed to dry before applying the finish coat.

- c. Finish coat shall be a baked polyester-urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
- d. Exterior of enclosures located outdoors shall be UV-resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
- 2. Stainless steel:
 - a. Stainless enclosures shall be provided with a Number 4 brushed finish - not painted.

B. Colors:

- 1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
- 2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
- 3. Panel interiors shall be manufacturer's standard white.

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install enclosures so that their surfaces are plumb and level within 1/8-inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to drywall is not permitted.
- B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.
- C. Provide floor stand kits for wall-mounted enclosures larger than 48 inches high.
- D. Provide 3-1/2-inch high concrete housekeeping pads for freestanding enclosures.
- E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
 - 1. Undercoat floor-mounted panels.
- F. Provide a full-size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

- G. All holes for field conduits, etc. shall be cut in the field. There shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or mis-cut holes shall require that the entire enclosure be replaced.
- H. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the Conduit Schedule, but shall be shown on the Loop Drawings prepared by the Contractor.
- I. Provide individually fused analog input module points with blown-fuse indicator lights, mounted external of the module on the output terminal strip.
- J. Side panels:
 - 1. Side panels shall be kept free off all control equipment and devices except for the components indicated on the Drawings. Any deviation must be sent to the engineer in writing asking for a deviation.

3.04 ERECTION, INSTALLATION, APPLICATION, AND CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17712

CONTROL SYSTEMS: UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Single-phase double conversion uninterruptible power supplies rated 10 kilovolt-amperes and below.
 - 2. Uninterruptible power supplies rated 10 kilovolt-amperes and below.

1.02 REFERENCES

- A. As specified in Sections 16050 - Common Work Results for Electrical and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Federal Communications Commission (FCC):
 - 1. FCC Part 15, Class A.
 - 2. FCC Part 15, Class B.
- C. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
 - 2. 1184 - IEEE Guide for Batteries for Uninterruptible Power Supply Systems.
 - 3. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 DEFINITIONS

- A. As specified in Sections 16050 - Common Work Results for Electrical and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. Critical load: Load supplied by the UPS.
 - 2. MOV: Metal oxide varistor.

1.04 SYSTEM DESCRIPTION

- A. Provide complete, factory-assembled, wired, and tested, true on-line double conversion UPS equipment including, but not limited to, rectifier, DC bus, inverter, battery charger, batteries, automatic bypass, and ancillary components as specified in this Section and as indicated on the Drawings.
- B. UPS loads as indicated on the Drawings.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Manufacturer and model number.
 - 2. Catalog data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - 4. Ratings:
 - a. Input voltage.
 - b. Output voltage.
 - c. Input/output power factor.
 - d. Efficiency.
 - e. Harmonic distortion.
 - f. Runtime.
 - 5. Noise specifications.
 - 6. Heat dissipation.
 - 7. Warranties and maintenance contracts:
 - 8. All communications requirements such as software, cards, etc.
 - 9. Alarms and status available for remote monitoring and system health.
- C. Shop drawings:
 - 1. Power distribution block diagrams.
 - 2. Front and rear views of equipment enclosures:
 - a. Front elevation including all control and indicating devices.
 - 3. Support points and weight of overall equipment.
 - 4. Schematic and control wiring diagrams including, but not limited to:
 - a. Line and load terminals.
 - b. Alarm and status terminals.
 - c. Manual maintenance bypass switch terminals.
 - d. External Battery or Step-down/Step-up Transformers if any.
 - e. External wiring requirements for all communication signals.
 - 5. Switching and overcurrent protective devices.
- D. Calculations:
 - 1. Include derating for temperature and elevation as necessary.
 - 2. UPS sizing computation:
 - a. Apply safety factors as specified in this Section.
 - b. Provide itemized list of critical loads, including individual VA and watt ratings.
 - 3. Battery time calculation based on specified runtime for total load with the safety factor multiplied to it. Table/graph for back-up time calculation.
 - 4. Load calculation shall include power for all shown in the power distribution drawing, which include but not limited to PLC power supply, field instruments (120VAC and 24VDC), Instrument power, Ethernet switches, and I/O modules. Refer to Network Drawings for additional information and notes.
 - 5. Total battery recharge time as a function of capacity utilized.

- E. Design data:
 - 1. Design mounting and anchorage for seismic design criteria specified in Section 01612 - Seismic Design Criteria:
 - a. Provide seismic kits as required to meet design criteria.
- F. Record documents:
 - 1. Provide Record Drawings of installed unit(s) including layout and wiring.
- G. Manufacturer's field reports.
- H. Operation and maintenance manuals:
 - 1. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
 - 2. Recommendations for maintenance procedures and intervals.
 - 3. Battery data/replacement information.
 - 4. Parts list.

1.06 QUALITY ASSURANCE

- A. Manufacturer qualifications:
 - 1. A minimum of 10 years' experience in the design, manufacture, and testing of solid-state UPS systems.
 - 2. ISO 9001 certified.
- B. Regulatory requirements for complete UPS system:
 - 1. UL listed per UL Standard 1778.
 - 2. IEEE C62.41, Categories A & B.
 - 3. FCC 15:
 - a. Greater than 2,000 VA - Class A.
 - b. Less than 2,000 VA - Class B.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Double-conversion true-online UPS manufacturers: The following, no equal:
 - 1. Free-standing UPS, 700-3,000 VA:
 - a. Vertiv, Liebert GXT4.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Double conversion true on-line UPS system requirements:
 - 1. System characteristics:
 - a. Provide free-standing UPS as specified and as indicated on the Drawings.
 - b. The minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
 - c. Battery runtime at full load and site ambient temperature as indicated in the UPS schedule.
 - d. Efficiency greater than 85 percent AC-AC, all modes.
 - e. Acoustical noise:
 - 1) Less than 55 dBA at 5 feet.
 - f. Output connections:
 - 1) Receptacles:
 - a) 700-2,500 VA units:
 - (1) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
 - b) 3,000 VA units:
 - (1) Provide a minimum of four NEMA Type 5-20R receptacles.
 - (2) Provide at least one NEMA Type L5-30R receptacle.
 - c) Greater than 3,000 VA units:
 - (1) Provide a minimum of four NEMA Type 5-20R receptacles.
 - (2) Provide at least one NEMA Type L14-30R receptacle.
 - 2) Provide hardwired connections as indicated on the Drawings.
 - g. Protection:
 - 1) Undervoltage:
 - a) Operate on battery power if incoming source voltage goes below UPS system limits of operation.
 - 2) Overvoltage:
 - a) Operate on battery power if incoming source voltage exceeds UPS system limits of operation.
 - 3) Overcurrent:
 - a) Provide input and output current-limiting protection to ensure adequate overcurrent protection for UPS.

- 4) Surge protection:
 - a) MOV-based.
2. Electrical characteristics:
 - a. AC input:
 - 1) Single-phase.
 - 2) Voltage as indicated in the UPS schedule.
 - a) Fully functional within +10 percent, -15 percent of nominal voltage at full load without depleting battery.
 - b) 120 V input:
 - (1) 2-wire plus ground.
 - c) 208/120 V or 240/120 input:
 - (1) 3-wire plus ground.
 - 3) Current:
 - a) Reflected total harmonic distortion (THD) less than 25 percent at rated load.
 - 4) Frequency range of operation:
 - a) 57-63 hertz.
 - 5) Power factor:
 - a) Not less than 0.95 lagging at rated load.
 - b. AC output:
 - 1) Single-phase.
 - 2) Voltage:
 - a) Regulation:
 - (1) Within 3 percent for 3,000 VA rating and below.
 - (2) Within 5 percent for greater than 3,000 VA rating - static load.
 - (3) Within 10 percent for greater than 3,000 VA rating - dynamic load.
 - b) Total harmonic distortion (THD) when operating on incoming power:
 - (1) Not more than 3 percent for linear loads with a crest factor of 3:1.
 - (2) Not more than 5 percent for non-linear loads with a crest factor of 3:1.
 - c) Transient response:
 - (1) Within 7 percent for a 20-100 percent step load.
 - (2) Transient recovery time to nominal voltage within 166 milliseconds.
 - 3) Load power factor:
 - a) UPS shall be capable of supporting the critical loads for all power factors experienced for their full range of operation.
 - 4) Frequency regulation:
 - a) Within 3.5 hertz when on utility power.
 - b) Within 1.0 hertz when on UPS power.
3. Environmental requirements:
 - a. Operating ambient temperature:
 - 1) UPS module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
 - 2) Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).

- b. Operating altitude:
 - 1) Project site conditions as specified in Sections 16050 - Common Work Results for Electrical and 17050 - Common Work Results for Process Control and Instrumentation Systems
- 4. System components:
 - a. Surge protective devices:
 - 1) MOV-supplied protection.
 - b. Inverter:
 - 1) Pulse-width modulated AC output signal.
 - 2) Overload withstand minimum time without transferring to bypass:
 - a) 101 to 110 percent for 2 minutes.
 - b) 111 to 125 percent for 10 seconds.
 - c) 126 to 150 percent for 1 second.
 - d) Greater than 150 percent for 96 milliseconds.
 - 3) Transfer load to bypass when overload capacity is exceeded.
 - c. Battery rectifier/charger:
 - 1) Recharge batteries to 90 percent in 6 hours or less.
 - d. Batteries:
 - 1) VRLA (valve regulated lead acid), sealed, maintenance free.
 - 2) Minimum 3-year float service life at 25 degrees Celsius.
 - 3) Integral to UPS enclosure or housed in a matching enclosure.
 - 4) Less than and including 6,000 VA: Hot-swappable.
 - 5) Automatically perform routine battery health monitoring and provide visual, audible, and/or serial warnings if abnormal battery conditions exist.
 - e. Automatic bypass switch:
 - 1) Integral to UPS system.
 - 2) Sense UPS overload, inverter failure, or over temperature, and automatically transfer loads to source power.
 - 3) Maximum detect and transfer time of 4-6 milliseconds.
 - 4) Automatic re-transfer without power interruption to critical load.
 - 5) Input shall match output in phase, voltage, frequency, and grounding.
 - 6) Rated to carry the full input current of the UPS.
 - 7) Provide ability for manual operation.
 - f. Manual maintenance bypass switch:
 - 1) Provides isolation of the UPS for maintenance purposes.
 - 2) Make-before-break design so that UPS can be isolated from the critical loads by placing these loads on source power without interruption of operation.
 - 3) Utility and UPS status indications.
 - 4) Supply necessary input/output cords and receptacles for connections with power source and UPS.
 - 5) Transfer time less than 6 milliseconds.
 - 6) Rated to carry the full input current of the UPS.
 - 7) Standalone UL-listed.
 - 8) Input match output in phase, voltage, frequency, and grounding.
 - 9) UPS input connection and UPS output plug:
 - a) 700 to 3,000 VA units: NEMA receptacle and plug to match UPS connections.
 - b) Above 3,000 VA units: NEMA receptacle and plug or hardwiring to match UPS connections.

- 10) Utility and load connections:
 - a) As indicated on the Drawings.
- 11) 700 to 3,000 VA units: One of the following or equal:
 - a) Vertiv, Liebert Micropod 2U.
 - b) Eaton Corp., Powerware HotSwap.
- 12) Above 3,000 VA units: By manufacturer of UPS, with connections matched for operation with UPS.
- g. UPS chassis:
 - 1) Electrically isolate from AC output neutral.
 - 2) Include an equipment ground terminal.
- h. Cooling:
 - 1) Forced air cooled.
- i. Locally displayed system indicators:
 - 1) Audible alarms during abnormal conditions:
 - a) UPS fault or overload condition.
 - b) Battery on.
 - c) Low battery.
 - d) Automatic bypass on/off.
 - e) Input power on.
 - f) Battery testing mode.
- j. Controls:
 - 1) Front-panel pushbuttons:
 - a) UPS start-up, shutdown, and manual bypass (for automatic bypass).
 - b) Testing.
 - c) Visual/audible alarms reset.
- k. Alarm contacts:
 - 1) Provide relay interface card and required interposing relays for 120 VAC discrete input status signals:
 - a) Low battery.
 - b) UPS alarm.
 - c) On UPS power.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install equipment in accordance with manufacturer's instructions.
- B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. Perform inspections and test procedures before UPS startup:
 - 1. Inspect equipment for signs of damage.
 - 2. Verify installation as indicated on the Drawings and specified in the Specifications.
 - 3. Inspect cabinets for foreign objects.
 - 4. Verify neutral and ground conductors are properly sized and terminated.
 - 5. Inspect battery cases.
 - 6. Inspect batteries for proper polarity.
 - 7. Check power and control wiring for tightness.
 - 8. Check terminal connectors for tightness.
 - 9. Ensure connection and voltage of the battery string(s).

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULE

TAG	MINIMUM RUNTIME	INPUT VOLTAGE / CONNECTION	SAFETY FACTOR	NOTES
PCM-600A UPS	30 Minutes	120 VAC	1.5	Free-standing
PCM-2100 UPS	30 Minutes	120 VAC	1.5	Free-standing

END OF SECTION

SECTION 17720

CONTROL SYSTEMS: PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Programmable logic controller (PLC) based control systems hardware.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE).

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. CPU: Central processing unit.
 - 2. I/O: Input/Output.
- C. Specific definitions:
 - 1. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.
 - 2. Application software: The software that is programmed specifically for the Project.

1.04 SYSTEM DESCRIPTION

- A. Provide all PLC hardware as indicated on the Drawings and as specified in this Section.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. CPU:
 - a. Processor type.
 - b. Processor speed.
 - c. Memory.
 - d. Internal processor battery backup time.
 - 2. I/O modules:
 - a. Type.

- b. Standard wiring diagram.
- C. Calculations:
 - 1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
 - 2. Submit calculations to verify that spare I/O requirements of this Section are met.
 - 3. Submit calculations to verify that PLC power supply requirements of this Section are met.
- D. Product data:
 - 1. Programming languages.
 - 2. Operating system requirements.
- E. Control logic:
 - 1. Fully annotated copy of programmed PLC logic.
 - 2. Cross-referenced index of all PLC registers or points.
- F. Provide application software for the specific Project process requirements.
 - 1. Fully annotated copy of programmed PLC logic in its native format.
 - 2. Cross-referenced index of all PLC registers or points.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.
- C. Additional requirements:
 - 1. Provide PLC system components by a single manufacturer:
 - a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
 - 2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
 - 3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects, and produced by manufacturers regularly engaged in the manufacture of these products.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. In addition to the spare parts requirements specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems
 - 1. Network/communications cards: 1 spare for every network or communications card in the system.
- C. Installed spare requirements:
 - 1. I/O points:
 - a. Provide total of 25 percent spare I/O capacity for each type of I/O at every PLC and remote inputs and outputs (RIO).
 - b. Wire all spare I/O points to field terminal blocks in the same enclosure the PLC resides in.
 - 2. PLC backplane capacity:
 - a. Provide 25-percent or 3 spare backplane slots, whichever is greater, in all racks containing I/O.
 - 3. PLC memory:
 - a. Provide 50-percent spare program volatile memory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. The following, no equal:
 - 1. General Electric:
 - a. RX3i.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Programmable logic controller:
 - 1. Construction:
 - a. Furnish plug-in modular system.

- b. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
 - 1) Temperature: 0 to 60 degrees Celsius.
 - 2) RFI: 80 to 1,000 MHz.
 - 3) Vibration: 10 to 500 hertz.
 - 4) Humidity: 0 to 95 percent.
 - c. Provide internal power supplies designed to protect against overvoltage and frequency distortion characteristics frequently encountered with the local power utility.
 - d. Design the PLC system to function as a standalone unit that performs all of the control functions described in this Section completely independent from the functions of the HMI system PC-based operator interfaces:
 - 1) Failure of the HMI system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
- 2. CPU:
 - a. CPU Model Number: IC695CPE305.
 - b. Configure each CPU so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
 - c. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, analog outputs, and communication cards to meet the specified requirements.
 - d. Capable of supporting and implementing closed-loop floating-point math and PID control that is directly integrated into the CPU control program.
- 3. Memory:
 - a. Non-volatile memory: On-board complementary metal-oxide-semiconductor (CMOS), electrically erasable programmable read-only memory (EEPROM).
 - b. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
 - 1) Reserve capacity:
 - a) Totally free from any system use.
 - 2) Programmed in a multi-mode configuration with multiple series or parallel contacts, function blocks, counters, timers, and arithmetic functions.
- 4. PLC power supply:
 - a. Power Supply Model Number:
 - 1) Primary backplane: IC695PSA140.
 - 2) Remote I/O backplane: IC694PWR321
 - b. Input: 120 VAC.
 - c. Mounted in the PLC housing or as indicated on the Drawings.
 - d. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
- 5. PLC input/output, I/O modules:
 - a. General:
 - 1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
 - 2) Provide I/O modules that:
 - a) Isolate in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.

- b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
 - c) Accept dual-ended inputs.
- 3) The use of common grounds between I/O points is not acceptable.
- 4) Provide modules that are removable without having to disconnect wiring terminals:
 - a) Utilize a swing-arm or plug-in wiring connector.
- 5) Provide at each PLC the I/O modules for the following:
 - a) Designated future I/O points contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies.
 - b) Installed spare capacity in accordance with the requirements of this Section.
 - c) Wire all spares provided to the field terminal strip.
- 6) Condition, filter, and check input signals for instrument limit conditions.
- 7) Filter, scale, and linearize the raw signal into an engineering-units-based measurement.
- 8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
- 9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.
- 10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
- b. Discrete input modules:
 - 1) Discrete input module model number: IC694MDL241.
 - 2) Defined as contact closure inputs from devices external to the input module.
 - 3) Provide inputs that are optically isolated from low-energy common-mode transients to 1,500 volts peak from users wiring or other I/O modules.
 - 4) With LEDs to indicate status of each discrete input.
 - 5) Input voltage: 24VDC.
 - 6) Provide input module points that are individually fused with blown-fuse indicator lights, mounted external of the module on the output terminal strip:
 - a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.
- c. Discrete output modules:
 - 1) Discrete output module model number: IC694MDL940.
 - 2) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
 - a) Triac outputs may be used, with the permission of the Engineer. Care must be used in applying this type of module to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
 - 3) Optically isolated from inductively generated, normal mode and low-energy common-mode transients to 1,500 volts peak.

- 4) LEDs to indicate status of each output point.
- 5) Output voltage: 120VAC.
- d. Analog input modules:
 - 1) Analog input module model number: IC695ALG616.
 - 2) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
 - 3) Analog-to-digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
 - 4) The analog-to-digital conversion updated with each scan of the processor.
 - 5) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
- e. Analog output modules:
 - 1) Analog output module model number: IC695ALG708.
 - 2) Signal type: Provide 4-20 mA for most applications; other levels are acceptable to interface to vendor control panels.
6. Communications modules:
 - a. Remote I/O adapter module:
 - 1) For any PLC location requiring more than 1 housing to mount all of the I/O modules or that is identified as a RIO, provide the appropriate remote I/O adapter module for communication with the secondary housing(s).
 - 2) Install the RIO adapter module in the PLC backplane and the RIO backplane.
 - 3) Provide adapter modules that support all available types of I/O modules required.
 - 4) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
 - 5) Complete diagnostic LEDs.
 - b. Network communications modules:
 - 1) General:
 - a) Install communications modules in the PLC backplane.
 - 2) Ethernet:
 - a) Ethernet module model number: IC695ETM001.
 - b) Ports: 2 RJ-45.
 - c) Communication rate: 100 Mbit/s.
 - 3) Profibus DP:
 - a) Profibus DP module model number: IC695PBM300.
 - b) Ports: 1.
 - 4) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
7. PLC backplane housing:
 - a. Mount the PLC power supply, CPU, communications module, and I/O modules in a suitable standard PLC backplane or housing.
 - b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
 - c. Provide a blank slot filler module for each spare slot.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Utilize personnel to accomplish or supervise the physical installation of all elements, components, accessories, or assemblies:
 - 1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.
- C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.
- D. General:
 - 1. The control system logic program shall reside at the PLC level.
- E. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.
- C. Perform training by pre-approved and qualified representatives of the ICSC and/or manufacturer of the PLC hardware and programming software:
 - 1. A representative of the ICSC may perform the PLC hardware training only if the representative has completed the manufacturer's training course for the PLC hardware.

3.11 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17733

CONTROL SYSTEMS: NETWORK MATERIALS AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Materials and equipment used in process control and LAN networks including:
 - a. Network switches.
 - b. Patch panels and other data network hardware.
 - c. Related accessories.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 802.1X - Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.
 - 2. 802.3 - Standard for Ethernet.
 - 3. 802.3ab - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Physical Layer Parameters and Specifications for 1000 Mb/s Operation over 4 pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T.
 - 4. 802.3u - Standards for Local and Metropolitan Area Networks: Supplement - Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100Mb/s Operation, Type 100BASE-T (Clauses 21-30).
 - 5. 802.11b - Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 SYSTEM DESCRIPTION

- A. Provide all network equipment identified in the Contract Documents.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product data:
 - 1. Include information on all network equipment.
 - 2. Manufacturer's operation and installation instructions.
- C. Shop drawings:
 - 1. Complete set of drawings including but not limited to:
 - a. System block diagram showing relationship and connections between devices provided under this Contract and existing equipment. Include manufacturer and model information, and address settings.
 - b. Network riser diagram.
 - c. Network port diagram, which physically locates all ports within the facility, and identifies their patch panel and switch port.
 - d. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, and nameplates.
 - e. Electrical connection diagrams.
 - f. Complete grounding requirements.
 - 2. Furnish data sheets for each component together with a technical product brochure or bulletin:
 - a. Manufacturer's model number.
 - b. Project equipment tag.
 - 3. Complete and detailed bills of materials broken up by each cabinet. Each bill of material item will include the following:
 - a. Quantity.
 - b. Description.
 - c. Manufacturer.
 - d. Part numbers.
- D. Test reports:
 - 1. As specified in Sections 16125 - Fiber Optic Cable and Appurtenances and 17950 - Testing, Calibration, and Commissioning and noted in this Section.
 - 2. Signed test results as described in this Section.
 - 3. Test results shall include:
 - a. Narrative describing the test procedures followed.
 - b. Block diagram of test set up.
 - c. Manufacturer's information on test equipment used.
 - d. Detailed test results.
 - e. A narrative summarizing the results of the testing and identifying any further action required.
- E. Operating manuals:
 - 1. Complete installation, operation, calibration, and testing manuals as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

- F. Record drawings:
 - 1. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 2. Electrical connection diagrams shall be revised to reflect any changes made in the field and submitted as record drawings.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Ethernet switches:
 - 1. Managed Enterprise Ethernet switches:
 - a. Manufacturers: The following, no equal:
 - 1) Cisco Catalyst 3850, model number WS-C3850-12X48U.

- b. Properties:
 - 1) Hardware:
 - a) 19-inch rack mountable modular switch.
 - b) Power supply:
 - (1) Provide redundant 120 VAC power supplies.
 - c) Console management port.
 - 2) Performance:
 - a) Switching capacity: 18 Gbps, minimum.
 - b) Address table size: 8,000 entries, minimum.
 - c) Gigabit throughput.
 - 3) Environment:
 - a) Operating temperature range: 32 to 113 degrees Fahrenheit.
 - b) Humidity: 10 to 90 percent, non-condensing.
 - 4) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:
 - a) Port Monitoring.
 - b) Remote switch management.
 - c) Port Security.
 - d) Rapid Spanning Tree protocol.
 - 5) Connector type:
 - a) Fiber: LC using SFP modules.
 - b) Copper: RJ-45.
 - 6) Ports:
 - a) 10/100/1000-Base-T:
 - (1) Protocol: IEEE 802.3 Type 10Base-T; IEEE 802.3u Type 100Base-TX; 802.3ab Type 1000Base-T.
 - (2) Auto-sensing.
 - (3) 48 ports.
 - (4) PoE.
 - b) GBIC or Transceiver module:
 - (1) If required, provide transceiver module to interface with single-port transceivers as required.
- 2. Managed Process Floor Ethernet switches:
 - a. Manufacturers: The following, no equal:
 - 1) 12 Ports: Cisco IE-4000-4GC4GP4G-E.
 - 2) 20 Ports: Cisco IE-4000-8GT8GP4G-E.
 - b. Properties:
 - 1) Hardware:
 - a) Power supply:
 - (1) Provide redundant power supplies.
 - (2) 24 VDC, 170 watts per power supply.
 - b) No fans or moving parts.
 - 2) Performance:
 - a) Enclosure:
 - (1) All metal housing.
 - (2) 15g Shock for 11ms minimum.
 - b) 10/100BASE-TX RJ-45 Copper Ports (quantity as indicated on the Drawings).
 - c) 100BASE-FX LC Fiber Duplex Ports (quantity as indicated on the Drawings).

- d) 1,000BASE-T RJ-45 Copper Ports (quantity as indicated on the Drawings).
- e) 1,000Base-SX LC Duplex Fiber Ports (quantity as indicated on the Drawings).
- f) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:
 - (1) SNMP.
 - (2) VLAN.
 - (3) QoS.
 - (4) Port Mirroring.
 - (5) DHCP Server
- g) IGMP Snooping with Ethernet I/P plug & play compatibility.
- h) 802.1d, 802.1w, 802.1D RSTP.
- 3) Environment:
 - a) Operating temperature range: 32 to 140 Degrees Fahrenheit.
 - b) Humidity: 10 to 95 percent, non-condensing.
- 4) Connector type:
 - a) Fiber: LC.
 - b) Copper: RJ-45:
 - (1) Quantity of copper and fiber ports as required to provide connections as indicated on the Drawings: As required to provide the number of connections required plus 20 percent spare ports of each type used.
- 5) Mounting:
 - a) DIN Rail mounting.

B. Patch panels:

1. General:

a. Fiber:

- 1) All optical fibers shall be provided with strain relief and terminated at a fiber patch panel. Final connections between the patch panel and the fiber optic network equipment shall be made via fiber optic patch cords.
- 2) All fibers, active and dark, shall be terminated at the patch panels.
- 3) Interconnect and patch panel housings shall provide space for excess fiber and provide strain relief for the fiber cable.
- 4) Fiber cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out buffer tubes.

2. Cabinet style fiber patch panels:

a. Wall mounted interconnect:

- 1) Use for the termination of a single cable outside of cabinets, in small enclosures or as indicated on the plans.
- 2) Wall mounted fiber interconnects shall be provided as complete units including the housing, the connector panels and the fiber connectors.
- 3) Wall mounted fiber interconnects shall provide physical protection for both the incoming cable and the outgoing patch cords.
- 4) Capacity:
 - a) As shown on the plans, minimum 24 connections.
- 5) Accessories:
 - a) Door lock.

- b) Blanks for unused connector panels.
- 6) Manufacturers: The following or equal:
 - a) Corning Cable Systems, WCH with CCH fiber termination panels.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. All racks shall be level and plumb.
- C. Install Velcro wrap on all cable bundles within the network rack/enclosure.
- D. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations:
 - 1. Cables shall be installed avoiding sharp bends.
 - 2. Install cable using lubricant designed for cable pulling.
 - 3. Cable ties or other cable supports shall be installed without crimping the LAN cables.
 - 4. Install LAN cables without splices.
 - 5. Installed bend radii shall not exceed 4 times the cable diameter.
 - 6. Terminated all pairs at the jack and the patch panel.
- E. Install cables a minimum of 40 inches away from electrical motors and transformers.
- F. Install cables a minimum of 12 inches away from fluorescent lighting.
- G. Individual pairs will be untwisted less than 1/2-inch at termination points.

- H. All cables and terminations shall be labeled with cable designations as specified in Section 16075 - Identification for Electrical Systems.
- I. Each data port shall be individually labeled with its patch panel/switch port ID:
 - 1. Labeling must be printed - no handwritten labels will be allowed.
- J. At the completion of the wiring installation, provide the following documentation:
 - 1. A plan-view of the premise(s) showing the jack numbering scheme.
 - 2. A printed certification report for the entire wiring installation showing compliance with all EIA/TIA specifications for data cable.
 - 3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.
 - 4. Each device with a unique IP address shall be individually labeled with its IP address. The labeling must be printed; handwritten labels will not be allowed.
- K. Managed Ethernet switches:
 - 1. Configure switches to prevent broadcast storms.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING

- A. Perform all firmware installations, configuration and other set up, as required, to place the network into proper operation.

3.09 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. After completion of the cable system tests and before placing the system in operation, power up all devices installed on the LAN and verify communication between the devices.
- C. Verify that all equipment is operable on the network simultaneously. Confirm that all network device communications settings are properly configured.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17735

CONTROL SYSTEMS: FIELDBUS EQUIPMENT AND DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Profibus components.
- B. Provide all components identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- C. International Electrotechnical Commission (IEC):
 - 1. 60529 - Degrees of protection provided by enclosures (IP Code).
- D. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. 802.3 - Standard for Information technology-Specific requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. NEMA:
 - 1. Type 1 enclosure in accordance with NEMA 250.
 - 2. Type 4 enclosure in accordance with NEMA 250.
 - 3. Type 4X enclosure in accordance with NEMA 250.
 - 4. Type 6 enclosure in accordance with NEMA 250.
 - 5. Type 12 enclosure in accordance with NEMA 250.
- C. Specific definitions:
 - 1. ABS: Acrylonitrile butadiene styrene.
 - 2. AWG: American wire gauge.
 - 3. CPE: Chlorinated polyethylene elastomer.
 - 4. CREST: Crosstalk resonance suppression technology.
 - 5. DP: Decentralized periphery.
 - 6. GPRS: General packet radio service.
 - 7. GSM: Global system for mobile communications.
 - 8. IP: Ingress protection.
 - 9. PA: Process automation.

10. PA66: Polyamide (Nylon) 66.
11. PBT: Polybutylene terephthalate.
12. TCP/IP: Transmission control protocol/internet protocol.
13. TPE: Thermo-plastic elastomer.

1.04 SYSTEM DESCRIPTION

- A. Provide all fieldbus components and equipment identified in the Contract Documents.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 - Submittal Procedures and 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Notify the Engineer if any installation condition does not meet the fieldbus component manufacturer's recommendations or specifications.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.08 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 1. Provide fieldbus components suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. As listed below in the individual component paragraphs.
- B. Provide components performing similar functions of the same type, model, or class, and from one manufacturer.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Profibus protocol:
 - 1. The following components are used for PROFIBUS DP systems:
 - a. Master scanner:
 - a) Refer to Section 17720: Control Systems: Programmable Logic Controllers.
 - b) Network shall operate at 187.5 kbps.
 - b. Profibus DP active terminator (Tuneable):
 - 1) Manufacturers: One of the following or equal:
 - a) Procentec.
 - 2) Transmission rate: 187.5 kbps.
 - 3) Rated voltage: 24 VDC (18.0 VDC to 30 VDC).
 - 4) Galvanically isolated, tested with 500 VDC.
 - 5) Maximum current consumption: 65 mA.
 - a) The ability to adjust network terminator voltage.
 - 6) Protection class: NEMA Type 4 or IEC IP20.
 - 7) LED indication.
 - 8) Ambient temperature:
 - a) Operating: 32 to 140 degrees Fahrenheit.
 - b) Storage: -40 to 158 degrees Fahrenheit.

2.07 ACCESSORIES

- A. Profibus surge protection:
 - 1. Profibus DP surge protector - Panel mounted.
 - a. Manufacturers: The following or equal:
 - 1) Phoenix Contact, PT 1x2+F-BE series base module with PT 3-PB Series protection module.
 - b. Nominal voltage: 5 VDC.
 - c. Maximum continuous operating voltage: 5.2 VDC.
 - d. Nominal discharge surge current: 10 kA.
 - e. Voltage protection level at 1 kilovolt per micro-second: 55 volts.
 - f. Shall withstand a maximum discharge surge current (8/20 micro second combination wave) of 10 kA.

2.08 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the fieldbus components and verify that the component will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.11 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17850

HVAC INSTRUMENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes requirements for:
 - 1. HVAC instrumentation for air temperature measurement and room differential pressure measurement.
 - 2. Refer to Section 17405 - Pressure/Vacuum Measurement: Direct for duct pressure measurement instrumentation.
 - 3. Refer to Section 17406 - Pressure/Vacuum Measurement: Differential for grease mist eliminator differential pressure measurement instrumentation.
- B. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.03 DEFINITIONS

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific Definitions:
 - 1. RTD - Resistance Temperature Detector.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures and Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Product Data:
 - 1. Dimensional Drawings.
 - 2. Materials of Construction:
 - 3. Measurement accuracy.
 - 4. Range and range ability.
 - 5. Enclosure Rating.
 - 6. Classification Rating.
 - 7. Power:
 - a. Voltage.
 - b. Wattage.
 - 8. Output options.

- C. Shop Drawings:
 - 1. Connection diagram.
 - 2. Loop diagram.
 - 3. Mounting drawings.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. As listed below.

2.02 MANUFACTURED UNITS

A. Room differential pressure sensors and transmitters.

1. General:
 - a. Differential pressure transmitter assembly shall include a pressure transducer and microprocessor based transmitter for measurement of differential pressure.
 - b. Provide stainless steel tubing as required from the sensing points to the transmitter.
2. Performance requirements:
 - a. Calibrated Differential Pressure Range: As specified in instrument list.
 - b. Reference Accuracy: Plus or minus 0.25 percent of calibrated span.
 - c. Stability: Plus or minus 0.5 percent of upper range limit per year.
3. Sensing Element:
 - a. Probe Sensing Range: -0.25 in. w.c. to +0.25 in. w.c.
4. Differential Pressure Transmitter:
 - a. Provided with electronic microprocessor.
 - b. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application.
 - c. 4 to 20 mA direct current output.
 - d. Transmitter enclosure: NEMA 4X
 - e. Enclosure Materials: Stainless steel.
 - f. Transmitter Mounting:
 - 1) As shown on the Drawings.
 - 2) Surface-mounted.
 - 3) Provide all necessary hardware for transmitter mounting.
5. Connections:
 - a. Process: 1/4 inch NPT.
 - b. Conduit: 1/2 inch NPT.
6. Overrange Protection: To 20 pounds per square inch.
7. Power: Loop powered 2-wire 24 volt direct current.
8. Manufacturer: One of the following or equal:
 - a. Omega Engineering.
 - b. Ashcroft IXLdp.

B. Duct air temperature sensors and transmitters.

1. General:
 - a. Air duct temperature measuring instrument shall include sensing element and temperature transmitter.
 - b. Duct mounted averaging sensors shall utilize a sensing element incorporated in a copper capillary with a minimum length of 20 feet. The sensor shall be installed according to manufacture recommendation and looped and fastened at a minimum of every 36 inches.
2. Performance requirements:
 - a. Temperature Range:
 - 1) As specified in instrument list or schedule.
 - b. Accuracy:
 - 1) Within 0.5 percent of calibrated span.
3. Sensing Element:
 - a. Averaging capillary type with minimum 4 elements.
4. Temperature Indicating Transmitter:
 - a. Microprocessor based loop-powered device.

- b. Compatible with duct temperature sensor.
 - c. 4 to 20 mA direct current output linearly proportional to temperature.
 - d. Transmitter enclosure: NEMA 4.
 - 5. Transmitter and sensor mounting:
 - a. As shown on the Drawings.
 - b. Surface-mounted transmitter.
 - c. Provide all necessary hardware for transmitter and sensor mounting.
 - 6. Manufacturer: One of the following or equal:
 - a. Honeywell.
 - b. Mamac TE-705.
- C. Room air temperature sensors and transmitters.
 - 1. General:
 - a. Temperature measuring instrument shall include sensing element and temperature transmitter.
 - 2. Performance requirements:
 - a. Temperature Range:
 - 1) As specified on the Drawings.
 - b. Accuracy:
 - 1) Within 0.1 percent of calibrated span.
 - 3. Sensing Element:
 - a. RTD.
 - b. Directly mounted to transmitter.
 - 4. Temperature Indicating Transmitter:
 - a. Microprocessor based loop-powered device.
 - b. Compatible with RTD temperature sensor.
 - c. 4 to 20 mA direct current output linearly proportional to temperature.
 - d. Transmitter enclosure: NEMA 4X.
 - 5. Transmitter and sensor mounting:
 - a. Surface-mounted transmitter.
 - b. Provide all necessary hardware for transmitter and sensor mounting.
 - 6. Manufacturer: One of the following or equal:
 - a. Omega Engineering
 - b. Greyston Energy Systems Inc.

2.03 ACCESSORIES

- A. Provide mounting hardware as shown on the Drawings.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.05 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.08 PROTECTION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments specified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 17903

SCHEDULES: I/O LIST

PART 1 GENERAL

1.01 SUMMARY

- A. The I/O list is not a take-off list. Additional information is as indicated on the Drawings and specified in the Contract Documents. Where any discrepancies between this list and the P&ID drawings arise, the P&ID shall govern.
- B. Abbreviations used in the I/O list are defined on the Drawings.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 I/O LIST

- A. I/O list attached.

END OF SECTION

DRAWING	FUNCTION	LOOP	LOCATION	I/O TYPE	EQUIPMENT	I/O DESCRIPTION	RACK	SLOT	POINT	NOTES
PI21-01	L	21.112	PLC-2100	AI	GRIT BASIN NO. 1	LEVEL	1	10	01	
PI21-04	F	21.215	PLC-2100	AI	GRIT WASHER NO. 1	FLOW	1	10	02	
PI21-10	P	21.511	PLC-2100	AI	GRIT BASIN NO. 1 FOUL AIR	PRESSURE	1	10	03	
PI21-13	A	21.931	PLC-2100	AI	ODOR CONTROL FAN ROOM	CGD	1	10	04	
PI21-13	A	21.932	PLC-2100	AI	ODOR CONTROL FAN ROOM	H2S	1	10	05	
PI21-17	T	21.810	PLC-2100	AI	GRIT REMOVAL BUILDING MAU NO. 1	OUTSIDE AIR	1	10	06	
PI21-17	PD	21.810	PLC-2100	AI	GRIT REMOVAL BUILDING MAU NO. 1	DIFF PRESS	1	10	07	
PI21-17	SI	21.810	PLC-2100	AI	GRIT REMOVAL BUILDING MAU NO. 1	SPEED IN	1	10	08	
PI21-17	T	21.811	PLC-2100	AI	GRIT REMOVAL BUILDING MAU NO. 1	DISCHARGE AIR	1	10	09	
PI21-01	L	21.001	PLC-2100	AI	GRIT INFLUENT CHANNEL	LEVEL	1	10	10	
PI21-10	PD	21.503	PLC-2100	AI	GREASE/MIST ELIMINATOR	DIFF PRESS	1	10	11	
PI21-10	P	21.514	PLC-2100	AI	GRIT WASHERS FOUL AIR	PRESSURE	1	10	12	
PI21-10	P	21.515	PLC-2100	AI	GRIT BINS FOUL AIR	PRESSURE	1	10	13	
PI21-02	L	21.122	PLC-2100	AI	GRIT BASIN NO. 2	LEVEL	1	11	01	
PI21-05	F	21.235	PLC-2100	AI	GRIT WASHER NO. 2	FLOW	1	11	02	
PI21-10	P	21.512	PLC-2100	AI	GRIT BASIN NO. 2 FOUL AIR	PRESSURE	1	11	03	
PI21-13	A	21.934	PLC-2100	AI	ODOR CONTROL FAN ROOM	CGD	1	11	04	
PI21-13	A	21.935	PLC-2100	AI	ODOR CONTROL FAN ROOM	H2S	1	11	05	
PI21-18	T	21.820	PLC-2100	AI	GRIT REMOVAL BUILDING MAU NO. 2	OUTSIDE AIR	1	11	06	
PI21-18	PD	21.820	PLC-2100	AI	GRIT REMOVAL BUILDING MAU NO. 2	DIFF PRESS	1	11	07	
PI21-18	SI	21.820	PLC-2100	AI	GRIT REMOVAL BUILDING MAU NO. 2	SPEED IN	1	11	08	
PI21-18	T	21.821	PLC-2100	AI	GRIT REMOVAL BUILDING MAU NO. 2	DISCHARGE AIR	1	11	09	
PI21-11	P	21.521	PLC-2100	AI	BIOFILTER NO. 1 INLET	PRESSURE	1	11	10	ADDITIVE BID ITEM NO. 4
PI21-11	P	21.522	PLC-2100	AI	BIOFILTER NO. 2 INLET	PRESSURE	1	11	11	ADDITIVE BID ITEM NO. 4
PI21-17	T	21.812	PLC-2100	AI	GRIT LOADING ROOM	TEMP	1	11	12	
PI21-17	PD	21.813	PLC-2100	AI	GRIT LOADING ROOM	DIFF PRESS	1	11	13	
PI21-03	L	21.132	PLC-2100	AI	GRIT BASIN NO. 2	LEVEL	1	12	01	ADDITIVE BID ITEM NO. 3
PI21-06	F	21.255	PLC-2100	AI	GRIT WASHER NO. 3	FLOW	1	12	02	ADDITIVE BID ITEM NO. 3
PI21-10	P	21.513	PLC-2100	AI	GRIT BASIN NO. 3 FOUL AIR	PRESSURE	1	12	03	
PI21-18	T	21.822	PLC-2100	AI	GRIT WASHER ROOM	TEMP	1	12	04	
PI21-18	PD	21.823	PLC-2100	AI	GRIT WASHER ROOM	DIFF PRESS	1	12	05	
PI21-18	T	21.832	PLC-2100	AI	GRIT REMOVAL BUILDING RESTROOM	TEMP	1	12	06	
PI21-18	T	21.842	PLC-2100	AI	GRIT REMOVAL BUILDING ELEC ROOM	TEMP	1	12	07	
PI21-17	SB	21.810	PLC-2100	AO	GRIT REMOVAL BUILDING MAU NO. 1	SPEED OUT	1	14	01	
PI21-17	T	21.810	PLC-2100	AO	GRIT REMOVAL BUILDING MAU NO. 1	TEMP SP	1	14	02	
PI21-18	SB	21.820	PLC-2100	AO	GRIT REMOVAL BUILDING MAU NO. 2	SPEED OUT	1	14	03	
PI21-18	T	21.820	PLC-2100	AO	GRIT REMOVAL BUILDING MAU NO. 2	TEMP SP	1	14	04	
PI21-17	AUX1	21.810	PLC-2100	DI	GRIT REMOVAL BUILDING MAU NO. 1	RUNNING	2	02	01	
PI21-17	AUX2	21.810	PLC-2100	DI	GRIT REMOVAL BUILDING MAU NO. 1	FAILED	2	02	02	
PI21-07	ZSO	21.305	PLC-2100	DI	GRIT DIVERTER GATE NO. 1	OPENED	2	02	03	
PI21-07	ZSC	21.305	PLC-2100	DI	GRIT DIVERTER GATE NO. 1	CLOSED	2	02	04	

DRAWING	FUNCTION	LOOP	LOCATION	I/O TYPE	EQUIPMENT	I/O DESCRIPTION	RACK	SLOT	POINT	NOTES
PI21-07	ZSO	21.315	PLC-2100	DI	GRIT DIVERter GATE NO. 2	OPENED	2	02	05	
PI21-07	ZSC	21.315	PLC-2100	DI	GRIT DIVERter GATE NO. 2	CLOSED	2	02	06	
PI21-07	ZSO	21.325	PLC-2100	DI	GRIT DIVERter GATE NO. 3	OPENED	2	02	07	ADDITIVE BID ITEM NO. 3
PI21-07	ZSC	21.325	PLC-2100	DI	GRIT DIVERter GATE NO. 3	CLOSED	2	02	08	
PI21-07	ZSO	21.335	PLC-2100	DI	GRIT DIVERter GATE NO. 4	OPENED	2	02	09	ADDITIVE BID ITEM NO. 3
PI21-07	ZSC	21.335	PLC-2100	DI	GRIT DIVERter GATE NO. 4	CLOSED	2	02	10	
PI21-12	XA2	21.800	PLC-2100	DI	FACP	FIRE ALARM TROUBLE	2	02	11	
PI21-12	XA1	21.800	PLC-2100	DI	FACP	FIRE ALARM SMOKE	2	02	12	
PI21-13	HS2	21.910	PLC-2100	DI	ODOR CONTROL FAN ROOM	SILENCE	2	02	13	
PI21-18	AUX1	21.820	PLC-2100	DI	GRIT REMOVAL BUILDING MAU NO. 2	RUNNING	2	03	01	
PI21-18	AUX2	21.820	PLC-2100	DI	GRIT REMOVAL BUILDING MAU NO. 2	FAILED	2	03	02	
PI21-14	JS4	2100	PLC-2100	DI	PCM-2100	ACB ALERT	2	03	03	
PI21-14	XA1	2100	PLC-2100	DI	PCM-2100	LO BATT	2	03	04	
PI21-14	AUX1	2100	PLC-2100	DI	PCM-2100	ON UPS POWER	2	03	05	
PI21-14	TSH	2100	PLC-2100	DI	PCM-2100	HIGH TEMP	2	03	06	
PI21-14	XA3	2100	PLC-2100	DI	PCM-2100	SWITCH FAIL	2	03	07	
PI21-14	JS1	2100	PLC-2100	DI	PCM-2100	PWR SUP OK	2	03	08	
PI21-14	JS3	2100	PLC-2100	DI	PCM-2100	REDUNDANCY ALERT	2	03	09	
PI21-14	JS2	2100	PLC-2100	DI	PCM-2100	PWR SUP OK	2	03	10	
PI21-14	SPD	2100	PLC-2100	DI	PCM-2100	SPD FAIL	2	03	11	
PI21-14	XA2	2100	PLC-2100	DI	PCM-2100	UPS FAIL	2	03	12	
PI21-11	ZCO	21.523	PLC-2100	DO	BIOFILTER NO. 1 WATER SOLENOID	OPEN	2	05	01	ADDITIVE BID ITEM NO. 4
PI21-11	ZCO	21.524	PLC-2100	DO	BIOFILTER NO. 2 WATER SOLENOID	OPEN	2	05	02	ADDITIVE BID ITEM NO. 4
PI21-17	MST	21.810	PLC-2100	DO	GRIT REMOVAL BUILDING MAU NO. 1	START	2	05	03	
PI21-17	MSP	21.810	PLC-2100	DO	GRIT REMOVAL BUILDING MAU NO. 1	STOP	2	05	04	
PI21-18	MST	21.820	PLC-2100	DO	GRIT REMOVAL BUILDING MAU NO. 2	START	2	05	05	
PI21-18	MSP	21.820	PLC-2100	DO	GRIT REMOVAL BUILDING MAU NO. 2	STOP	2	05	06	
PI21-13	XA1	21.910	PLC-2100	DO	ODOR CONTROL FAN ROOM	GO LIGHT	2	05	07	
PI21-13	XA2	21.910	PLC-2100	DO	ODOR CONTROL FAN ROOM	NO-GO LIGHT	2	05	08	
PI21-13	XA3	21.921	PLC-2100	DO	ODOR CONTROL FAN ROOM	HORN	2	05	09	
PI16-40	AUX1	600A	PLC-600A	DI	PCM-600A	ON UPS POWER	1	04	01	
PI16-40	JS1	600A	PLC-600A	DI	PCM-600A	PWR SUP OK	1	04	02	
PI16-40	JS2	600A	PLC-600A	DI	PCM-600A	PWR SUP OK	1	04	03	
PI16-40	JS3	600A	PLC-600A	DI	PCM-600A	REDUNDANCY ALERT	1	04	04	
PI16-40	JS4	600A	PLC-600A	DI	PCM-600A	ACB ALERT	1	04	05	
PI16-40	SPD	600A	PLC-600A	DI	PCM-600A	SPD FAIL	1	04	06	
PI16-40	TSH	600A	PLC-600A	DI	PCM-600A	HIGH TEMP	1	04	07	
PI16-40	XA1	600A	PLC-600A	DI	PCM-600A	LO BATT	1	04	08	
PI16-40	XA2	600A	PLC-600A	DI	PCM-600A	UPS FAIL	1	04	09	
PI16-40	XA3	600A	PLC-600A	DI	PCM-600A	SWITCH FAIL	1	04	10	

SECTION 17950

TESTING, CALIBRATION, AND COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Testing requirements that apply to process control and instrumentation systems for the entire Project.

1.02 REFERENCES

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Electronics Industries Alliance (EIA).
- C. Telecommunications Industry Association (TIA).

1.03 DEFINITIONS

- A. As specified in Sections 01756 - Commissioning and 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Specific definitions:
 - 1. PTO: Profibus Trade Organization.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 - Submittal Procedures.
- B. General:
 - 1. Reference additional detailed test submittal scheduling and prerequisite requirements as specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Test procedures:
 - 1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware is fully operational and in compliance with the requirements specified in the Contract Documents.
 - 2. Provide a statement of test objectives for each test.
 - 3. Prepare specific procedures for each process system.
 - 4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.

5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), and how the testing equipment will be used.
6. Describe the expected role of the Engineer, as well as any requirements for assistance from Owner's staff.
7. Provide the forms and checklists to be used.

D. Test forms:

1. Provide test and calibration forms and checklists for each of the following:
 - a. Calibration.
 - b. Factory acceptance tests (FAT).
 - c. Loop validation tests.
 - d. Installation tests.
 - e. Functional tests.
 - f. Instrumentation Fine-Tuning.
 - g. Communication Testing including all digital bus and all forms of Ethernet.
2. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
3. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (Engineer and Owner) witnessing the test.
4. Some sample test forms are included at the end of this Section. These test forms show the minimum required test form content. They are not complete, and have not been customized for this Project. The Contractor is to develop and submit test forms customized for the Project and meeting all of the specified test and submittal requirements.

E. Testing binders:

1. Sub-system to be tested, provide and submit a test binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
2. Fill out in advance headings and all other information known before the test.
3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
4. Include or list reference material and provide separately at the time of the test.
5. Record test results and verify that all test requirements and conditions have been met.

F. FAT procedure additional minimal requirements:

1. Prepare and submit a FAT procedure which includes:
 - a. Control system testing block diagram.
 - b. Estimated test duration.
 - c. Details on the simulator construction, components, and operation.

G. Test reports:

1. At the conclusion of each test, submit a complete test report, including all test results and certifications.
2. Include all completed test binders, forms, and checklists.

3. Submission, review, and acceptance of each test report is required before the start of the sub-system.

1.06 QUALITY ASSURANCE

- A. Test personnel:
 1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this Project and the equipment, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.11 WARRANTY (NOT USED)

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS (NOT USED)

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Source testing:

1. Provide manufacturer services as specified in the table below.

Section Number	Section Title	Source Testing (Witnessed or Non-Witnessed)
11324	Grit Washer/Dewatering Units	Control Panel - Witnessed
17710	Control Systems - Panels, Enclosures, and Panel Components	Witnessed
17950	Testing, Calibration, and Commissioning	Witnessed

2. FAT - general:

- a. Performed during the Commissioning Phase, source testing activity.
- b. Before shipment to the Project Site, the complete PCIS system including all PCMs, PLCs, LCPs, peripherals, communications equipment, and other SCADA equipment, shall be assembled, and connected, for a fully functional FAT of the integrated system.
- c. Perform tests to show that the integrated system hardware is fully operational and in compliance with the requirements specified in the Contract Documents.
- d. Additional factory tests are specified in other sections of the Instrumentation and Control Specifications.
- e. The FAT will be witnessed.
- f. Right of observation: The Owner retains the right to observe all factory test activities including any and all subsystem preparation, pretests, troubleshooting, retests, and warm-up.
- g. The Owner reserves the right to test any specified function, whether or not explicitly stated in the test submittal.
- h. Correction of deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
- i. Any changes and/or corrections shall be noted on the test forms. Engineer shall witness the revisions and/or corrections prior to leaving the test site.
- j. If the corrections and/or revisions are too extensive to be made while the Engineer is scheduled to be at the FAT test site, the FAT shall be, at the Engineer's sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the Contractor.

3. Testing simulation:

- a. The FAT shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the SCADA system. All inputs and outputs shall be simulated and proper control and system operation shall be validated.
- b. The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
- c. The hardware simulator may consist of a PLC, operating under a SCADA software package, or other approved software that has its I/O points wired

to PLC's I/O points. Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.

4. Preliminary FAT:
 - a. A complete preliminary FAT (pre-FAT) shall be conducted utilizing test procedures approved by the Engineer. The pre-FAT test procedure shall be a subset of the full FAT.
 - b. The purpose of the pre-FAT is to provide assurance to the Engineer that the SCADA system is ready for the full, witnessed FAT, in terms of both stability and functionality. Troubleshooting of hardware shall occur during and before the pre-FAT, not during the FAT. The Contractor shall fully test the SCADA system and fix all deficiencies found before the full FAT.
 - c. The Owner shall have the right to witness any or all of the pre-FAT testing and shall be notified in writing 20 days before the start of the pre-FAT.
 - d. The pre-FAT test results submittal shall include a letter, signed by the Contractor's project manager or company officer, certifying that the system is complete, has been tested successfully, and is fully ready for the full, witnessed FAT. The submittal shall include completed pre-FAT test forms, signed by the Contractor's staff, and shall be submitted for review before the start of the FAT.
5. Panel inspections:
 - a. The Engineer will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the accepted shop drawings.
 - b. Provide panel inspection forms as part of the FAT procedures submittal.
 - c. Inspection to include, as a minimum: Layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
 - d. A sample FAT control panel form has been provided at the end of this Section.
6. I/O test:
 - a. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
 - b. Test methodology:
 - 1) Discrete inputs: Apply appropriate input at panel terminal, observe input card indicator, observe data value at each indicated data address, observe data received on all operator interface displays (SCADA workstations and local operator interface (LOI) displays).
 - 2) Discrete outputs: Issue commands from operator interface screen, verify output card indicator light and measure response at field wiring terminals. Repeat for each operator interface screen.
 - 3) Analog inputs: Apply appropriate analog input signal at panel terminals, observe data value at each indicated data address, and observe data properly received at each operator screen. Check each point at 0 percent, 50 percent, and 100 percent of scale.
 - 4) Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at panel wiring terminals.
 - c. Test forms to include, but not be limited to:
 - 1) PLC and panel number.

- 2) I/O type.
- 3) I/O tag name.
- 4) Panel terminal block numbers.
- 5) Rack/slot/number of I/O point.
- 6) Check-off for correct response for each I/O point.
- 7) Space for comments.
- 8) Initials of individual performing test.
- 9) Date test was performed.
- 10) Witness' signature lines.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Installation supervision:
 1. Provide as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 COMMISSIONING

- A. Owner training:
 1. Complete Owner training as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- B. Installation testing:
 1. General:
 - a. The Owner reserves the right to test any specified function, whether or not explicitly stated in the test submittals.
 - b. Failure testing:
 - 1) In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
 - a) Equipment failure.
 - b) Operator error.
 - c) Communications sub-system error.
 - d) Power failure.
 - e) Process equipment failure.
 - f) High system loading conditions.

- c. Conduct testing Monday through Friday during normal working hours for no more than 8 hours per day.
 - 1) Testing at other times requires approval of the Engineer.
- 2. Sequencing:
 - a. See additional requirements specified in the Sequencing article of Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- 3. Calibration:
 - a. After installation but before starting other tests, calibrate and adjust all instruments, devices, valves, and systems, in conformance with the component manufacturer's instructions and as specified in these Contract Documents.
 - b. Components having adjustable features are to be set carefully for the specific conditions and applications of this installation. Test and verify that components and/or systems are within the specified limits of accuracy.
 - c. Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
 - d. Calibration points:
 - 1) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to NIST.
 - e. Field verify calibration of instruments that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
 - f. Analyzer calibration:
 - 1) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the manufacturers' technical representatives.
 - g. Complete instrument calibration sheets for every field instrument and analyzer.
 - h. Calibration tags:
 - 1) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
 - 2) Sign the tag when calibration is complete.
- 4. LAN cable post-testing:
 - a. After installing the cable and connectors, test all cables using the LAN certification to confirm the installation meets the requirements of the specification.
 - b. Provide test documentation that includes the cable number, total length of cable, a permanent hard copy, as well as a-USB or CD copy of all traces.
 - 1) After installing connectors:
 - 2) Perform cable end-to-end testing on all installed cables from both ends of the cable. Test shall include cable system performance tests and confirm the absence of wiring errors.
 - 3) Submit a signed test report presenting the results of the cable testing.
 - 4) Repair or replace any portions of the system not meeting ANSI/TIA/EIA standards for a Category 6 installation. Repaired sections shall be retested.
 - c. Submit 3 copies of all final documentation (including traces), using the approved test form, to the Engineer upon successful completion of the testing.

5. Industrial network testing:
 - a. Profibus test procedures:
 - 1) Provide qualified personnel and test equipment required to conduct the inspection and test procedures as specified in this Section.
 - a) The scope of qualification and testing services is based on the network representation as indicated on the Drawings. The scope of qualification and testing services shall include the following network types:
 - (1) Profibus DP networks.
 - b) Network qualification and testing activities:
 - (1) Network installation qualification, testing, and documentation:
 - (a) This qualification and testing activity focuses on the physical media and its installation.
 - (b) Conduct a physical inspection to establish the network configuration:
 - (c) Validate the node type and quantity.
 - (d) Identify improper installation and damaged components.
 - (e) Validate integrity of cables and connectors via a physical media test to confirm the signal propagation capabilities of the network media.
 - (f) Corrective measures shall be recommended based on the results of the inspections and testing.
 - (2) Network operations qualification, testing, and documentation:
 - (a) This qualification and testing activity takes place after the network is commissioned and is under normal operating conditions.
 - (b) The network performance is monitored and measured using non-intrusive test equipment and procedures.
 - (c) The test results are analyzed and corrective measures recommended.
 - (3) Report:
 - (a) Prepare a report that documents the results of the qualification and testing activities.
 - (b) Document the installed condition of the network and provide baseline values for future network maintenance and testing activities.
 - (4) The report to include, but not limited to, the following:
 - (a) Executive summary for each network.
 - (b) Inspection and test results for each network.
 - (c) Calculated network parameters.
 - (d) Recommendations.
 - (e) Description of test procedures and required test equipment.
 - (5) Network agency specifications:
 - (a) The testing and qualifications services will adhere to the recommended standards and practices of the referenced standards bodies and agencies:
 - Profibus networks.

- Profibus network requirements, application specifications, designs, and services shall be in conformance with the applicable PTO specifications.
- (6) Manufacturer's specifications and guidelines:
- (a) Include all applicable manufacturer's specifications and guidelines.
 - (b) Manufacturer's specifications and guidelines may supersede the specifications of the applicable governing body for the associated network but at a minimum must meet all of the governing body's requirements.
 - (c) Test sequence and responsibilities:
 - All qualification and testing activities will be conducted by the Contractor. Figure 1, Network Test Sequence and Responsibilities, defines the general test sequence:
 - Before commencing any network inspection or testing activities, verify that all network segments and nodes are in their final installed condition.
 - The Contractor or installer to provide all necessary components and labor required to address changes required to bring the network into compliance. The installer shall be available at the time of network inspection and testing to address network deficiencies.
 - Before commencing any network inspection or testing activities, inspect all network components and all deficiencies addressed.

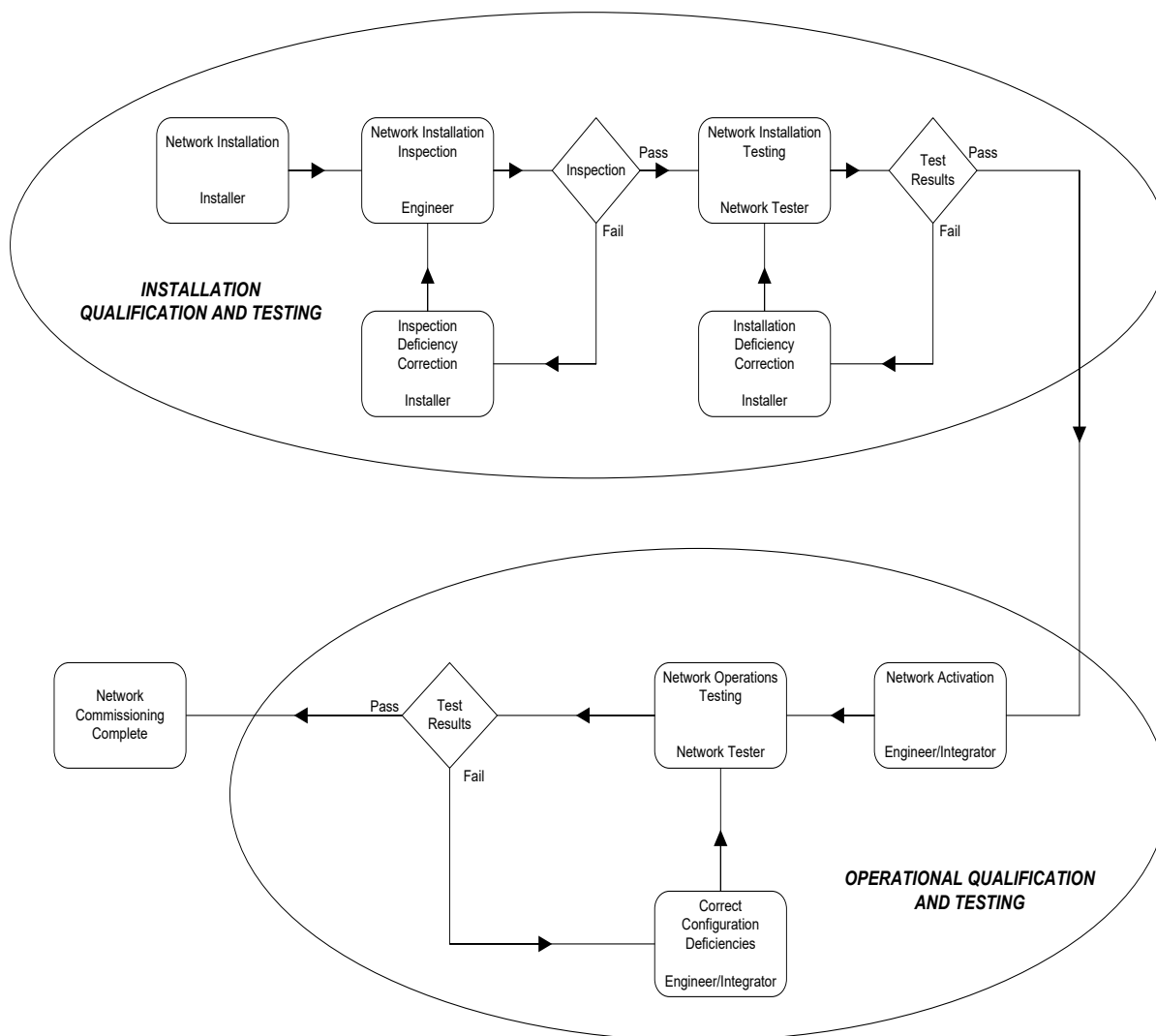


Figure 1
Network Test Sequence and Responsibilities

- c) Profibus test procedure:
- (1) The following prerequisite conditions must be completed before commencing the qualification and testing activities:
 - (a) Installation qualification and testing:
 - All cabling installed, terminated, and labeled.
 - All network node devices installed.
 - All node devices physically disconnected from the network.
 - (b) Manufacturer's data and specifications for all installed network components, available on-site for use by the network testing firm.
 - (c) A complete set of construction drawings and specifications with all addenda and change orders are available on-site for use by the network testing firm.

- d) Operations qualification and testing:
 - (1) Network installation qualification and testing successfully completed.
 - (2) Network is commissioned and is operating under normal conditions.
 - (3) Process and process equipment is not dependent on operation of the network.
- b. Network operation may be interrupted for inspection and testing.
- c. Test equipment:
 - 1) The following test equipment will be utilized in the execution of the described qualification and testing procedures.
 - a) Network line analyzer, ProfiTrace v1.6.
 - b) Oscilloscope, Fluke Scopemeter Series 190 or equivalent.
 - c) Digital VOM, Fluke 87 Multimeter or equivalent.
 - d) Network bus monitor, ProfiTrace v1.6.
- d. Installation qualification and test procedures:
 - 1) Visual and mechanical inspection:
 - a) Compare network devices nameplate data with drawings and specifications.
 - b) Confirm network components are PTO compliant.
 - c) Verify labeling of all trunk cables.
 - d) Confirm minimum cable distance between nodes.
 - e) Verify the presence/absence of stub lines.
 - f) Verify network terminators are in place.
 - g) Verify power supply source and connections for active terminations.
 - h) Verify total network node count.
 - i) Verify power supply specifications including quantity, ratings, locations, and configuration. Verify power supply source of supply location, conductor size, and rating.
 - j) Inspect accessible network cabling for adherence to specified installation practices:
 - (1) Cable installed in conduit or protective raceway.
 - (2) Cable proximity to high voltage wiring.
 - (3) Exposure to extreme temperatures, shock, vibration, chemicals, or moisture.
 - (4) Bend radius.
 - k) Inspect cable and conductor terminations for adherence to specified installation practices.
 - l) Check all accessible components for evidence of physical damage.
 - m) Check grounding techniques including ground conductor sizes and termination points.
 - n) Non-permissible cable length.
 - o) Wrong cable type.
 - p) Signal reflections.
- e. Electrical tests:
 - 1) Measure network resistance.
 - 2) Measure network cable length.
 - 3) Line analysis for the following conditions:
 - a) Short circuit between signal lines A and B.
 - b) Short circuit between signal lines A and B and the cable shield.

- 4) Shield continuity.
- 5) Cross-wired signals lines.
- 6) Terminator installed in wrong position.
- 7) Poor transmission or reception levels.
- 8) Non-permissible stub line.
- f. Generate slave list.
- g. Measure power supply voltage at active terminations.
- h. Evaluation:
 - 1) Confirm the network cable topology (length and configuration) does not exceed data rate limitations.
 - 2) Confirm total stub length (if required by design) does not exceed data rate limitations.
 - 3) Calculate spare trunk length for the specified data rate.
- i. Operations qualifications and test procedures:
 - 1) Electrical tests:
 - a) Examine the data traffic between the master and each slave device.
 - b) Verify baud rate.
 - c) Confirm signal level.
 - d) Verify network cycle time.
 - e) Generate "live" slave list.
 - f) Verify and record scanner diagnostic data including node status and error codes.
 - g) Monitor and capture network waveform.
- j. Evaluation:
 - 1) Confirm all specified slave devices appear on the live list.
 - 2) Evaluate data traffic between master and each slave to confirm proper slave configuration and performance.
 - 3) Inspect waveform capture for evidence of excessive noise.
 - 4) Evaluate and report any failed or questionable network tests.
 - 5) Evaluate and report network error codes and related symptoms.
6. Ultrasonic and radar check out:
 - a. Check response under all operating conditions.
 - b. Track all responses through trend charts in the SCADA system.
 - c. Provide Echo Transmission and signal quality on all level transmitters including guided and unguided units.
 - 1) Provide printout of the actual transmission and all parameters.
7. Loop check/validation:
 - a. Check all control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the SCADA system. Issue commands from the SCADA system and verify proper responses of field devices. Use actual process inputs wherever available.
 - b. Provide "end-to-end" tests:
 - 1) Test SCADA system inputs from field device to SCADA system operator workstations.
 - 2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
 - 3) Observe and record responses at all intermediate devices.

- 4) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
- 5) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
- c. Retest any loop following any necessary corrections.
- d. Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
- e. Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).
- f. Apply provisional settings on controllers and alarm setpoints.
- g. Record all analog loop test data on test forms.
- h. Exercise each field device requiring an analog command signal, through the SCADA system. Vary, during the validation process, the output from the PLC SCADA system and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal. Manually set the output from the SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
- i. Exercise each field device providing a discrete input to the SCADA system in the field and observe the proper operation shall be observed at the operator workstation:
 - 1) Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
 - 2) Exercise starters, relay contacts, switch contacts, and observe proper operation.
 - 3) Calibrate and test instruments supplying discrete inputs, and observe proper operation.
- j. Test each device accepting a discrete output signal from the SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
 - 1) Stroke valves through outputs from the SCADA system, and confirm proper directional operation. Confirm travel limits and any feedback signals to the SCADA system.
 - 2) Exercise motors starters from the SCADA system and verify proper operation through direct field observation.
 - 3) Exercise solenoids and other field devices from the SCADA system and verify proper operation through direct field observation.
- k. Include in the test forms:
 - 1) Analog input devices:
 - a) Calibration range.
 - b) Calibration data: Input, output, and error at each test value.
 - c) Analog input associated PLC register address.
 - d) Value in PLC register at each test point.
 - e) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
 - 2) Analog output devices:
 - a) Calibration range.

- b) Test value at each test point.
- c) Analog output associated PLC register address.
- d) Control variable value at field device at each test point.
- e) Physical device response at each test point:
 - (1) Response to be actual valve position, or motor speed, etc.
- 3) Discrete instrument input devices:
 - a) Switch setting, contact action, and dead band.
 - b) Valve position switches:
 - (1) Response in the PLC as the valve is stroked from the PLC.
 - (2) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
 - c) Operator interface switches (control stations and other pilot devices) and associated response.
 - d) Starter and drive auxiliary device contact response.
 - e) Response of all other discrete inputs to the PLC.
- 4) Discrete output devices:
 - a) Observed response of field device to the discrete output from the PLC.
 - b) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
- 5) Test equipment used and associated serial numbers.

C. Functional Testing:

- 1. General:
 - a. Commence Functional tests after completion of all loop check/validation tests:
 - 1) As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems, Sequencing and Scheduling article.
 - b. Provide "end-to-end" tests:
 - 1) Test SCADA system inputs from field device to SCADA system operator workstations.
 - 2) Test SCADA system outputs from SCADA operator workstations to field devices and equipment.
 - 3) Observe and record responses at all intermediate devices.
 - 4) Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
 - 5) For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
 - c. Functional to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
 - d. Additional tests are specified in other Instrumentation and Control Sections.
 - e. Follow approved detailed test procedures and check lists for Functional Test activities.
- 2. Loop tuning:
 - a. Assist the Owner in requirements to optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process

variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.

- b. Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve 1/4-wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
 - c. If excessive oscillations or system instability occur, as determined by the Engineer, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
3. Functional validation sheets:
- a. Document each Functional test on an approved test form.
 - b. Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the Engineer. Show tuning parameters on the charts, along with time, date, and sign-off by Contractor and Engineer.
 - c. Include on the form, functions which can be demonstrated on a loop-by-loop basis:
 - 1) Loop number and P&ID number.
 - 2) Control strategy, or reference to specification tested.
 - 3) Test procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence loop test checklist forms modified to meet the requirements of the Functional test. Otherwise, create new forms.
 - d. For functions that cannot be demonstrated on a loop-by-loop basis (such as overall plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
 - 1) Specification page and paragraph of function demonstrated.
 - 2) Description of function and/or text from specification.
 - 3) Test procedures: use the FAT loop test checklist forms modified to meet the specific testing conditions of the Functional test.
4. Functional certification:
- a. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.
 - 1) Including all test forms with test data entered, submitted to the Engineer with a clear and unequivocal statement that all Functional test requirements have been satisfied.

D. Instrumentation Fine-Tuning:

1. After the Process Operational Period, test PCIS system for additional 60 days as specified in this Section to identify issues and make corrections, as needed.
2. General:
 - a. The performance test is part of the Work that must be completed as a condition of substantial completion and final completion for the entire Project.
 - b. The complete PLC control and SCADA system must run continuously for the duration of the performance test.

- c. Test and use the entire process control system under standard operating conditions.
 - d. Exercise all system functions.
 - e. Log failure, any system interruption and accompanying component, subsystem, or program failure including time of occurrence, duration of each failure, failure classification, and cause:
 - 1) Provide a competently trained technician on call for the Project Site during all normal working days and hours from the start of the performance test until final acceptance of the system.
 - a) Response time to the Project Site: 24 hours or less, for a major failure.
3. SCADA system testing:
- a. Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
 - b. Failure of the SCADA system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
 - 1) Corrective action is required before restarting the performance test.
 - c. Only those components, sub-systems, and systems covered in this Section and supplied under this Contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.
4. Failures:
- a. Classify failures as either major or minor:
 - 1) Minor failure:
 - a) A small and non-critical component failure that can be corrected by the Owner's operators.
 - b) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
 - c) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
 - d) Failure of one printer or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e., alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
 - 2) Major failure:
 - a) Considered to have occurred when a component or subsystem, causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
 - b) Cause termination of the performance test.
 - c) Start a new acceptance test when the causes of a major failure have been corrected.
 - d) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.
5. Technician report:
- a. Each time a technician is required to respond to a system malfunction, they must complete a report, which includes details concerning the nature

of the complaint or malfunction and the resulting repair action required and taken.

- b. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
- c. If a technician has performed work but no report is written, then a major failure is considered to have occurred.
- d. Each report shall be submitted within 24 hours to the Engineer and the Owner, or its representative.

3.08 FIELD QUALITY CONTROL (NOT USED)

3.09 ADJUSTING (NOT USED)

3.10 CLEANING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES

A. Example test forms:

- 1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of Project-specific test forms for this Project.
- 2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

END OF SECTION

	FACTORY ACCEPTANCE TEST - CONTROL PANELS	
1. GENERAL INSPECTION A. Structural Inspection ☐ Verify Lifting Lugs Installed ☐ Verify enclosure has lock and lock is functional ☐ Confirm that seismic bracing components are provided per manufacturer's installation instructions B. Exterior Inspection ☐ Cabinet exterior is clean, scratch, and dent free ☐ Inspect externally for corrosion and damage ☐ Verify enclosure door opens and closes easily ☐ Verify enclosure has a 3-point latch ☐ Verify enclosure has a flange mounted disconnect (where voltages greater than 120 VAC enter the cabinet) ☐ Verify enclosure has the appropriate NEMA rating (1, 1G, 12, 3R, 4, 4X, etc.) ☐ Verify enclosure is the appropriate size (not grossly larger than design, and will still fit in the plant) Nameplates ☐ Cabinet has identification nameplate ☐ All door labels are straight, spelled correctly, and match the tagging defined in the Contract ☐ Cabinet has a nameplate that includes the following: ☐ Power source(s) ☐ Circuit ID(s) ☐ Integrator's Logo ☐ Short Circuit KAIC ratings ☐ If labels are screwed to door, silicone was utilized to cover screw holes (Labels screwed to the door of a NEMA 4/4X panel technically violates the NEMA rating.) Door Devices ☐ All devices penetrating the outside of panel have gaskets, silicone or both ☐ All door devices are installed (HMIs, Pilot Devices, etc.) ☐ Door mounted equipment is mounted straight and square ☐ All exterior or door mounted equipment present and accounted for, installed and securely fastened ☐ NEMA classification has not been violated due to penetrations ☐ Door mounted equipment has the same NEMA rating as the panel ☐ All door mounted equipment installed at the correct height ☐ All door mounted equipment installed in the correct positions and order (layout of door mounted equipment is grouped properly and in a logical manner) ☐ Doors with multiple penetrations have adequate bracing (if needed) ☐ Visually check condition of indicators , controllers and annunciators ☐ Check that pilot lights illuminate correctly ☐ Check the Push-To-Test function ☐ Ensure correct pilot light color Peripheral Devices ☐ Horn / Beacon is installed (where required) ☐ Silence and Reset pushbutton		
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____ TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____		

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
1. GENERAL INSPECTION (continued) C. Interior Inspection ☐ Cabinet is cleaned of marks and dirt. ☐ Inspect internally for corrosion and damage. ☐ Back panel is clean of marks and dirt. ☐ Interior of panel vacuumed and shall be free of all debris. ☐ Check that the panel roof is clean and clear of foreign materials. ☐ Bottom of panel has been cut out (where bottom entry is required), with angle iron welded around the bottom perimeter. Re-painting has been performed. ☐ If internal light door limit switch is provided, ensure the light automatically turns "on" when the doors are open. ☐ Intrusion alarms (where required). Interior Labeling ☐ All panel mounted equipment has identification labeling, by using either a Brothers or Phenolic type tags. ☐ Verify that door mounted components are mounted square and symmetrical. ☐ Verify that nameplates are straight, legible, and spelled correctly. ☐ All terminal blocks are identified/labeled with permanent labels including tight end blocks and caps. ☐ All wiring shrink labeled and or phased correctly to the specifications. ☐ All wire labels shrunk completely rotated and aligned alike for easy identification. ☐ All fuses and circuit breakers are labeled with ID and current rating. ☐ System Integrator's label or labels installed on door. ☐ Panel manufacturer model/serial number tag is present. ☐ All required safety/warning tags installed and straight. ☐ Correct UL (typically UL 508) or cUL tag installed and registered and all other associated tags installed and straight (the UL tag might not be installed in the panel at the factory test. If the panel is modified due to changes during the factory test or a punch list generated from the factory test, the UL labeling would need to be re-applied. Some UL shops do not apply the UL label until the panel is released to be shipped.). Wireways ☐ Plastic wire way covers installed properly. ☐ Plastic wireways have no sharp edges. ☐ No wire Ties inside the wireways. ☐ No sharp edges on wire ties. ☐ Separation: White duct is used for DC voltages, Gray duct is used for AC voltages. ☐ Ensure wiring duct is not over-full, includes provision for 20% more wiring and the cover may easily be installed. Panduit recommends 50% duct fill, but 40% is a better practice.												
<table style="width: 100%; border: none;"> <tr> <td style="width: 60%;">PROJECT NAME: _____</td> <td style="width: 40%;">TEST DATE: _____</td> </tr> <tr> <td>FACILITY NAME: _____</td> <td>TESTED BY: _____</td> </tr> <tr> <td>PROCESS AREA: _____</td> <td>COMPANY: _____</td> </tr> <tr> <td>NETWORK ID: _____</td> <td>PAGE: _____</td> </tr> <tr> <td>WITNESSED BY: _____</td> <td>SIGNATURE: _____</td> </tr> </table>			PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____											
FACILITY NAME: _____	TESTED BY: _____											
PROCESS AREA: _____	COMPANY: _____											
NETWORK ID: _____	PAGE: _____											
WITNESSED BY: _____	SIGNATURE: _____											

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
1. GENERAL INSPECTION (continued) C. Interior Inspection (continued) Wiring ☐ Visually check terminals and condition of internal wirings ☐ Verify that the control panel has been assembled and wired as designed ☐ Verify that all components are operational and perform the functions intended ☐ Verify that all components are sized appropriately for the application ☐ Verify that equipment control circuits function as intended ☐ Back of door wiring is labeled and neatly formed ☐ Back panel to door wiring has sufficient bending radius with spiral wrap ☐ Wire connection has been verified wired to correct points within the panel ☐ Individual wires have been given a pull test to verify a good terminal connection ☐ Wire and cable minimum bending radius have not been violated ☐ All equipment installed straight and square to back panel ☐ Wire colors are correct: ☐ Black and White > AC hot and neutral, respectively ☐ Red > AC control signals ☐ Blue > DC power and control (Blue w/White stripe for DC ground) ☐ Yellow > Foreign voltages (those still present when panel power is disconnected) ☐ Green > AC equipment ground ☐ Black > TSP (+) ☐ White > TSP(-) ☐ Analog wiring shields are continuous (connected by a dedicated terminal block for such shields) ☐ Analog shield wires are grounded within the panel, where not otherwise grounded at the transmitter itself ☐ Discrete inputs are separately fused or protected by a circuit breaker on a "per loop" basis ☐ Intrinsic Safety Wiring ☐ Ensure wiring associated with intrinsic safety circuits or intrinsic safety barriers is kept away from all other wiring by UL minimum distances or by a physical (grounded metal) barrier preventing non-intrinsically safe wiring from coming in contact with intrinsically safe circuits or wiring ☐ Verify all spare terminals are installed according to the percentage listed in the specifications Grounding ☐ Equipped with "Blackburn" or other grounding type lug ☐ Lug is securely fastened to the panel structure ☐ Verify Grounding bar is installed ☐ Verify Isolated ground bar is installed												
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">PROJECT NAME: _____</td> <td style="width: 50%; border: none;">TEST DATE: _____</td> </tr> <tr> <td style="border: none;">FACILITY NAME: _____</td> <td style="border: none;">TESTED BY: _____</td> </tr> <tr> <td style="border: none;">PROCESS AREA: _____</td> <td style="border: none;">COMPANY: _____</td> </tr> <tr> <td style="border: none;">NETWORK ID: _____</td> <td style="border: none;">PAGE: _____</td> </tr> <tr> <td style="border: none;">WITNESSED BY: _____</td> <td style="border: none;">SIGNATURE: _____</td> </tr> </table>			PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____											
FACILITY NAME: _____	TESTED BY: _____											
PROCESS AREA: _____	COMPANY: _____											
NETWORK ID: _____	PAGE: _____											
WITNESSED BY: _____	SIGNATURE: _____											

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
2. POWER TEST A. AC Power ☐ AC Power is routed correctly within the panel, and is isolated from DC and network wiring. ☐ All fuses are installed and sized properly. ☐ All breakers are installed and sized properly. ☐ 24 VDC Power Supplies are functional. ☐ 24 VDC Power fail contacts are functional. ☐ 24 VDC power supplies are redundant, and have diode modules enabling the hot swap-over between supplies. ☐ 24 VDC supplies are equipped with dry contact failure alarms, wired as PLC inputs to signal failure of any DC power supply. Such alarm inputs to the PLC have been tested as being functional. ☐ Dedicated receptacle is wired to receive a dedicated AC supply. ☐ Verify continuity for all DC commons, ground and AC neutrals. ☐ Verify that the CP temporary input power is connected correctly and is the correct voltage. ☐ Close the CP main circuit breaker(s). ☐ Verify that voltages at subsequent circuit breakers are correct. ☐ Close circuit breakers. ☐ Verify that power feeding interruptible and uninterruptible power supplies is correct. ☐ Turn on power supplies if they are not already on. ☐ Verify that voltages at distribution terminals are correct. ☐ Energize any remaining hardware such as the PLC. B. Uninterruptible Power Supply (UPS) ☐ Mounted appropriately within the cabinet, on a dedicated shelf, or rear of a swing-out sub panel. ☐ Is equipped with maintenance bypass switch (or at least plug/receptacle means for bypassing the unit). ☐ Test all UPS alarms (on inverter, failure, battery failure etc.) ☐ Turn off the AC power supply and verify that the UPS will be switched on to supply the designated vital loads in the control panel. 3. CONTROLS & AUXILIARY DEVICES TEST ☐ Verify all interposing and auxiliary relays are functioning. ☐ Verify panel lights are functioning. Ventilation and Heating ☐ If ventilation fans are fitted, check the fans operate correctly any associated air filters are clean and not blocked. ☐ Verify components are installed in the correct orientation for proper air flow. 4. HARDWIRED INTERLOCK AND SAFETY TEST ☐ Verify that hardwired interlocks through the control panel as shown on schematic drawings are functioning. For example, outlet high pressure switch interlock to a pump. ☐ Verify that all hardwired safety devices through the control panel is functioning. For example, the pull cord emergency stops of conveyors.												
<table style="width: 100%; border: none;"> <tr> <td style="width: 60%;">PROJECT NAME: _____</td> <td style="width: 40%;">TEST DATE: _____</td> </tr> <tr> <td>FACILITY NAME: _____</td> <td>TESTED BY: _____</td> </tr> <tr> <td>PROCESS AREA: _____</td> <td>COMPANY: _____</td> </tr> <tr> <td>NETWORK ID: _____</td> <td>PAGE: _____</td> </tr> <tr> <td>WITNESSED BY: _____</td> <td>SIGNATURE: _____</td> </tr> </table>			PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____											
FACILITY NAME: _____	TESTED BY: _____											
PROCESS AREA: _____	COMPANY: _____											
NETWORK ID: _____	PAGE: _____											
WITNESSED BY: _____	SIGNATURE: _____											

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
5. PLC TEST A. Components ☐ PLC interior High Temperature alarm is installed, wired to the PLC, and is shown to be functional. ☐ Relays have transient suppression across their coils. This is particularly important for DC coil relays, where diodes in reverse polarity are often used. ☐ TVSS is installed across the main incoming 120 VAC. PLC and PLC Rack ☐ Verify all cards are securely seated. ☐ Ensure clearance around PLC rack has been met, such that convective heat transfer is not impeded by devices erroneously mounted in the "no encroachment" area. Confirm with manufacturer clearance recommendations. B. PLC I/O Test ☐ Furnish I/O test forms and test all the listed input and output points as follows: ☐ Discrete Inputs: Simulate a field contact closure by "shorting" across the appropriate terminal blocks. Observe the transition between a logical "0" and "1" in the PLC software. ☐ Discrete Outputs: Force the output bit to toggle between logical "0" and logical "1" using the PLC software. Measure contact resistance at the wired terminal blocks using a digital meter selected for the "ohms" setting. ☐ Analog Inputs: Connect a signal generator to the appropriate terminal blocks. Tailor the connection depending on whether a 2-wire or 4-wire simulation is required. Modulate the 4-20mA signal. Observe the associated PLC internal memory register to transition between 0-65535 or if scaled in engineering units, between 0 and the maximum scaled engineering unit. The latter method is preferred. ☐ Analog Outputs: Force the output register to a value between 0-65535 or 0-100%, if the scaling block can be manipulated. Observe the measured 4-20mA value increment and decrement using a digital ammeter. C. Redundant Controllers (where required) Test ☐ Remove Communication cable from primary PLC to verify switching to backup PLC ☐ Remove Communication cable from backup PLC to verify switching back to primary PLC ☐ Remove Power cable from primary PLC to verify switching to backup PLC ☐ Remove Power cable from backup PLC to verify switching back to primary PLC D. PLC Control Logic Verification ☐ The PLC control strategy is verified by following the Control Logic Verification Form based on the specifications. Each control strategy will be verified by simulating the process and checking the state or value of PLC outputs. The results of equipment status and alarms and process instrument values and trends shall also be verified on the Plant SCADA graphic screens stored in a temporary SCADA computer. Since all PLC input and output wiring has been verified and some field devices are not available during Factory Acceptance Testing, certain inputs will be simulated either by means of additional hardware and/or software as described below. ☐ ☐ ☐ DI states are either simulated by hardwired switches or forced inputs using a programming terminal. ☐ For example, when starters and drives are not provided as part of the contract, jumpers may be installed from the output call relays to the running confirmation inputs to simulate the running state of the motors.												
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">PROJECT NAME: _____</td> <td style="width: 50%; border: none;">TEST DATE: _____</td> </tr> <tr> <td style="border: none;">FACILITY NAME: _____</td> <td style="border: none;">TESTED BY: _____</td> </tr> <tr> <td style="border: none;">PROCESS AREA: _____</td> <td style="border: none;">COMPANY: _____</td> </tr> <tr> <td style="border: none;">NETWORK ID: _____</td> <td style="border: none;">PAGE: _____</td> </tr> <tr> <td style="border: none;">WITNESSED BY: _____</td> <td style="border: none;">SIGNATURE: _____</td> </tr> </table>			PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____											
FACILITY NAME: _____	TESTED BY: _____											
PROCESS AREA: _____	COMPANY: _____											
NETWORK ID: _____	PAGE: _____											
WITNESSED BY: _____	SIGNATURE: _____											

	FACTORY ACCEPTANCE TEST - CONTROL PANELS											
5. PLC TEST (continued) D. PLC Control Logic Verification (continued) Typical Fault Logic ☐ If the fault input is high and the disable (if applicable) for the fault is not high and the common disable (if applicable) is not high begin timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output. If the fault alarm is a shutdown alarm stop the associated motor and latch the alarm so that it remains present even if the condition clears. ☐ The fault condition must return to normal and the alarm must be reset for a latched alarm to clear. Typical Fail to Start Logic ☐ If the motor is called to run (call output high) and no running feedback is received (running input is low) and the fail to start and common alarm disables (if applicable) are not high start timing. If any of these conditions changes, stop timing and reset the timer. If the timer reaches its preset, activate the alarm output, stop calling the motor and latch the alarm. 6. HMI OR OIT TEST HMI / OIT Functionality ☐ Communication with PLC ☐ Screen Layouts ☐ Screen Navigation ☐ Set Point Entry ☐ Animation ☐ Color Correctness (Green=Run, Red=Off, Amber=Alarm, or the agreed upon convention) ☐ Alarms ☐ Acknowledge and Reset ☐ Security / Access Levels / Passwords 7. NETWORK COMMUNICATION TEST A. Network Components ☐ Fiber optic cabling terminates in a patch panel ☐ Media converters are installed and functional ☐ Terminating resistors have been installed for trunk/tap topologies or where required ☐ Wire and cable bending limitations have not been violated B. Networking Functions ☐ Verify data transfer via the network to different PLCs as shown on the Network Block Diagrams ☐ Verify network traffic rate and error margin is acceptable												
<table style="width: 100%; border: none;"> <tr> <td style="width: 60%;">PROJECT NAME: _____</td> <td style="width: 40%;">TEST DATE: _____</td> </tr> <tr> <td>FACILITY NAME: _____</td> <td>TESTED BY: _____</td> </tr> <tr> <td>PROCESS AREA: _____</td> <td>COMPANY: _____</td> </tr> <tr> <td>NETWORK ID: _____</td> <td>PAGE: _____</td> </tr> <tr> <td>WITNESSED BY: _____</td> <td>SIGNATURE: _____</td> </tr> </table>			PROJECT NAME: _____	TEST DATE: _____	FACILITY NAME: _____	TESTED BY: _____	PROCESS AREA: _____	COMPANY: _____	NETWORK ID: _____	PAGE: _____	WITNESSED BY: _____	SIGNATURE: _____
PROJECT NAME: _____	TEST DATE: _____											
FACILITY NAME: _____	TESTED BY: _____											
PROCESS AREA: _____	COMPANY: _____											
NETWORK ID: _____	PAGE: _____											
WITNESSED BY: _____	SIGNATURE: _____											

	FACTORY ACCEPTANCE TEST - CONTROL PANELS			
8. FAT DOCUMENTATION AND RECORD Panel Documentation ☐ As-built panel drawings showing actual panel construction and devices arrangement and c/w Bill of Material. ☐ Panel schematic and interconnection drawings. ☐ P&ID drawings and schematic drawings for the process area controlled by the panel that is to be tested. ☐ I/O list test forms of the process area to be tested. ☐ FAT procedure of the process area to be tested. ☐ Test record forms of the process area to be tested. Forms shall include area for signature of responsible test personnel. ☐ Hard copy of the PLC application program of the process area to be tested. ☐ Hard copy of the HMI/OIT graphic screens of the process area to be tested. 9. FAT TOOLS AND SOFTWARE ☐ Simulation software if required ☐ Digital volt meter Fluke 87 ☐ Process meter Fluke 787 ☐ Laptop computer with PLC application program ☐ Temporary SCADA computer with HMI software and applicable graphic screens ☐ Jumper wires				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____ </td> <td style="width: 50%; vertical-align: top;"> TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____ </td> </tr> </table>			PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____
PROJECT NAME: _____ FACILITY NAME: _____ PROCESS AREA: _____ NETWORK ID: _____ WITNESSED BY: _____	TEST DATE: _____ TESTED BY: _____ COMPANY: _____ PAGE: _____ SIGNATURE: _____			

	INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

☐ ☐
 No Yes

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

REMARKS: _____

CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
SIGNATURE _____	SIGNATURE _____
DATE _____	DATE _____

	SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

<u>FIELD CALIBRATION CHECK</u>						
CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR	ACTUAL TRIP POINT WAS	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT = _____	SET PT = _____	
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET = _____	RESET = _____	

NOTE: PERM IS ABBREVIATION FOR PERMISSIVE

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐
 No Yes

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐
 INDICATOR

☐ OTHER DESCRIPTION _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

<u>BENCH CALIBRATION CHECK</u>				
INPUT RANGE = _____		OUTPUT RANGE = _____		
HEAD CORRECTION = _____		☐ LINEAR		
CALIBRATED SPAN = _____		☐ SQUARE ROOT		
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPECIFICATION SHEET NO. _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

<u>FIELD CALIBRATION CHECK</u>				
INPUT RANGE = _____		OUTPUT RANGE = _____		
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

	TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

- ☐ DIRECT ☐ REVERSE
☐ ACTION VERIFIED AT 50% SPAN
☐ ACTION VERIFIED AT _____ SPAN

CONTROLLER SETTINGS								
SETTING	GAIN	PB	RESET (INTEGRAL)	DERIV. (RATE)	HIGH LIMIT	LOW LIMIT	ELEV. ZERO	ZERO SUPP
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS					
	GAIN	PB	RESET (REPEAT/MIN)	RESET (MIN/REPEAT)	DERIVATION (MINUTES)
FLOW	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

INSTRUMENT LOOP IS PART OF EQUIPMENT START-UP/SHUTDOWN INTERLOCKS?

No Yes

- ☐ VALVE TAG NO. _____ SERIAL NO. _____
- ☐ TRANSDUCER TAG NO. _____ SERIAL NO. _____
- ☐ SOLENOID TAG NO. _____ SERIAL NO. _____
- ☐ VOLUME BOOSTER TAG NO. _____ SERIAL NO. _____
- ☐ POSITIONER _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

TRANSducer CHECK					
INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

- ☐ BENCH CALIBRATED PER ABOVE _____
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ VALVE SPECIFICATION NO. _____
- ☐ TRANSDUCER SPECIFICATION NO. _____
- ☐ SOLENOID SPECIFICATION NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS _____
- ☐ VALVE DETAIL NO. _____
- ☐ TRANSDUCER DETAIL NO. _____
- ☐ SOLENOID DETAIL NO. _____

	CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK			
FLOW CHECK	☐ PROCESS FLOW DIRECTION THROUGH THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS		ON LOSS OF POWER SOLENOID FAILS
	☐ OPEN ☐ CLOSE	☐ TO VENT ☐ TO VALVE	
TRAVEL CHECK	FULL OPEN AT _____ PSI	FULL CLOSED AT _____ PSI	MEASURED TRAVEL _____ INCHES
	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET
POSITIONER CHECK			
VALVE FULL OPEN AT _____ PSI TO POSITIONER			
VALVE FULL CLOSED AT _____ PSI TO POSITIONER			
VOLUME BOOSTER CHECK			
BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT _____ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)			

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE _____ DATE _____

DEVICENET INSTALLATION TESTING					
DeviceNet Network _____					
Network Installation Characteristics					
<u>Architecture</u> ☐ Single Master or ☐ Multi Master ☐ Redundant Power Supplies ☐ Per Network	<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> <u>Baud Rate</u> ☐ 125 kBaud ☐ 250 kBaud ☐ 500 kBaud </td> <td style="width: 50%; vertical-align: top;"> <u>Trunk Media</u> ☐ Thick Round ☐ Thin Round </td> </tr> <tr> <td colspan="2" style="vertical-align: top;"> <u>Drop Media</u> ☐ Thick Round, Unshielded ☐ Thin Round, Shielded ☐ Thick Round, Shielded </td> </tr> </table>	<u>Baud Rate</u> ☐ 125 kBaud ☐ 250 kBaud ☐ 500 kBaud	<u>Trunk Media</u> ☐ Thick Round ☐ Thin Round	<u>Drop Media</u> ☐ Thick Round, Unshielded ☐ Thin Round, Shielded ☐ Thick Round, Shielded	
<u>Baud Rate</u> ☐ 125 kBaud ☐ 250 kBaud ☐ 500 kBaud	<u>Trunk Media</u> ☐ Thick Round ☐ Thin Round				
<u>Drop Media</u> ☐ Thick Round, Unshielded ☐ Thin Round, Shielded ☐ Thick Round, Shielded					
<u>Installed Node List</u> ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18 ☐ 19 ☐ 20 ☐ 21 ☐ 22 ☐ 23 ☐ 24 ☐ 25 ☐ 26 ☐ 27 ☐ 28 ☐ 29 ☐ 30 ☐ 31 ☐ 32 ☐ 33 ☐ 34 ☐ 35 ☐ 36 ☐ 37 ☐ 38 ☐ 39 ☐ 40 ☐ 41 ☐ 42 ☐ 43 ☐ 44 ☐ 45 ☐ 46 ☐ 47 ☐ 48 ☐ 49 ☐ 50 ☐ 51 ☐ 52 ☐ 53 ☐ 54 ☐ 55 ☐ 56 ☐ 57 ☐ 58 ☐ 59 ☐ 60 ☐ 61 ☐ 62 ☐ 63 ☐ All nodes present and in accordance with network drawings/specifications ☐ ODVA approved devices ☐ Nodes/devices accessible for inspection and maintenance ☐ Nodes/devices properly addressed Comments: _____ _____ _____					
Media Inspection					
<u>Trunk Cable</u> ☐ ODVA approved ☐ Labeling complete ☐ Cable/conductor terminations ☐ Terminating resistors at ends	<u>Drop Cable</u> ☐ ODVA approved ☐ Labeling complete ☐ Cable/conductor terminations ☐ Maximum drop length < 20'	<u>Installation</u> ☐ No evidence of physical damage ☐ Installed in protective raceway ☐ Bending radius not exceeded ☐ Cable supports in place ☐ V- and shield are grounded ☐ Clearance from high temperature/voltage sources ☐ No installation subject to vibration			
Comments: _____ _____ _____					

Network Power SuppliesPower Supply Equipment

- ☐ ODVA compliant
☐ Quantity and ratings

Supply Source (120 VAC)

- ☐ Overcurrent protection
☐ Conductor size

Network Power Tap (24 VDC)

- ☐ Overcurrent protection
☐ Conductor size

Comments:

CHECKED BY (COMPANY)

ACCEPTED BY
(COMPANY)

SIGNATURE

SIGNATURE

DATE

DATE

PROFIBUS INSTALLATION QUALIFICATION AND TESTING

General Network Description

The Profibus network serves the RO pretreatment, blended water, and concentrate processes and consists of both DP and PA slave devices. The master is located in programmable logic controller, PLC-900. Profibus DP repeaters are deployed in the network to essentially support a radial network topology from each process control panel.

Network Design Characteristics

ARCHITECTURE

MASTER ☐ SINGLE ☐ REDUNDANT
 TOTAL NODE COUNT ≤ 126 ☐
 REPEATER COUNT _____
 CASCADED REPEATER COUNT <9 _____
 NODE COUNT PER DP SEGMENT <32 ☐
 DP/PA SEGMENT COUPLERS _____
 REDUNDANCY (DP/PA COUPLERS) _____
 ACTIVE TERMINATORS ☐
 PROFIBUS DIAGNOSTICS ☐ PA ONLY ☐ DP & PA
 SURGE PROTECTION FOR SLAVES LOCATED OUTSIDE ☐
 SURGE PROTECTION FOR MEDIA ENTERING THE CONTROLLER CABINET ☐
 INTRINSIC SAFETY WIRING: REQUIRED FOR ANY PA NETWORK ☐

BAUD RATE (kbits/sec)

☐ 9.6 ☐ 187.5 ☐ 3,000
☐ 19.2 ☐ 50 ☐ 6,000
☐ 93.75 ☐ 1,500 ☐ 12,000

INSTALLED NODE LIST

☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	☐ 11	☐ 12	☐ 13	☐ 14	☐ 15
☐ 16	☐ 17	☐ 18	☐ 19	☐ 20	☐ 21	☐ 22	☐ 23	☐ 24	☐ 25	☐ 26	☐ 27	☐ 28	☐ 29	☐ 30	☐ 31
☐ 32	☐ 33	☐ 34	☐ 35	☐ 36	☐ 37	☐ 38	☐ 39	☐ 40	☐ 41	☐ 42	☐ 43	☐ 44	☐ 45	☐ 46	☐ 47
☐ 48	☐ 49	☐ 50	☐ 51	☐ 52	☐ 53	☐ 54	☐ 55	☐ 56	☐ 57	☐ 58	☐ 59	☐ 60	☐ 61	☐ 62	☐ 63
☐ 64	☐ 65	☐ 66	☐ 67	☐ 68	☐ 69	☐ 70	☐ 71	☐ 72	☐ 73	☐ 74	☐ 75	☐ 76	☐ 77	☐ 78	☐ 79
☐ 80	☐ 81	☐ 82	☐ 83	☐ 84	☐ 85	☐ 86	☐ 87	☐ 88	☐ 89	☐ 90	☐ 91	☐ 92	☐ 93	☐ 94	☐ 95
☐ 96	☐ 97	☐ 98	☐ 99	☐ 100	☐ 101	☐ 102	☐ 103	☐ 104	☐ 105	☐ 106	☐ 107	☐ 108	☐ 109	☐ 110	☐ 111
☐ 112	☐ 113	☐ 114	☐ 115	☐ 116	☐ 117	☐ 118	☐ 119	☐ 120	☐ 121	☐ 122	☐ 123	☐ 124	☐ 125	☒ R 126	☒ R 127

☐ ALL NODES PRESENT IN ACCORDANCE WITH NETWORK DESIGN DOCUMENTS.

LEGEND

☒ **M** MASTER NODE PRESENT AT THIS ADDRESS
☐ **D** PROFIBUS DP NODE PRESENT AT THIS ADDRESS
☐ **P** PROFIBUS PA NODE PRESENT AT THIS ADDRESS
☐ **R** RESERVED ADDRESS
☐ NO DEVICE PRESENT AT THIS ADDRESS

COMMENTS (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)

PROJECT NAME: _____
 FACILITY NAME: _____
 PROCESS AREA: _____
 NETWORK ID: _____
 WITNESSED BY: _____

TEST DATE: _____
 TESTED BY: _____
 COMPANY: _____
 PAGE: _____

SIGNATURE: _____

PROFIBUS INSTALLATION QUALIFICATION AND TESTING

Media Inspection

CABLING	DP NETWORK	PA NETWORK SEGMENTS				
PI COMPLIANT	☐	☐	☐	☐	☐	☐
LABELING COMPLETE	☐	☐	☐	☐	☐	☐
GROUNDING	☐	☐	☐	☐	☐	☐
CABLE AND CONDUCTOR TERMINATIONS	☐	☐	☐	☐	☐	☐
NO STUB LINES (DP ONLY)	☐	☐	☐	☐	☐	☐
TERMINATING RESISTORS (IN PLACE)	☐	☐	☐	☐	☐	☐
DEDICATED DIAGNOSTICS BUS INSTALLATION	☐	☐	☐	☐	☐	☐
NO EVIDENCE OF PHYSICAL DAMAGE	☐	☐	☐	☐	☐	☐
INSTALLATION IN PROTECTIVE RACEWAY	☐	☐	☐	☐	☐	☐
CLEARANCES FROM HIGH TEMPERATURE SOURCES	☐	☐	☐	☐	☐	☐
CLEARANCES FROM HIGH VOLTAGE SOURCES	☐	☐	☐	☐	☐	☐
BEND RADIUS	☐	☐	☐	☐	☐	☐
NO INSTALLATION SUBJECT TO VIBRATION, SHOCK, HIGH FLEX, CHEMICALS, OR MOISTURE	☐	☐	☐	☐	☐	☐
TERMINATING RESISTORS TURNED ON AT CORRECT LOCATION	☐	☐	☐	☐	☐	☐
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)						

Device Inspection

DEVICE QUANTITY/TYPE	INSTALLATION
☐ TOTAL SLAVE COUNT	☐ NO EVIDENCE OF PHYSICAL DAMAGE
☐ MOST UPDATED DEVICE DRIVER INSTALLED?	☐ ACCESSIBLE FOR INSPECTION AND MAINTENANCE
☐ INSTALLED DEVICES COMPLY WITH DRAWINGS AND SPECIFICATIONS	☐ FDT COMPLIANT DEVICES
☐ PI COMPLIANCE DEVICES	
☐ DIAGNOSTICS MODULE INSTALLED	
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)	

Power Supplies

ACTIVE TERMINATIONS	COUPLERS	REPEATERS
☐ SOURCE LOCATION	☐ SOURCE LOCATION	☐ SOURCE LOCATION
☐ OVERCURRENT PROTECTION	☐ OVERCURRENT PROTECTION	☐ OVERCURRENT PROTECTION
☐ CONDUCTOR SIZE	☐ CONDUCTOR SIZE	☐ CONDUCTOR SIZE
☐ GROUNDING	☐ GROUNDING	☐ GROUNDING
<u>COMMENTS</u> (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)		

PROJECT NAME: _____	TEST DATE: _____
FACILITY NAME: _____	TESTED BY: _____
PROCESS AREA: _____	COMPANY: _____
NETWORK ID: _____	PAGE: _____
WITNESSED BY: _____	SIGNATURE: _____

**PROFIBUS
INSTALLATION QUALIFICATION AND TESTING**

DP Network Media Testing

DESCRIPTION	SEGMENT ID													
TRUNK LENGTH (feet)														
ALLOWABLE TRUNK LENGTH AT SPECIFIED DATA RATE:														
MEASURED TRUNK LENGTH:														
SPARE TRUNK LENGTH														
RESISTANCE MEASUREMENTS (ohms)														
NETWORK CABLE: NO TERMINATIONS														
ONE TERMINATION														
TWO TERMINATIONS														
POWER SUPPLY VOLTAGE (volts DC)														
ACTIVE TERMINATOR														
REPEATER CP1100-RPT1														
REPEATER CP1000-RPT1														
REPEATER CP1000-RPT2														
REPEATER CP2700-RPT1														
CABLE TEXTS	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SHORT CIRCUIT BETWEEN SIGNAL LINES AND SHIELD	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SHIELD CONTINUITY	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR OPEN SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR CROSSED SIGNAL LINES	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR CORRECT TERMINATOR POSITION	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
CORRECT CABLE TYPE AND LENGTH	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
TESTED FOR SECURE AND TIGHT CONNECTORS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
COMMENTS (Comments referenced by number. Refer to the Comments, Observations, and Recommendations Summary.)														

PROJECT NAME: _____	TEST DATE: _____
FACILITY NAME: _____	TESTED BY: _____
PROCESS AREA: _____	COMPANY: _____
NETWORK ID: _____	PAGE: _____
WITNESSED BY: _____ SIGNATURE: _____	

APPENDIX A - GEOTECH REPORT



GEOTECHNICAL INVESTIGATION

**SOUTH VALLEY WATER RECLAMATION FACILITY
PROJECT 5 GRIT BUILDING**

7495 SOUTH 1300 WEST

WEST JORDAN, UTAH

PREPARED FOR:

**CAROLLO ENGINEERS
7090 SOUTH UNION PARK AVENUE, SUITE 600
MIDVALE, UTAH 84047**

ATTENTION: JAMES DIXON

PROJECT NO. 1180225

MAY 3, 2018

TABLE OF CONTENTS

EXECUTIVE SUMMARY.	Page 1
SCOPE.	Page 2
SITE CONDITIONS.	Page 2
FIELD STUDY.	Page 3
SUBSURFACE CONDITIONS.	Page 3
SUBSURFACE WATER.	Page 4
PROPOSED CONSTRUCTION.. . . .	Page 4
RECOMMENDATIONS.	Page 5
A. Site Grading.	Page 5
B. Foundations.	Page 7
C. Concrete Slab-on-Grade.	Page 9
D. Lateral Earth Pressures.	Page 9
E. Seismicity, Liquefaction and Faulting.	Page 11
F. Water Soluble Sulfates and Corrosion Potential.	Page 12
LIMITATIONS.	Page 13
REFERENCES.. . . .	Page 14

FIGURES

EXPLORATORY BORING LOCATION	FIGURE 1
EXPLORATORY BORING LOGS, LEGEND AND NOTES	FIGURE 2
CONSOLIDATION TEST RESULTS	FIGURE 3
GRADATION TEST RESULTS	FIGURE 4
SUMMARY OF LABORATORY TEST RESULTS	TABLE I

EXECUTIVE SUMMARY

1. The subsurface materials encountered at the site consist of approximately 12 to 14 feet of fill overlying lean clay. Interlensed sand and gravel was encountered below the clay at depths of approximately 24 and 17 feet in Borings B-1 and B-2, respectively. The sand and gravel extends the full depth investigated, approximately 36 feet.
2. Subsurface water was encountered at depths of approximately 17½ and 17 feet in Borings B-1 and B-2, respectively, when measured 9 days after drilling. Fluctuations in the water level can be expected over time.
3. The high loads and variability of the subsurface conditions based on the borings will result in potentially more settlement than desired unless a mat foundation is used. We estimate settlement for an average pressure of 2,000 pounds per square foot placed over an area of 75 by 50 feet to range from ½ to 1½ inches between the two boring locations. The settlement can be reduced by preloading the site as has been done in the past for other structures. Lowering the site or supporting heavy structures on deep foundations would be other options to reduce settlement.
4. The proposed building may be supported on spread footings bearing on properly-compacted structural fill extending down to the natural undisturbed soil and may be designed for a net allowable bearing pressure of 3,500 pounds per square foot. A mat foundation would also provide suitable support for the proposed building.
5. We understand that the existing fill consisting of clayey gravel with sand was compacted for support of structures. Compaction tests should be performed in the base of foundation excavations to confirm proper compaction.
6. Geotechnical information related to foundations, subgrade preparation and materials is included in the report.

SCOPE

This report presents the results of a geotechnical investigation for the proposed Project 5 grit building to be constructed at the South Valley Water Reclamation Facility located at 7495 South 1300 West in West Jordan, Utah. The report presents the subsurface conditions encountered, laboratory test results and recommendations for foundations. The study was conducted in general accordance with our proposal dated March 26, 2018.

A geotechnical study was performed for Montgomery Watson Harza for a previous expansion of the facility near this area. The report is dated March 10, 2005 with Project No. 1050028.

Field exploration was conducted to obtain information on the subsurface conditions. Samples obtained from the field investigation were tested in the laboratory to define physical and engineering characteristics of the on-site soil. Information obtained from the field and laboratory was used to define conditions at the site for our engineering analysis and to develop recommendations for the proposed foundations.

This report has been prepared to summarize the data obtained during the study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to construction are included in the report.

SITE CONDITIONS

At the time of our field study, the area of the proposed addition was a grass-covered field. There were no permanent structures or pavement in this area.

The ground surface at the site is relatively flat with a gentle slope down to the east.

There are fields south, east and west of the site and structures for the facility to the north.

FIELD STUDY

The field study was conducted on April 16, 2018. Two borings were drilled at the approximate locations indicated on Figure 1 using 8-inch hollow-stem auger powered by a track-mounted drill rig, to minimize damage to the grass as requested by the plant representative. The borings were logged and soil samples obtained by an engineer from AGECE. Logs of the subsurface conditions encountered in the borings are presented on Figure 2.

SUBSURFACE CONDITIONS

The subsurface materials encountered at the site consist of approximately 12 to 14 feet of fill overlying lean clay. Interlensed sand and gravel was encountered below the clay at depths of approximately 24 and 17 feet in Borings B-1 and B-2, respectively. The sand and gravel extends the full depth investigated, approximately 36 feet.

A description of the soil encountered in the borings follows:

Fill - The upper approximately 1 and ½ feet of fill in Borings B-1 and B-2, respectively, consists of lean clay with sand. It is very moist, dark brown and contains organics. The lower fill consists of clayey gravel with sand. It is moist to very moist and brown. We understand this fill was placed in a controlled manner and compacted to provide support for future structures. The N-values obtained from borings are consistent with well-compacted fill.

Laboratory tests performed on the granular fill indicate the fill has dry densities of 131 to 134 pounds per cubic foot (pcf), consistent with well-compacted fill and moisture contents of 8 to 10 percent.

Lean Clay - The clay contains silty sand and sandy silt layers. It is soft to medium stiff, wet and brown to gray.

Laboratory tests on the clay indicate it has a natural moisture content of 30 percent and a natural dry density of 91 pcf. Results of a consolidation test performed on the clay indicate it will compress a small to moderate amount with the addition of small to moderate loads. Results of the test are presented on Figure 3.

Poorly-graded Sand with Silt and Gravel to Poorly-graded Gravel with Silt and Sand -

The sand and gravel contains small to moderate amounts of silt, and silty sand and sandy silt layers. It is medium to very dense, wet and gray to brownish gray.

Results of laboratory tests are included on the boring logs and on Table I.

SUBSURFACE WATER

Subsurface water was encountered at depths of approximately 17 ½ and 17 feet in Borings B-1 and B-2, respectively, when measured 9 days after drilling. Fluctuations in the water level can be expected over time.

PROPOSED CONSTRUCTION

We understand that the grit building will have concrete tanks on one side and equipment on the other side. The load over the building is estimated by the structural engineer to be about 2,000 pounds per square foot.

If the proposed construction or loads are significantly different from those described above we should be notified so that we can reevaluate the recommendations given.

RECOMMENDATIONS

Based on the proposed construction, the following recommendations are given:

A. Site Grading

1. Existing Fill

The fill consisting of clayey gravel with sand is suitable for use as structural fill below the proposed building. If the fill was compacted to at least 95 percent of the maximum dry density determined by ASTM D1557, it would be suitable in its current condition for support of the building foundations. If it was compacted to a lower density then it should be removed and replaced in a properly compacted condition. Compaction of the fill should be measured in foundation excavations.

2. Excavation

Excavation at the site can be accomplished with typical excavation equipment. Where very moist to wet clay is encountered, low ground pressure equipment or equipment supported outside and above excavations will likely be needed.

Excavations that extend below the water level should be dewatered prior to and during excavation and concrete and fill placement.

3. Shoring

Care should be taken to maintain stability of excavations during construction. Proper side slopes or shoring should be provided for safety of workers and to support existing adjacent facilities. Proper shoring should be used where appropriate. Shoring should be designed to restrain the soil mass along with the surcharge from construction equipment and other loads.

Active lateral loads may be calculated using an equivalent fluid weight of 50 and 40 pcf above the water table and 25 and 20 pcf plus the hydrostatic pressure below the water table for cohesive and granular soils, respectively. The lateral load calculation should include the effective seepage forces, sloping backfill, surcharge and other loading conditions which are not included in the values given above. An appropriate factor of safety should be used in design for shoring systems and trench boxes.

4. Unretained Cut Slopes

Temporary, unretained cut slopes may be constructed at 1 horizontal to 1 vertical or flatter. The cut slopes indicated above assume that the excavation will be properly dewatered. If water is allowed to flow into the excavation, slopes will need to be significantly flatter. It is the responsibility of the contractor to provide appropriate slopes to assure safe working conditions and stability of adjacent facilities. Additional evaluation of excavation slopes by a qualified engineer may be required during the construction process.

5. Compaction

Compaction of materials placed at the site should equal or exceed the minimum densities as indicated below when compared to the maximum dry density as determined by ASTM D 1557.

<u>Fill To Support</u>	<u>Compaction</u>
Foundations and Floor Slabs	≥ 95 %
Retaining Wall Backfill	85 - 90 %

To facilitate the compaction process, the fill should be compacted at a moisture content within 2 percent of the optimum moisture content.

Fill should be frequently tested during construction for compaction.

6. Materials

Materials placed as fill to support foundations should be nonexpansive granular soil free of organics, debris and other deleterious materials. The fill consisting of clayey gravel with sand may be used as structural fill and as backfill around the proposed structure if it meets the recommendations given below. The natural clay and fill consisting of clay are not recommended for use as structural fill below the structure but may be considered for use as backfill outside the area of the structure.

Use of the on-site soil as fill will likely require moisture conditioning to facilitate proper compaction. Drying of the soil may not be practical during cold or wet periods of the year.

Structural fill should consist of non-expansive granular soil with less than 35 percent passing the No. 200, a liquid limit of less than 35 percent and a maximum size of 4 inches. Free-draining gravel is recommended for use as fill below the original free-water level. A support fabric should be provided between the free-draining gravel and the natural soil.

B. **Foundations**

Spread footings or mat foundations may be used to support structural loads.

1. Bearing Material

With the proposed construction and the subsurface conditions encountered, the proposed building may be supported on spread footings bearing on properly-compacted structural fill extending down to the natural undisturbed soil. Compacted structural fill should extend down to the undisturbed natural soil and out away from the edge of the footings at least a distance equal to the depth of fill beneath the footings.

Unsuitable fill, topsoil, organics, debris and other deleterious materials should be removed from below proposed foundation areas.

2. Bearing Pressure

Footings bearing on properly-compacted structural fill may be designed using an allowable net bearing pressure of 3,500 pounds per square foot.

3. Subgrade Modulus

Subgrade modulus values of 5, 10 and 20 pci may be used in design of a mat foundation. We can review the results of the mat analysis to determine a reasonable value for use in design or the most conservative design may be used.

4. Temporary Loading Conditions

The allowable bearing pressure may be increased by one-third for temporary loading conditions such as wind or seismic loads.

5. Settlement

The high loads and variability of the subsurface conditions based on the borings will result in potentially more settlement than desired. We estimate settlement for an average pressure of 2,000 pounds per square foot placed over an area of 75 by 50 feet to range from ½ to 1 ½ inches between the two boring locations. The settlement can be reduced by preloading the site as has been done in the past for other structures. Lowering the site or supporting heavy structures on deep foundations would be other options to reduce settlement.

6. Frost Depth

Exterior footings and footings beneath unheated areas should be placed at least 30 inches below grade for frost protection.

7. Foundation Base

The base of footing excavations should be cleared of loose or deleterious material prior to structural fill or concrete placement.

8. Construction Observation

A representative of the geotechnical engineer should observe footing excavations prior to structural fill or concrete placement.

C. Concrete Slab-on-Grade

1. Slab Support

Concrete slabs may be supported on properly compacted structural fill extending down to the undisturbed natural soil. Topsoil, debris, unsuitable fill and other deleterious materials should be removed from below proposed floor slabs.

2. Underslab Sand and/or Gravel

A 4-inch layer of free draining sand and/or gravel with less than 5 percent passing the No. 200 sieve should be placed below the concrete slabs for ease of construction and to promote even curing of the slab concrete.

3. Vapor Barrier

A vapor barrier should be placed under the concrete floor if the floor will receive an impermeable floor covering. The barrier will reduce the amount of water vapor passing from below the slab to the floor covering.

D. Lateral Earth Pressures

1. Lateral Resistance for Footings

Lateral resistance for spread footings is controlled by the sliding resistance developed between the footing and foundation soil plus the passive resistance

of the soil. A friction value of 0.45 may be used for ultimate resistance in design of footings.

2. Subgrade Walls and Retaining Structures

The following equivalent fluid weights are given for design of subgrade walls and retaining structures. The active condition is where the wall moves away from the soil. The passive condition is where the wall moves into the soil and the at-rest condition is where the wall does not move. The values listed below assume a horizontal surface adjacent the wall.

Soil Type	Active	At-Rest	Passive
Clay & Silt (above water table)	50 pcf	65 pcf	250 pcf
Clay & Silt (below water table)	*25 pcf	*30 pcf	*120 pcf
Sand and Gravel (above water table)	40 pcf	55 pcf	300 pcf
Sand and Gravel (below water table)	*20 pcf	*25 pcf	*140 pcf

**Hydrostatic pressure should be added to these values.*

3. Seismic Conditions

Under seismic conditions, the equivalent fluid weight should be increased by 35 pcf for active condition, increased by 20 pcf for the at-rest condition and decreased by 35 pcf for the passive condition. This assumes a peak ground acceleration of 0.58g which represents a 2 percent probability of exceedance in a 50-year period (IBC, 2015).

4. Safety Factors

The values recommended above assume mobilization of the soil to achieve soil strength. Conventional safety factors used for structural analysis for such items as overturning and sliding resistance should be used in design.

E. Seismicity, Liquefaction and Faulting

1. Seismicity

Listed below is a summary of the site parameters for the 2015 International Building Code:

a.	Site Class	D
b.	Short Period Spectral Response Acceleration, S_s	1.38g
c.	One Second Period Spectral Response Acceleration, S_1	0.45g

2. Liquefaction

The site is located within an area mapped as having a "moderate" potential for liquefaction (Salt Lake County, 2002). Research indicates that the soil type most susceptible to liquefaction during a large magnitude earthquake is loose, clean sand. In order for liquefaction to occur, the soil must be saturated. The liquefaction potential for soil tends to decrease with an increase in fines content and density.

Based on the subsurface conditions encountered at the site, liquefaction may occur in some of the sand layers below the site. We expect the main result of this liquefaction would be settlement of the ground. The amount of settlement is estimated to be less than 1 inch with less than half of this differential across the structure.

3. Faulting

There are no mapped active faults extending near or through the site. The closest fault considered to be active is the Granger Fault located approximately 3.6 miles to the north/northwest of the site (Utah Geological Survey, 2018).

F. Water Soluble Sulfates and Corrosion Potential

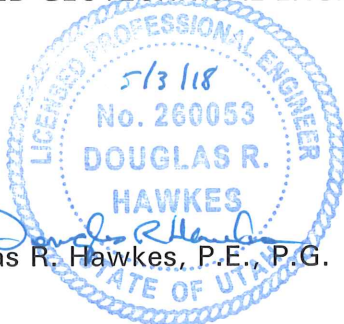
Previous testing at the site has found the natural soil to have less than 0.1 percent water soluble sulfate. Based on the results of the test and published literature, the natural soil possesses negligible sulfate attack potential on concrete. No special cement type is needed for concrete placed in contact with the natural soil.

The fill consisting of clayey gravel with sand would not be expected to have a high sulfate content. The corrosion potential of the fill would be expected to be low to moderate. The natural clay would be expected to have moderate to high corrosion potential. The fill could be tested to determine its corrosion potential.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices in the area for the use of the client for design purposes. The conclusions and recommendations included within the report are based on the information obtained from the borings drilled at the approximate locations indicated on the site plan and the data obtained from laboratory testing. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface conditions or groundwater level is found to be significantly different from what is described above, we should be notified to reevaluate the recommendations given.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.


Douglas R. Hawkes, P.E., P.G.


Reviewed by Jay R. McQuivey, P.E.

DRH/rs

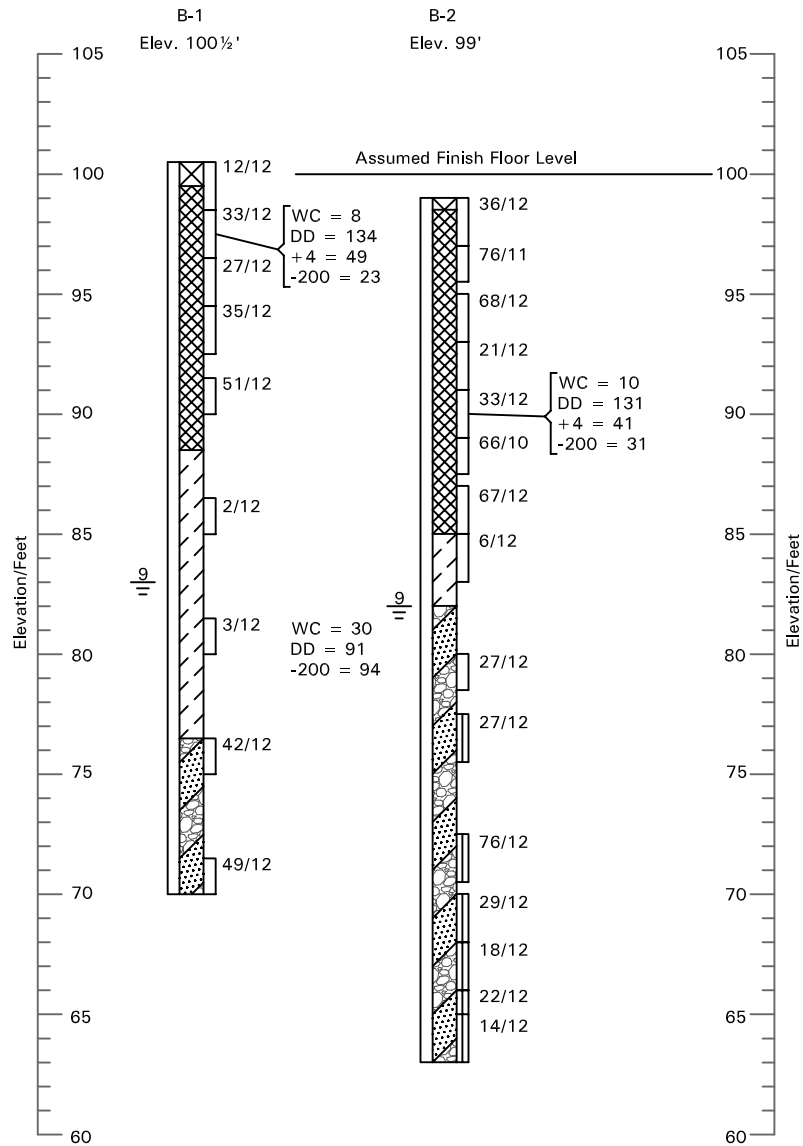
REFERENCES

International Building Code, 2015; International Code Council, Inc., Falls Church, Virginia.

Salt Lake County, 2002; Surface Rupture and Liquefaction Potential Special Study Areas Map, Salt Lake County, Utah, adopted March 31, 1989, updated March 2002, Salt Lake County Public Works - Planning Division, 2001 South State Street, Salt Lake City, Utah.

Utah Geological Survey, 2018; Utah Quaternary Fault and Fold Database, <http://geology.utah.gov/resources/data-databases/qfaults/> Accessed January 4, 2018.





LEGEND:

- Fill; lean clay with sand, very moist, dark brown, organics.
- Fill; clayey gravel with sand, moist to very moist, brown.
- Lean Clay (CL); silt and sand layers, soft to medium stiff, wet, brown to gray.
- Poorly-graded Sand with Silt and Gravel to poorly-graded Gravel with Silt and Sand (SP-SM/GP-GM); small to moderate amount of silt, silty sand and sandy silt layers, medium to very dense, wet, gray to brownish gray.
- 10/12 California Drive sample taken. The symbol 10/12 indicates that 10 blows from a 140 pound automatic hammer falling 30 inches were required to drive the sampler 12 inches.
- 10/12 Standard Penetration Test. The symbol 10/12 indicates that 10 blows from a 140 pound automatic hammer falling 30 inches were required to drive the sampler 12 inches.
- Indicates slotted 1 1/2 inch PVC pipe installed in the boring to the depth shown.
- Indicates the depth to free water and the number of days after drilling the measurement was taken.

NOTES:

1. The borings were drilled on April 16, 2018 with 8-inch diameter hollow-stem auger.
2. The locations of the borings were measured approximately by pacing from features shown on the site plan provided.
3. The elevations of the borings were measured by automatic level and refer to the benchmark shown on Figure 1.
4. The boring locations and elevations should be considered accurate only to the degree implied by the method used.
5. The lines between materials shown on the boring logs represent the approximate boundaries between material types and the transitions may be gradual.
6. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water will occur with time.
7. WC = Water Content (%);
DD = Dry Density (pcf);
+4 = Percent Retained on the No. 4 Sieve;
-200 = Percent Passing the No. 200 Sieve.

Approximate Vertical Scale 1" = 8"

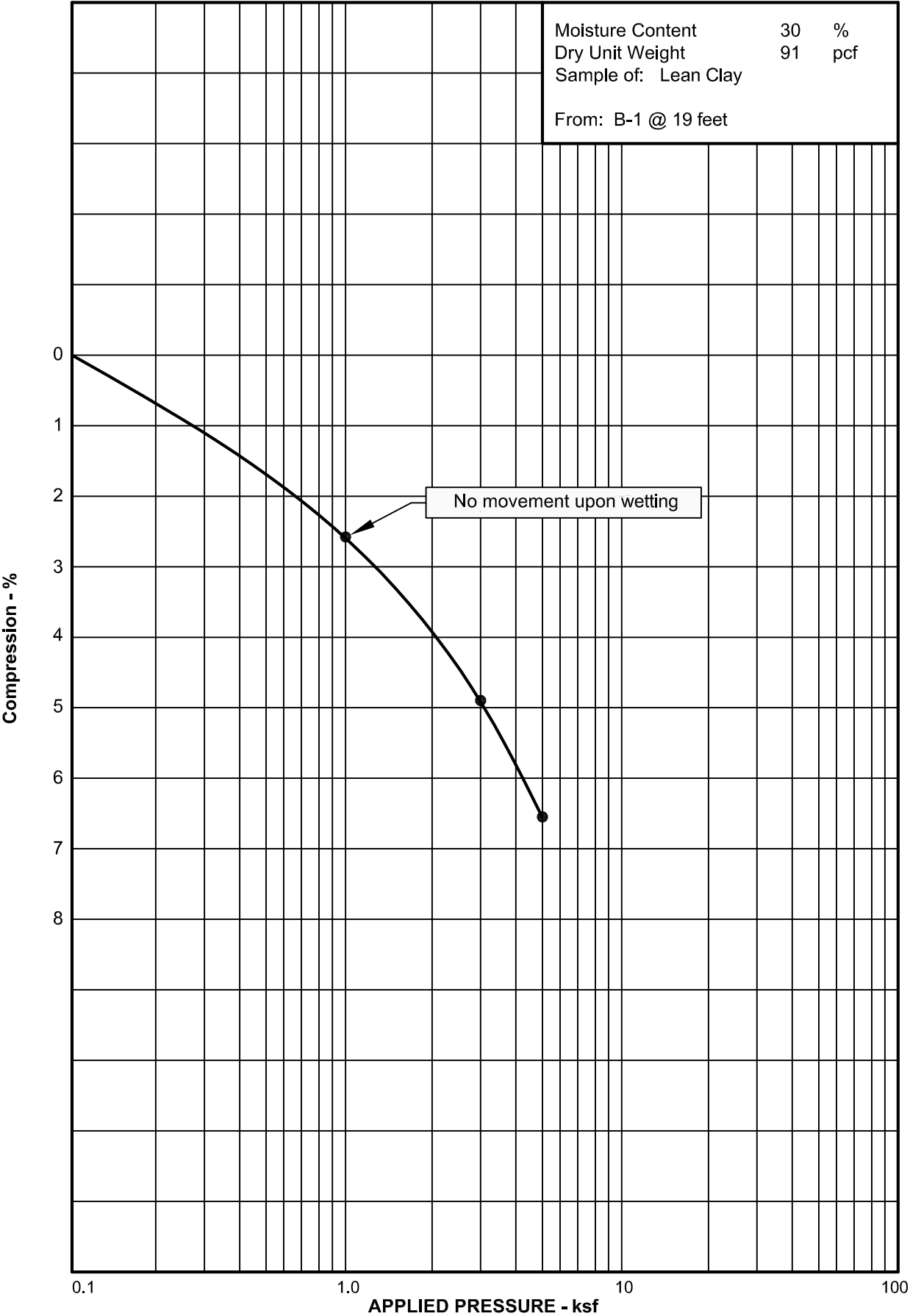
1180225

AGEC

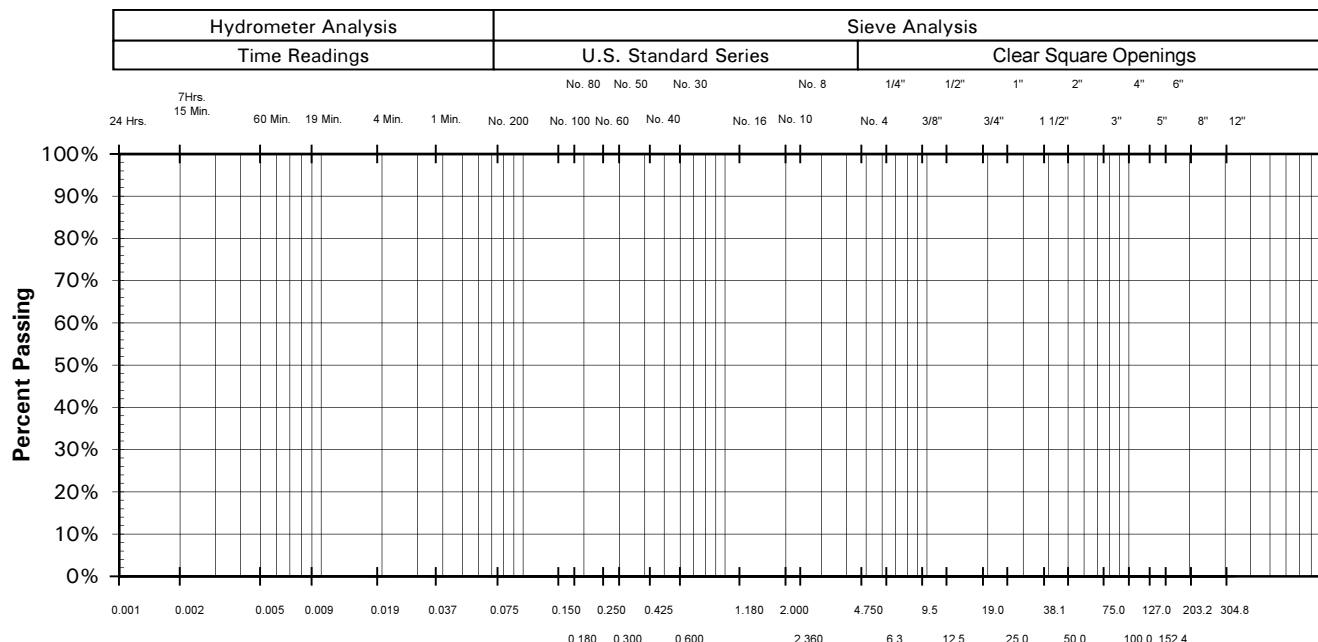
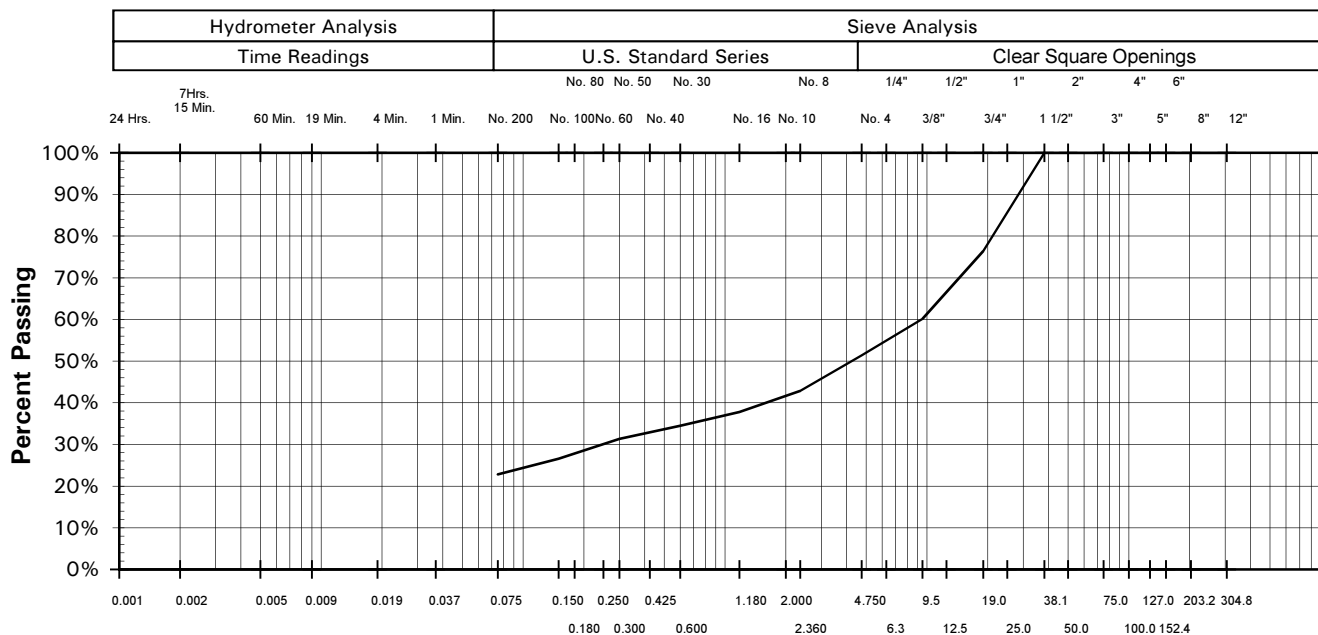
Exploratory Boring Logs, Legend and Notes

Figure 2

Applied Geotechnical Engineering Consultants, Inc.



APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.



APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NUMBER: 1180225

[illegible]

