Sussex County Engineering Department
Sussex County, Delaware

PROJECT SPECIFICATION

CONTRACT S19-10

INLAND BAYS REGIONAL WASTEWATER FACILITY: PHASE #2 EXPANSION

DECEMBER 2018

FINAL FOR BID

VOLUME II of II (DIVISION 12-17)

01/07/2019

COUNTY ENGINEER DATE

WHITMAN, REQUARDT & ASSOCIATES, LLP

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LICENSE
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DELAWARE
PROFESSIONAL ENGINEER
1/7/19

Sussex County Engineering Department
Sussex County, Delaware

INLAND BAYS REGIONAL WASTEWATER FACILITY (IBRWF): PHASE #2 EXPANSION CONTRACT S19-10

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SECTION 13215

STORAGE TANKS

PART 1 - GENERAL

1.01 DESCRIPTION

This section includes the requirements for furnishing and installing bulk chemical storage tanks as specified herein and as shown on the contract drawings.

1.02 QUALITY ASSURANCE

A. Equipment design, workmanship, testing and operation shall be as specified in section GENERAL MECHANICAL REQUIREMENTS.

B. Tank shall be tested for the degree of surface cure using Barcol hardness and acetone sensitivity methods as indicated in the referenced ASTM Specifications.

C. Tanks shall be visually inspected for laminate quality and workmanship as indicated in the referenced ASTM Specifications.

1.03 SUBMITTALS

Shop drawings including dimensioned drawings, details of construction, materials, connection details, and handling and installation instructions shall be submitted in accordance with Section 01300, SUBMITTALS.

PART 2 - PRODUCTS

2.01 SODIUM HYPOCHLORITE STORAGE TANKS

A. The Sodium Hypochlorite bulk storage tank shall be constructed of fiberglass reinforced plastic (FRP) designed for above ground atmospheric service. The tank shall be the vertical cylindrical type with flat bottom and flat top, double wall construction (including the tank bottom) and shall include all the features as shown on the contract drawings. The tank shall be suitable for the storage of the following:

Sodium Hypochlorite 15% concentration with a specific gravity of 1.24 at 68^{O} F.

B. Single walled tank inner and outer walls shall be constructed with sodium hypochlorite compatible resins.

C. Tank shall have a nominal capacity and approximate size as shown on the contract drawings.

D. Tank shall be contact molded, designed and fabricated in accordance with ASTM Specification D-4097-01, "Contact-Molded-Glass-Fiber-Reinforced Thermo set Resin Chemical Resistant Tanks". Centrifugal cast tank construction shall not be acceptable.

E. Tanks shall be manufactured by an ASME/ANSI RTP-1 certified vendor, Augusta Fiberglass, or equal.

2.02 (FRP) MATERIALS AND CONSTRUCTION

A. Resin

1. The resin used shall be a commercial-grade, corrosion-resistant thermoset that has either been evaluated in a laminate by test accordance with ASTM C-581 or that has been determined by previous documented service to be acceptable for the service conditions.

2. The resin shall contain no pigment, dyes, colorants, or filler.

3. A thixotropic agent that does not interfere with visual inspection of the laminate quality, or with the required corrosion resistance of the laminate may be added for viscosity control.

4. Resin pastes used to fill crevices before overlay shall not be subject to the limitations as specified herein before under paragraph 2.02.

5. Ultraviolet absorbers shall be added to the exterior surface for improved weather resistance.

B. Reinforcement

1. Chopped Strand Mat - Chopped strand mat shall be constructed from chopped commercial-grade E-type glass strands bonded together using a binder. The strands should be treated with a sizing that is chemically compatible with the resin system used.

2. Continuous Roving - Continuous roving shall be a commercial-grade of E-type glass fiber with a sizing that is chemically compatible with the resin system used.

3. Woven Roving - Woven roving shall be in accordance with ASTM specification D-2150.

4. Surface Mat - The reinforcement used for the inner surface shall be either a commercial-grade chemical resistant glass surface mat.

C. Laminate Construction Requirements

1. Structural Tank - The laminate comprising the structural tank cylindrical shell and heads shall consist of a corrosion-resistant barrier comprised of an inner surface, interior layer, and a structural layer.

a. Inner Surface - The inner surface exposed to the chemical environment shall be a resin-rich layer 0.010 to 0.020 inch thick, reinforced with a suitable chemical-resistant glass fiber surface mat or with an organic fiber surface mat, in accordance with paragraph B.2.

b. Interior Layer - The inner surface layer exposed to the corrosive environment shall be followed with a layer composed of resin, reinforced only with noncontinuous glass-fiber strands applied in a minimum total of 3 oz/ft^2. The combined thickness of the inner surface and interior layer shall not be less than 0.130 inch.

i. Glass content of the inner liner and the interior combined shall be 27% by weight.

ii. The degree of cure of the laminate shall be of such as to exhibit a Barcol hardness of the inner surface of at least 90% of the resin manufacturer's minimum specified hardness for the cured laminate.

c. Contact Molded Structural Layer - Subsequent reinforcement shall be comprised of 1.5 oz/ft^2 chopped strand mat or equivalent weight of chopped roving, or shall be comprised of chopped strand mat or chopped roving and such additional number of alternating plies of 24 oz/yd^2 woven roving to a thickness as required to meet the physical properties that are used for the design. Each successive ply or pass of reinforcement shall be well-rolled prior to the application of additional reinforcement. Where woven roving is used, chopped strand glass reinforcement shall be used as alternating and final layers. All woven roving and chopped strand shall be overlapped. Laps in subsequent layers shall be staggered at a least 2.25 inch from laps in the preceding layer.

D. Lifting lugs shall be provided.

E. Tank shall be provided with a minimum 30 inch diameter access manway and cover located as shown on the contract drawings, with 1/8 inch thick full face Viton gaskets and cad plated bolting. Tank shall be configured with fill, vent, drain, level sensor mount and miscellaneous nozzles as shown on the contract drawings. Drain shall be capable of completely emptying contents of tank.

F. All flanged nozzles shall be of a hand lay up construction with pipe stub molded integrally with the pipe flange. Compression molded or cemented on flanges are not acceptable. Nozzles 4-inch in diameter and smaller shall be gusseted conically or with four (4) 3/8 inch thick plate gussets. Conical gussets shall extend from the flange OD to the tank wall. Plate gussets shall be suitably laminated to the flange back side, hub, pipe neck, and tank wall.

G. Threaded fittings shall be used only where indicated on the drawings. Where specified, threaded fittings shall be installed with laminates inside and outside as required for flanged nozzles in the referenced ASTM specifications. Threaded fittings shall be of glass-fiber reinforced resin with molded threads.

H. The double walled FRP tank shall conform to the industry standard entitled NBS-PS 15-69 and/or ASTM D 4097-01 for Hand Lay-up fabrication. The tank side walls and bottom shall be constructed of two walls to the full structural wall thickness and entirely in accordance with the construction specification. Between the two side walls, polypropylene mesh spacer shall be used and between tank bottom shells PVA layer (mold release agent) shall be used. In addition to the tank connections shown on the contract drawings, innerwall leak detection connections, external and internal tank flushing drains and vents shall be provided.

PART 3 - EXECUTION

3.01 HANDLING AND INSTALLATION

A. Tanks shall be handled and installed in accordance with the fabricator's instructions.

B. Installation on support pad shall include foundation with grout or roofing felt or other material to suit manufacturer's recommendations.

3.02 TESTS

After the tank has been installed a 24 hour hydrostatic test shall be performed by the Contractor with no leakage allowed, in accordance with the fabricator's instructions.

END OF SECTION 13215

SECTION 14600

HOISTS AND CRANES

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SECTION 14600

MONORAIL HOISTS

PART 1 - GENERAL

1.01 SCOPE

Provide all labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the monorail hoist equipment as specified herein and as shown on the Contract Drawings. General orientation and capacity shall be as shown on the Contract Drawings.

1.02 SUBMITTALS

A. Shop drawings shall be submitted for all items specified herein as specified in **DIVISIONS 0 AND 1**.

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, materials of construction, and specifications on hoist, wheels, gears and bearing, trolley drive system, hoist motor and assemblies, hook, brakes, starting system, variable speed drive system, conductors (bus bar, festoon, cable reel), controls, remote control system, and accessories.
3. Structural design calculations for monorail track and support system and calculations of deflection and loads on building steel stamped by a registered professional engineer.
4. Detail Shop Drawings of monorail track, brackets, hangers, and their attachments to building structural steel.
5. Power and control wiring diagrams, including terminals and numbers.
6. Motor nameplate data in accordance with NEMA MG 1, and include any motor modifications.
7. Factory finish system

B. Provide complete operation and maintenance manuals in accordance with **DIVISIONS 0 AND 1**.

1.03 EQUIPMENT DESIGN

Equipment design, workmanship, testing and operation shall be as specified under **SECTION 15000, GENERAL MECHANICAL REQUIREMENTS**.

1.04 MANUFACTURER'S INSPECTION AND START-UP

The Contractor shall furnish the services of the monorail hoists manufacturers' qualified field representatives to inspect the equipment after installation, instruct owner personnel in operation and maintenance, and supervise initial operation for a minimum of one 8 hour day as specified under **DIVISIONS 0 AND 1**.

1.05 MANUFACTURER'S CERTIFICATE

The Contractor shall furnish the Engineer with a Manufacturer's Certificate, as specified under **DIVISIONS 0 AND 1** certifying the monorail hoists have been installed in a complete and satisfactory manner ready for operation.

1.06 QUALITY CONTROL

A. The specifications of the American Institute of Steel Construction, current edition, shall be followed in designing all equipment of structural steel construction. Other parts such as forgings, stampings and castings, shall be designed with a factor of safety based on the ultimate strength of the material of not less than 5. The standards of the American Welding Society shall be followed in designing supporting steel or equipment which is manufactured by welding operations.

B. Equipment specified under this section shall conform to applicable standards of the Monorail Manufacturers Association (MMA) and the Crane Manufacturer's Association of America (CMAA).

PART 2 - PRODUCTS

2.01 MONORAIL HOISTS – GENERAL

A. The trolley, hoist and all appurtenances shall be provided as a complete unit by the hoist manufacturer.

B. References made hereinafter to a particular model hoist of one manufacturer are made for convenience only to identify a particular style and arrangement of crane and/or hoist. Models of other manufacturers which meet all detailed requirements of the specifications and include comparable features of construction as that specified shall also be considered.

C. The following requirements shall apply to monorails:

1. Monorail track capacities and hanger spacings shall be determined so that deflection shall not exceed one four hundred and fiftieth of

the span but not exceed 1¼ inch maximum deflection between hanger points with the maximum gross load.

2. Rails shall be joined with web type and other suitable couplings to provide flush, level connections. The maximum gap permitted between adjacent ends of load carrying flanges shall be 1/16 inch.

3. Suitable safety stops shall be provided at all open end tracks and operating stop points such as walls and equipment. They shall be capable of withstanding the impact of the loaded carrier.

4. All necessary clamps, hanger rods and other fittings from which the track is suspended shall be provided as part of the overhead track system. The hangers shall be properly spaced to support the specified loads. All tracks shall be flexibly suspended using double ball and socket flexible fittings except where other means of support are shown on the drawings, and providing minimum 1-1/2 inches adjustment. Adequate side sway and end strain bracing shall be provided. The suspension shall provide adequate angular displacement in all directions so as not to place the rods in bending during crane operations. The gauge of runways must be held to a tolerance of plus or minus 1/16 of an inch from the nominal dimensions.

5. All hanger rods 3/4 inch diameter and larger shall be furnished with a roll form thread throughout their length. The allowable stress in the hanger rods shall not exceed 20 percent of the ultimate strength of the material used. Test results shall be furnished upon request. Hanger rod nuts shall be furnished with set screws or other means to prevent nuts from backing off.

6. All rail sections shall be mounted to the support beams. The supporting beams shall be specified and provided under DIVISION 5 - METALS.

2.02 TROLLEY STOPS

A. Trolley stops shall be located on monorails so as to allow maximum travel of the trolley hoist while also preventing contact between the hoist and building structure and equipment.

B. Suitable safety stops shall be provided and shall be capable of withstanding the impact of the loaded carrier at normal speed.

2.03 MANUAL TROLLEY HOIST

A. Hoist mechanism shall be a manual trolley hoist, lightweight aluminum body, high speed, spur geared, ball or roller bearing, hand-operated chain hoist with a retaining brake built into the hoisting mechanism and shall be fully enclosed, suitable for use and storage in a corrosive environment.

B. Hook shall be of high-grade forged steel construction and shall have swivel anti-friction bearings and safety clips.

C. The load wheel shall have accurately formed chain pockets to fit the load chain.

D. Hoist operating wheel shall be provided with chain guides and the chain shall be of sufficient length to hang 3 feet above the operating floor.

E. Pull required to lift the rated load shall not exceed 85 pounds.

F. The load and operating chains shall be zinc-plated for corrosion resistance and the load chain shall have a load safety factor of at least 5 to 1.

G. The load chain shall reach the operating floor and the hoist shall be equipped with a chain collector basket.

H. Monorail beam and hoist shall be epoxy painted for corrosion protection.

I. Provide Harrington “NTH Low Headroom Trolley Hoist,” Yale “Load King LTP2,” or equal.

2.04 PORTABLE GANTRY CRANES

A. The portable gantry cranes shall be of the load carrying capacity on the contract drawings. The cranes shall be suitable for lifts as shown on the drawings.

B. The cranes shall be all steel construction with an adjustable height.

C. The portable crane shall be Wallace, Model S4T12-S10AC, or equal.

2.05 ACCESSORIES

Two pairs of nylon hoisting straps (14-foot and 10-foot) shall be provided for each hoist/crane for handling equipment and valves. Hoisting straps shall be of the same capacity as the hoist with two points of contact.

2.06 PAINTING

Painting shall be in accordance with **DIVISION 9, FINISHES**. Field painting shall not be required except where finish is damaged by handling, weather or other reasons. The damaged portion shall be field-primed and finished with sufficient finished coats to give a smooth, unmarred appearance, with primer and finish being the same type and color as originally used in the factory application.

PART 3 - EXECUTION

3.01 INSTALLATION

Install the monorail hoists in accordance with the manufacturer's recommendations.

3.02 TESTING

A. After erection and prior to final inspection, the monorail hoists shall be given a full load test to demonstrate their fitness for the service they must perform and to check the performance of all essential points. The tests shall consist of loading the units to their respective rated capacities and raising and lowering the hooks the full limit of their travel.

B. With the full load of the units, hoists shall be run through all sections of the railing at least three times. The hoists shall be raised and lowered the full length of their travel at any point along the rails that the Engineer requests.

C. The above tests shall be performed to the satisfaction of the Engineer. In the event the equipment does not satisfactorily meet the specifications, such changes as may be required shall be made and the tests repeated until complete satisfaction is obtained at no additional cost to Owner.

D. Weights to perform the above tests shall be provided by the Contractor.

3.03 USE OF HOISTS

The Contractor may use the new hoists for his purposes. Any damage which may occur by such use however, shall be corrected by the Contractor prior to final acceptance and at no additional cost to the Owner.

END OF SECTION 14600

SECTION 15000

GENERAL MECHANICAL REQUIREMENTS

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SECTION 15000

GENERAL MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SCOPE OF WORK

The provisions of this entire section of the specifications are intended to govern the quality of design, fabrication, workmanship, operation, etc., of all materials, equipment and appurtenances to be furnished and installed under the various sections of the mechanical specifications and all other sections that include mechanical equipment as part of the specified items.

1.02 SUBMITTALS

Shop drawings, including dimensioned drawings, descriptive literature, performance data, electrical characteristics, and in general all information necessary to prove compliance with the specifications, shall be submitted as required in **DIVISIONS 0 AND 1**.

1.03 GUARANTEE

All materials, equipment, workmanship and performance shall be guaranteed for the period and in accordance with the provisions in **DIVISIONS 0 AND 1**.

1.04 MANUFACTURER'S CERTIFICATES

The Contractor shall furnish Manufacturer's Certificates for all equipment items as required in **DIVISIONS 0 AND 1**.

1.05 OPERATION AND MAINTENANCE MANUALS

The Contractor shall provide manufacturer's operation and maintenance manuals as required in **DIVISIONS 0 AND 1**.

1.06 MANUFACTURER'S LISTS

Within thirty days after the date of award of contract, the Contractor shall submit to the Engineer a complete list of proposed manufacturers for all equipment and materials to be used except for those required to be listed in the Bid Form. Complete separate manufacturer's lists shall be submitted for each Mechanical and Equipment section of the specifications. No consideration will be given to partial or incomplete

lists. After approval of each manufacturer's list, detailed shop drawing and/or material lists shall be submitted as specified hereinafter.

1.07 STANDARDS

A. Where standards, codes or specifications are referred to, the reference is to particular standards, codes or specifications together with all the latest amendments and errata applicable at the time the bids are taken. These are listed below:

AMCA	Air Moving and Conditioning Association, Inc.
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating & Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
IEEE	Institute of Electrical & Electronics Engineers
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
NSF	National Sanitation Foundation
OSHA	Occupational Safety and Health Act
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
UL	Underwriters Laboratories, Inc.

1.08 GENERAL DESIGN OF EQUIPMENT AND MACHINERY

A. All equipment and machinery furnished under this contract shall be of the latest and most improved design suitable for the service of which it is to be used. All equipment and machinery shall be designed and constructed to operate efficiently, continuously and quietly under the specified requirements with a minimum of labor, power, maintenance, renewals and repairs. The design and construction of all equipment and machinery shall be such as to permit operation with minimum noise, wear and vibration when properly installed.

B. Ample room for erecting, repairs, inspecting and adjusting all equipment and machinery shall be provided. The design, construction and installation of all equipment and machinery shall conform to and comply with the latest safety codes and regulations.

C. The design and construction of the several units shall be such that they shall present a uniform appearance and the arrangement shall be such that their operation shall be in harmony in every respect. Whenever possible, fittings and fixtures of the same make and model shall be used for the several units and their connections. All equipment of identical type and service shall be the product of the same manufacturer.

D. All equipment selected shall be of such size and general arrangement to suit the space in which it is to be installed.

E. The various parts of the equipment and machinery shall be of plain shape and good lines, especially designed and constructed for strength and durability. Castings shall be designed and constructed to cool uniformly without shrinking strains and shall have good sized fillets at all re-entrant corners. Sudden change of section shall be avoided.

F. Whenever possible, parts of each unit shall be made to gauge and be a duplicate of and interchangeable with the same parts of other machines of the same size and kind.

G. The workmanship shall be of the highest class throughout.

H. All assemblies shall be completely shop fabricated and structural steel parts shall be shop erected. Assemblies and structural steel parts shall be matchmarked before being disassembled for shipment. Parts shall be shipped assembled in as large unit as possible to minimize field re-assembly. All parts shall be amply proportioned for all stresses which may occur during operation, and for any additional stresses which may occur during fabrication and erection.

I. Unless otherwise specified, welding shall be in accordance with the latest standard specifications for "Gas Tight Welding" of the American Welding Society.

J. Unless otherwise specified, galvanizing shall be hot-dipped, in accordance with the latest standard specifications for "Zinc Coating" of the ASTM, Serial Designation A-123.

K. Unless otherwise specified herein, starters, H-O-A switches, pushbuttons and other electrical devices shall be specified and provided Division 16, and shall be arranged as shown on the Contract Drawings.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Unless otherwise specified, materials shall be in accordance with the following latest Standard Specifications of the ASTM:

Structural Steel	A-36
Iron Castings	A-48 or A-126
Welding Steel Pipe	A-53
Zinc (Hot-Galvanizing)	A-123
Steel Bolts	A-307
Babbitt	B-23
Bronze Castings	B-30
Bronze (Silicone)	B-98
Bronze (Manganese)	B-138

B. All materials shall, if required, be tested and shall fulfill all requirements specified. Physical tests may be made by the Owner. The Contractor at his own expense shall furnish test pieces and samples in the number, shape, size and finish required by the Engineer. All broken material shall become the property of the Owner. The failure of test specimens to fully conform to the requirements of the specifications shall be sufficient cause for rejection of the whole melt or stock from which samples were obtained.

C. Iron castings shall be smooth, clean and free from scale, lumps, blisters and other defects. No plugging, welding or filling will be allowed.

D. The alloy grade number of all babbitt shall be that bearing alloy of a composition recommended by the manufacturer of the equipment or machinery for the service required, subject to the approval of the Engineer.

E. All bronze shall be made of new material and shall be free from objectionable imperfections. If the materials show signs of improper mixing when being machined, the castings will be rejected.

2.02 JOURNALS, BEARINGS AND KEYS

A. Journals and bearing surfaces shall be of sufficient size and properly proportioned for the least wear and to avoid heating under all conditions, and where necessary, provisions shall be made for easy removal and for proper adjustments. Journals shall be suitable boxes which, where necessary, shall be lined with babbitt metal hammered into grooves and bored in place. If bearings are of the ball bearing type, both inner and outer races as well as the balls shall be heat treated steel to resist wear. The balls shall be of ample size

to carry the maximum loads with a large factor of safety to prevent flaking, spalling, or crushing. The balls shall be properly spaced and held in position by rugged continuous spacing or retainer rings.

B. Pins and keys shall be properly proportioned. Keys, nuts and all other parts which might otherwise work loose shall be secured with approved locking devices.

C. Unless otherwise specified, all anti-friction bearings, including ball, roller, and tapered roller bearings, shall have a minimum AFBMA B-10 life rating of 50,000 hours. Rating life is defined as the number of hours that 90% of a group of bearings will complete or exceed before the first evidence of fatigue develops in the material of either ring or any of the rolling elements.

2.03 LUBRICATION

A. All bearings, except those specifically requiring oil or water lubrication shall be pressure grease lubricated. All lubrication points shall be readily accessible, away from locations dangerous to workmen. Pressure grease lubrication fittings shall be the "Alemite" type as made by the Stewart Warner Corporation, or equal. The pattern of the fitting shall be selected for accessibility in lubricating and shall meet the approval of the Engineer. Housings of grease lubricated bearings shall be automatically exhausted to atmosphere to prevent excessive greasing. Where lubrication points cannot be reached or for safety reasons, tubing should be installed to a point where the Owner can access the fitting. Tubing material shall be selected for installed atmosphere. Material and location of tubing shall be submitted to the Engineer for approval. Grease fittings shall not be painted.

B. The Contractor shall furnish one, Alemite Professional Series grease gun with whip hose Product No. 500-E or equal, one grease gun holder and the necessary Alemite adapters and/or extensions to accommodate the grease fittings on the provided equipment.

C. The Contractor shall furnish lubrication charts or schedules for each piece of equipment or machinery. The charts or schedules shall designate each point of lubrication, the type of lubricant to be applied and the frequency of lubrication. Charts and schedules shall be submitted to the Engineer in quadruplicate, bound in folios, with each chart or schedule protected by a transparent plastic envelope.

D. The Contractor shall furnish one year's supply of each type of lubricant required. A typewritten list shall be furnished with the lubricants, designating the specific lubricant to be used with each piece of equipment. This is in

addition to the required operating and maintenance manuals, which will also contain lubrication requirements.

2.04 MOTORS AND CONTROLS - GENERAL

A. Motors and controls shall conform to the latest requirements of IEEE and NEMA, and where applicable, shall be UL listed. Minimum sizes are specified with the driven equipment. Motor starting and control equipment is specified either with the motor which is controlled or in an electrical specification section. The Contractor shall consult all specification sections to determine responsibility for motors and controls and shall provide complete motor performance specifications with shop drawing submittal data. All shop drawings and motor submittal data shall identify motor duty type or model in addition to nameplate data and performance specifications, including efficiencies and power factors.

B. Motors shall be designed, built and tested in accordance with the latest revision of NEMA Standard MG 1.

C. Motors shall be suitable for use under the conditions and with the equipment to which applied, and designed for operation on the electrical systems specified or indicated.

D. Motor capacities shall be such that the horsepower rating and the rated full-load current will not be exceeded while operating under the specified operating conditions. Under no condition shall the motor current exceed that indicated on the nameplate.

E. Motor sizes noted in the individual equipment specifications are minimum requirements only. It is the responsibility of the equipment manufacturers and of the Contractor to furnish motors, electrical circuits and equipment of ample capacity to operate the equipment without overload, without exceeding the rated full-load current, or overheating at full-load capacity under the most severe operating service of this equipment. Motors shall have sufficient torque to accelerate the total WR^2 of the driven equipment to operating speed.

F. Motors shall be continuous duty type and shall operate quietly at all speeds and loads.

G. Motors shall be designed for operation on 60 hertz power service. Unless otherwise specified or shown, motors less than 1/2 horsepower shall be single phase, and motors 1/2 horsepower and larger shall be 3 phase.

H. Motors shall be mounted so that the motor can be removed without removing the entire driven unit.

I. Single phase motors smaller than 1/20 horsepower shall be ball or sleeve bearing, drip-proof, totally enclosed or explosion proof, as specified, 115 volts, permanent split capacitor or shaded pole type. These motors shall not be used for general power purposes and shall only be provided as built-in components of such mechanical equipment as fans, unit heaters, humidifiers and damper controllers.

J. Single phase motors 1/20 horsepower and larger shall be ball bearing, drip-proof, totally enclosed or explosion proof, as specified, with Class A or B insulation, as standard with the motor manufacturer; 115, 115/230, 208 or 230 volts as required; capacitor start-induction run, permanent split capacitor, or repulsion start-induction run type.

K. Except as otherwise specified in the various specification sections, 3 phase motors shall meet the requirements of this paragraph. Motors shall be NEMA design B squirrel cage induction type. Insulation shall be Class F and motor shall be rated at no greater than 50 deg. C rise for open motors and 65 deg C rise for closed motors both above an ambient temperature of 45 deg. C. At 40 deg. C ambient temperature explosion-proof and totally enclosed and inverter duty motors shall have a 1.00 service factor and dripproof motors shall have a service factor of 1.15 or higher. Motors specified for operation at 480 volts shall be nameplated 460 volts.

L. Unless otherwise specified, three phase motors shall be the NEMA Premium™ type. Minimum three phase motor efficiencies at full load for motors having nominal rated speeds of:

	RPM		
HP	**3600 (2-pole)**	**1800 (4-pole)**	**1200 (6-pole)**
ODP MOTORS			
1	--	85.5	82.5
1-1/2	84	86.5	86.5
2	85.5	86.5	87.5
3	85.5	89.5	88.5
5	86.5	89.5	89.5
7-1/2	88.5	91.0	90.2
10	89.5	91.7	91.7
15	90.2	93.0	91.7
20	91.0	93.0	92.4
25	91.7	93.6	93.0

HP ODP MOTORS	RPM 3600 (2-pole)	1800 (4-pole)	1200 (6-pole)
30	91.7	94.1	93.6
40	92.4	94.1	94.1
50	93.0	94.5	94.1
60	93.6	95.0	94.5
75	93.6	95.0	94.5
100	93.6	95.4	95.0
125	94.1	95.4	95.0
150	94.1	95.8	95.4
≥ 200	95.0	95.8	95.4

TEFC MOTORS	RPM 3600 (2-pole)	1800 (4-pole)	1200 (6-pole)
1	77.0	85.5	82.5
1-1/2	84.0	86.5	87.5
2	85.5	86.5	88.5
3	86.5	89.5	89.5
5	88.5	89.5	89.5
7-1/2	89.5	91.7	91.0
10	90.2	91.7	91.0
15	91.0	92.4	91.7
20	91.0	93.0	91.7
25	91.7	93.6	93.0
30	91.7	93.6	93.0
40	92.4	94.1	94.1
50	93.0	94.5	94.1
60	93.6	95.0	94.5
75	93.6	95.4	94.5
100	94.1	95.4	95.0
125	95.0	95.4	95.0
150	95.0	95.8	95.8
≥ 200	95.4	96.2	95.8

Three phase motors shall be the Premium Efficiency Motor of U.S. Electrical Motors, the MAC II High Efficiency motor of Westinghouse Electric Corporation, or equal.

M. Motors 25 horsepower and larger shall be as specified with the driven equipment in these specifications.

N. Belt-connected motors shall have adjustable bases and set screws to maintain proper belt tension. All fan motors shall have adjustable sheaves for speed adjustment.

2.05 FLANGES AND BOLTS

A. Flanges, where threaded on pipe shall be of the same material as the pipe and bolt holes shall be drilled and spot-faced on the back. Stud holes shall not be drilled through. Flanges shall be uniform in thickness and shall come fair and, if required, shall be turned or chipped in a neat and workmanlike manner.

B. Jacking screws shall be provided for covers, etc. where required, and also suitable eye bolts for lifting. Bolts and nuts shall be of the best quality of open hearth, free machining steel. Bolts shall have good, sound well-fitting threads; nuts shall be cold pressed. Where noted as galvanized, all heads, nuts and threads shall be of the American Standard regular sizes.

2.06 COUPLINGS

A. Except where otherwise specified for a particular item of equipment, all equipment where flexible couplings are specified or are required for the purpose, a standard self-aligning forged steel coupling with sealed lubrication, as manufactured by Thomas, Koppers, Falk, Sier-Bath, or equal shall be provided between each motor and its driven equipment. One hub of the coupling shall be firmly fixed and keyed to the equipment shaft with the other hub similarly secured to the abutting drive shaft. Couplings shall be placed as close as possible to the driven equipment and the motor bearings to make compactly arranged units. Couplings shall be of all metal construction and shall be moistureproof and dustproof. Arrangement of couplings shall be such that there is sufficient room to place a dial indicator for alignment checking of shafts of the motor driven equipment. Each coupling shall be provided with an easily removable guard meeting all OSHA requirements.

B. All equipment and motors/drives shall be field aligned using a dial indicator in accordance with the procedures established by the latest revision of the Hydraulic Institute Standards. Parallel and angular misalignment shall not exceed the limits recommended by both the equipment and the coupling manufacturer.

2.07 EQUIPMENT BEDPLATES

A. All items of mechanical equipment mounted on masonry floors shall be provided with a concrete pad four inches high, or higher, as required to accommodate piping connections to equipment. Where motors 10

horsepower and larger, and equipment driven by motors 10 horsepower and larger, are to be mounted on a raised concrete pad, L-shaped threaded mounting studs shall be cast into the concrete; insert type anchors installed after setting of the concrete will not be acceptable for these applications.

B. The various items of motor driven equipment, such as pumps, shall be mounted on structural steel bedplates. The bedplates shall be adequate size to accommodate the equipment and its motor, to form an integral rigid mounting platform. Steel or brass shims shall be used to level equipment bedplates mounted in contact with concrete pads or floors. Jacking bolts or jacking (leveling) nuts on mounting studs shall not be used in lieu of shims. Bedplates shall be grouted to the concrete base and shall be filled with grout in all instances where the manufacturer has made provision for introducing grouting mixture into bedplate cavities. It shall be the contractor's complete responsibility to determine the proper method, to provide all materials and components required, and to coordinate the work, to set, couple, align and install all equipment in a satisfactory manner.

C. All centrifugal fans and air compressors shall be mounted on steel springs or rubber-in-shear vibration isolation units as recommended by the manufacturer. These may be either shop provided with the equipment or separately field mounted.

2.08 CONTROLS

Controls shall be as described in Divisions 16, 17 and as shown on Contract Drawings.

PART 3 - EXECUTION

3.01 MANNER OF INSTALLATION

A. The general arrangement of pipe and equipment shall be as shown on the Drawings. Detailed drawings of proposed departures due to actual field conditions or other causes shall be submitted to the Engineer for approval. The Contractor shall carefully examine the drawings and shall be responsible for the proper fitting of materials and equipment as indicated, without substantial alteration. Because of the small scale of the drawings, it is not possible to indicate the exact location of piping, all offsets, fittings and accessories which may be required. The Contractor shall carefully investigate the space requirements for proper clearances and the structural and finish conditions affecting his work and shall arrange such work accordingly, furnishing such offsets, fittings, valves and accessories as may be required to meet such conditions.

B. Each trade shall determine the location, size, etc. of all chases and openings required for the proper installation of its work, and shall see that such are provided. Where it is necessary to run pipes or ductwork through walls or fittings, the trade performing the work shall notify the Contractor so that proper provisions can be made for same. Each trade shall furnish and set all inserts, sleeves, hanger supports, etc. required for its work and shall be responsible for their proper and permanent location.

C. All piping and ductwork exposed to view shall be run generally parallel with the lines of the structure and as close to walls and columns as may be practical and consistent with proper grade and the maintenance of proper clearances for access to all parts requiring servicing.

D. The Contractor, in the prosecution of the work, shall do no cutting of masonry, concrete or other materials after same have been installed, without the written permission of the Engineer.

3.02 TESTING

A. After erection, the Contractor shall adjust and balance all equipment and systems, and shall demonstrate that all equipment is operating in a satisfactory manner. Adjustments shall be made as necessary. All defective parts on machinery shall be replaced.

B. The Engineer shall be notified in advance of all tests and all tests shall be conducted to his entire satisfaction.

C. See paragraph, MANUFACTURER'S CERTIFICATE, for further requirements on selected major items of equipment.

3.03 MISCELLANEOUS

A. Finished parts shall be well protected in the shop, during transportation and before and after erection to prevent injury of any kind. Injured parts which in the opinion of the Engineer are damaged or which cannot be refitted, shall be promptly replaced by the Contractor without expense to the Owner. All exposed finished parts of machinery shall be greased or oiled before shipment.

B. The Contractor shall furnish all tools of special nature which are required for making adjustments (by the Owner after the work has been turned over to him) to equipment, but will not be required to furnish standard tools.

C. All exposed belts, gears, and drives shall be protected with guards. Guards may be of the equipment manufacturer's standard design, but must meet all the OSHA Standards.

3.04 PAINTING AND LABELING

A. All fabricated or assembled surfaces normally painted shall be thoroughly dry and free from all rust, grease, dirt or scale. Unless otherwise specified, shop prime painting and field finish painting shall be specified in **DIVISION 9, FINISHES**. The Contractor is reminded to correlate the selection of shop prime coats to be compatible with subsequent field applied coats of paint. The Contractor shall "touch-up" paint any item damaged during shipping or installation.

B. All control panels, valve operators, etc., shall have identifying nameplates screwed or bolted to the enclosure. Nameplates shall be minimum 3/4 inches high plastic with white background and 1/4 inch high engraved black letters.

3.05 ADJUSTMENTS TO RELATED WORK

The final work shall include any adjustment that may be required by the approved equipment furnished, with modifications made to concrete shapes and to dimensions shown on the contract drawings as may be required to suit the details of the approved equipment furnished, all at no additional cost to the Owner.

3.06 CERTIFICATION OF WELDERS

A. All shop and field welding under this contract for steel piping and other piping systems shall be done by experienced operators who are skilled and have had experience in the method and materials used. All welders shall be qualified as specified in the ASME Code for Unfired Pressure Vessels, Paragraph U-70.

B. For field welding, the Contractor shall submit to the Engineer for his review and approval a certified statement, from an approved testing agency for each welder he proposes to use for welded piping. Each certified statement shall indicate that the welder has, within six months from proposed employment on this project, been successfully qualified under the requirements of Section IX of the ASME Boiler Construction Code. All certificates and qualifications shall be at the Contractor's expense. The Engineer will return the certified statements to the Contractor for retention on job in the Contractor's field office. Any work installed by an individual who has not been qualified by the testing agency and approved by the Engineer shall be removed by the

Contractor and shall be replaced with work installed by qualified and approved welders at the Contractor's expense.

C. Care shall be exercised during all welding operations to prevent injury or damage to personnel and property.

3.07 SCAFFOLDING - RIGGING - HOISTING

Unless otherwise specified, the Contractor shall design and furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any materials and equipment furnished. The Contractor shall remove same from the premises when no longer required.

3.08 SUPPLEMENTARY SUPPORTING STEEL

All supplementary supporting steel required to support ducts, piping, electrical services, equipment, etc. shall be provided by the Contractor.

3.09 OPERATING INSTRUCTIONS

A. Upon completion of all work and testing, the Contractor shall furnish the necessary technicians, skilled laborers and helpers and shall operate all systems and equipment for the period specified in Division 1. During this period, the Contractor shall fully instruct the Owner and/or his representatives in the operation, maintenance, lubrication and adjustment of all systems and equipment.

B. The Operating and Maintenance Manuals specified hereinbefore are to be available at the time of the instruction period, however, if they are not the Contractor shall provide the Owner with one copy of the manufacturer's operating literature for each major system or item of equipment. Installation and operating sheets or booklets normally shipped with equipment may be used for this purpose.

C. The Contractor shall schedule the instruction period for a time mutually agreeable with the Owner and Engineer.

3.10 FOUNDATIONS – SUPPORTS – PIERS

The Contractor shall furnish and install all necessary foundations, supports, pads, bases and piers required for all air handling equipment, piping, pumps, tanks, compressors and for all other equipment furnished under this contract, and shall submit drawings to the Engineer for approval before purchase, fabrication or construction of same. Construction of foundations, supports, pads, bases and piers,

where mounted on the floor, shall be of the same materials and same quality of finish as the adjacent and surrounding flooring material.

END OF SECTION 15000

SECTION 15056

ELECTRIC MOTOR ACTUATOR

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SECTION 15056

ELECTRIC MOTOR ACTUATORS

PART 1 - GENERAL

1.01 DESCRIPTION

Provide all coordination, labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the equipment as shown or specified and in accordance with the requirements of the Contract Documents.

1.02 SUBMITTALS

A. Furnish detailed shop drawings for all items specified herein in accordance with Division 1. Shop drawing shall include a schedule that identifies each actuator and its respective location, what it is mounted to, horsepower, voltage, wiring and control diagrams, sizing calculations and other pertinent design information as indicated in ANSI/AWWA C542, latest editions.

B. Furnish detailed Operation and Maintenance manual for all items specified herein in accordance with Division 1.

1.03 EQUIPMENT DESIGN

A. Mechanical equipment design, workmanship, testing and operation shall be as specified herein and in accordance with Section 15000, General Mechanical Requirements.

B. Electrical and Instrumentation equipment design, workmanship, testing and operation shall be as specified herein and in accordance with Division 16 and 17.

1.04 QUALITY ASSURANCE

A. The equipment manufacturer shall have a minimum of 10 years experience in manufacturing equipment similar, equal or larger size, to that specified.

B. The Equipment Manufacturer shall provide a list of at least 10 exclusively different U.S. installations where equipment identical to that proposed to be provided has been in successful operation. The term "installation" shall mean individual projects/contracts. Multiple equipment units for a project shall be considered as 1 installation toward meeting the experience requirements. Installation information shall include, but not be limited to, the following:

1. Name and location of the installation.
2. Name of person in direct responsible charge for the equipment.
3. Address and phone number of person in direct responsible charge.
4. Month and year the equipment was placed in operation.
5. Capacity of Equipment

C. The equipment shall conform to all applicable requirements of ANSI, ASTM, AWWA, IEEE, NEC, NEMA and the related governing bodies listed in Section 15000 General Mechanical Requirements.

D. For all motor actuated valves, gates, and miscellaneous equipment the same electric motor actuator manufacturer shall be used. Contractor shall coordinate the actuator with the respective equipment manufacturer. Actuators shall be supplied by the respective equipment manufacturer that the electric motor actuator is used on.

1.05 DELIVERY, STORAGE AND HANDLING

A. The equipment shall be packaged to minimize possible damage from moisture, temperature variations and impact due to shipping conditions. Exposed threads shall be protected with tape or caps, openings shall be closed by caps or plugs. Detailed installation instructions shall accompany the equipment.

B. The Contractor shall inspect the equipment when it is delivered to ensure that it is not damaged. Store the equipment in a dry location and maintain the equipment per Manufacturer’s recommendations.

C. Dispose of packing materials in accordance with state and federal regulations.

D. Delivery, storage and handling shall be in accordance with Division 1.

1.06 MANUFACTURER'S INSPECTION AND START-UP

A. The Contractor shall furnish the services of the equipment manufacturer's qualified field representative to inspect the equipment after installation, provide startup services, and supervise all initial start-up operations and functional testing as specified herein. Services shall be provided as required to ensure complete and operational equipment for a minimum of one (1) eight (8) hour day.

B. In the event that the equipment does not perform as specified, the Contractor, at no additional expense to the Contract, Owner or the Owner’s representative, shall make provisions for the field representative to stay on site until all problems are resolved to the Owners satisfaction.

1.07 MANUFACTURER'S CERTIFICATE

The Contractor shall furnish the Engineer with a Manufacturer's Certificate, signed by an authorized representative of the Manufacturer, certifying that the equipment is installed in a complete and satisfactory manner and has been functionally tested such that it is ready for operation.

1.08 TRAINING

Provide the service of a qualified manufacturer’s representative to thoroughly train Owners personnel in the operation and maintenance of the equipment installed. Training shall be provided by as required to ensure Owner’s personnel understanding of equipment for a minimum of two (2) hours.

1.09 WARRANTY AND GUARANTEE

Contractor shall warrant and guarantee to the Owner that all work will be in accordance with the Contract Documents and that the equipment, material, workmanship, performance and installation will not be defective for (2) two years from the date the system is placed in operation which shall be upon completion of operation tests.

PART 2 – MATERIALS

2.01 ELECTRIC ACTUATOR

A. The Contractor shall provide electric actuators in the locations shown on the Contract Drawings. Actuators shall be suitable for electric and manual operation. Size and type of valve or slide gate shall be as indicated in the Contract Documents. The physical characteristics, torque, rotation, weight, and other pertinent information of the equipment that the Actuator is mounted on shall be coordinated by the Contractor. The electric actuator shall include, but not be limited to, the motor, reduction gearing, reversing contactor starter with local controls, open/stop/close pushbuttons, local/remote selection switch, remote control, position and torque limitation switches with electronic logic controls and monitoring equipment. Electric Actuators shall be manufactured by Rotork or approved equal.

B. General:

1. Comply with latest version of AWWA C542.
2. Size to 1-1/2 times the maximum required operating torque. Motor stall torque shall not exceed torque capacity of valve.
3. Controls integral with the actuator and fully equipped as specified in AWWA C542.
4. Stem protection for rising stem valves or gates.
5. Actuator shall be matched to the valve or gate on which it is installed.
6. Operator shall be suitable for use in temperatures from -20 to +140 deg F.
7. All actuators shall be from one manufacturer.
8. Unless otherwise noted NEMA 4X enclosures shall be provided. Where required by NFPA, NEMA 7 explosion proof operators shall be provided in areas that are rated for Class 1, Division1.
9. Contain 120-volt space heaters, if required to prevent condensation.
10. Suitable for full 90-degree rotation for quarter-turn valves or for use on multi-turn valves or gates, as applicable
11. Manual override hand wheel.
12. Valve position indication.

C. The motor shall be specifically designed for actuator service and provide suitable starting and operating torque for intended service. The motor shall be totally enclosed, non-ventilated construction with a minimum NEMA Class F insulation, with 155 deg C temperature rating for one complete duty cycle (open-close-open). Motor shall be equipped with internal thermostat to protect against motor overload. Motor bearings shall

be of the anti-friction type, and permanently lubricated. Actuator Power Supply:

1. 480 volts, 3-phase, unless otherwise indicated.

2. Control power transformer, 120-volt secondary.
3. Externally operable power disconnect switch.

D. Interfaces shall be provided for remote positive switching OPEN, MIDDLE, CLOSE and INTERLOCK controls, which can be internally fed from the actuator 24V DC.

E. All rotating power train components shall be immersed in grease or oil. Lubricants shall be premium grade and suitable for ambient conditions of - 20 to 140 degs F. Adequate seals shall be provided on all shafting.

F. The Contractor shall coordinate the required motor starting and operating torque with the valve manufacturer in order to properly size the operator. All torque and position settings and indication contacts shall be field adjustable. The torque and position limit settings shall be adjustable as follows:

1. Position setting range - up to 100,000 turns with resolution to 15 degrees of actuator. Operator shall be designed to operate and hold a quarter turn valve in 1 percent increments, from fully closed to fully open

2. Torque setting range - 40% to 100% of rated torque. The unit will have a battery which shall supply power to store position settings in memory in case of power loss. Battery shall have minimum life of 7 years.

3. Limit Switch:

   a. Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120 volts ac.
   b. Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.
   c. Housed in actuator control enclosure.

G. Valve position indication shall be provided locally by a back-lit Liquid Crystal Display, from fully Open to fully Closed, in 1 percent increments. A current position transmitter shall be provided for transmission of a 4-20 mA analog signal proportional to valve position. The 4-20 mA signal shall be a contactless, internally fed signal selectable for minimum signal corresponding to fully closed or open, with automatic zero and span setting. Operator shall be capable of accepting a 4-20 mA signal from the Plant Control System for remote positioning.

H. Operator controls shall be as shown on the Contract Drawings. All status indications shall be available as output contacts for wiring to the Plant Control System.

I. Provide a fabricated steel, ductile iron or cast aluminum hand wheel for manual operation. Hand wheel shall be connected directly to drive sleeve or shall be geared as required. Unit

shall be provided with lockable declutching lever in the motor position.

2.02 ACTUATOR SERVICE TYPES

A. Open-Close and Throttling Service:

1. Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 10 minutes, travel time adjustable from 5 to 10 seconds, initially set for 5 seconds.
2. Actuator suitable for throttling operation of valve at intermediate positions.
3. LOCAL-REMOTE Selector Switch, padlockable in each position:

   a. Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.
   b. Remote OPEN-CLOSE maintained control dry contact inputs when valve actuator is in REMOTE position. Valve travel stops when valve reaches full OPEN/CLOSED position or when remote command contact opens.
   c. Auxiliary contact that closes in REMOTE position.

4. OPEN and CLOSED indicating lights.
5. OPEN and CLOSED auxiliary dry contacts for customer connections. Provide two sets of contacts each for open and closed position. One set shall be closed when valve is in respective position and open when not. The other set shall open when valve is in respective position and closed when not.
6. Auxiliary contacts shall be rated for 120 V-AC, 1 amp (minimum) electrical connections.
7. Integral reversing motor starter with built-in overload protection.
8. Valve shall remain in last position on loss of operator power.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install the equipment and appurtenances in accordance with the manufacturer's recommendations.

B. Installation of the equipment shall not be attempted until the equipment manufacturer has provided detailed installation manuals to the Contractor and the Contractor and manufacturer have instructed key field personnel in detail regarding installation of the equipment.

3.02 LUBRICATION

A. Lubricate the equipment in accordance with manufacturer’s recommendation prior to startup and refill as necessary until the operation of the equipment is turned over to the Owner.

B. Provide a list of recommended lubricants and a lubrication schedule in accordance with Division 15.

C. Furnish one year’s worth of all types of premium lubricants that the equipment requires.

3.03 PAINTING

All exposed metal parts of the equipment shall be cleaned, primed and finished with the manufacturer's paint system that is in accordance with Division 9. All field touch-up painting shall be in accordance with Division 9.

3.04 ADJUSTING

Furnish qualified personnel to balance and adjust equipment to minimize reactionary forces, excess noise and vibration that are outside the limits of the manufacturer's recommendation. Provide corrective measures as recommended by the manufacturer or Owner's representative. Equipment Alignment shall be in accordance with 15000.

3.05 TOOLS

Furnish all tools of special nature which are required for making adjustments (by the Owner after the work has been turned over to him) to equipment, but will not be required to furnish standard tools that are typically available from most home improvement stores.

3.06 PERFORMANCE TESTS

After fabrication, the equipment shall be fully tested. Two types of tests shall be performed: Proof of Design and Performance Tests in accordance with AWWA C542, latest edition. The equipment shall not be shipped to the job site prior to the Engineer approval of the test report and test data. Failure to achieve the performance requirements outline in the Contract Documents or performance proposed in the accepted submittal documents, whichever is more restrictive, shall be cause for rejection.

3.07 FIELD PERFORMANCE TESTS

A. When the actuator, instrumentation, electrical controls and all related equipment and piping have been installed and are in working order, the Contractor shall conduct a field test of the actuators in the presence of the Engineer.

B. The field tests need not repeat all of tests previously done by the manufacturer, but shall be sufficiently complete to demonstrate that the actuators are operating in a satisfactory manner within acceptable limits, capable of meeting the performance requirements in accordance with the Contract Documents in such a manner to make possible the issuance of the "Manufacturer's Certificate" as described above.

3.08 CLEANING

Clean the equipment and work area from all construction debris in accordance with Division 1. The equipment provided shall be free from debris prior to placing into service.

END OF SECTION

SECTION 15060

PIPE, VALVES AND FITTINGS

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SECTION 15060

PIPE, VALVES AND FITTINGS

PART 1 - GENERAL

1.01 SCOPE

The Contractor shall furnish and install all materials, equipment and appurtenances necessary for the complete and satisfactory installation of all piping systems within and under structures, as shown on the Contract Drawings and as required for a complete installation as specified herein.

1.02 SHOP DRAWINGS

A. Shop drawings, shall be submitted for items specified herein as specified under **DIVISIONS 0 and 1**. For material and equipment readily identified in standard publications of equipment manufacturers, it will be sufficient to state only the catalog number and to provide catalog cuts of the item in the submission.

B. Layout Drawings

1. Piping Layout Drawings
A layout of all systems requiring piping 4-inches and larger shall be submitted. These layouts shall be two line drawings accompanied by a bill of materials. Layouts of the other piping systems inside the building shall be submitted as single line drawings.

2. Piping Support Layout Drawings
The pipe support systems are required to be designed by the Contractor, as described in this Section. Piping support layout drawings are required to be submitted. Drawings shall show location of each support, sway brace, hanger, guide, component, and anchor. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number. Single line piping drawings are not acceptable. Piping support systems shall be designed and Shop Drawings prepared and sealed by a Registered Professional Engineer in the state having jurisdiction over the project.

C. The following qualifications and procedures shall be submitted:

1. Weld Inspection and Testing Agency: Certification and qualifications.
2. Welding Inspector: Certification and qualifications.

3. Welders; List of qualified welders and welding operators, and current test records for qualified welder(s) and weld type(s) for factory and field welding.
4. Weld Procedures: Records in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
5. Nondestructive inspection and test procedures.
6. Certified welding inspection and test results.

1.03 EQUIPMENT DESIGN

Equipment design, workmanship, testing and operation shall be as specified under **SECTION 15000, GENERAL MECHANICAL REQUIREMENTS**.

1.04 PIPE SUPPORT DESIGN REQUIREMENTS

A. General:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. Piping Smaller than 24 Inches: Supports are shown only where specific types and locations are required; additional pipe supports may be required.
3. Piping 24 Inches and Larger: Support systems have been designed for piping shown.
4. Meet requirements of MSS SP 58, MSS SP 69, MSS SP 89, and ASME B31.3 or as modified by this section.

B. Pipe Support Systems:

1. Pipe support systems shall be designed for gravity and thrust loads imposed by weight of pipes or internal pressures, including weight of fluid in pipes and insulation.
2. Seismic loads in accordance with governing codes and as shown on Structural Notes Drawing.
3. Wind loads in accordance with governing codes and as shown on Structural Notes Drawing.

C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support. Adhesive anchors shall not be used where subject to sustained tension loads.

1.05 GENERAL NOTES

A. Unless otherwise specified herein, starters, H-O-A switches, pushbuttons, and other electrical devices shall be specified and provided under **DIVISION 16, ELECTRICAL** of the specifications, and shall be arranged as shown on the Contract Drawings.

B. Unless otherwise specified herein, motors shall meet the requirements specified in **SECTION 15000, GENERAL MECHANICAL REQUIREMENTS**. Type of enclosure (open drip proof, totally enclosed, etc.) shall be as specified herein.

C. Certain types of pipes and piping systems are specified under section, **DIVISION 2, SITEWORK**.

D. Selected miscellaneous piping systems may be specified in other sections of the specifications. Miscellaneous piping systems which may not be described specifically by any section of these specifications shall be of the type of pipe and fittings as directed by the Engineer or as shown on the drawings.

E. The Contractor shall verify all dimensions of valves, special castings and fittings, pipe, equipment, etc., so that all of the pipe work performed will fit together properly and will conform to the arrangement as shown on the drawings. In selecting laying lengths of fittings, the Contractor shall be guided by the dimensions of equipment to which connections are made and by the indicated dimensions on the drawings. All pipe and specials shall be accurate to the dimensions shown. Hubs, spigots, and flanges shall be at right angles to the axis of the opening, and openings shall be at the exact angle specified.

F. All piping shall be subject to inspection and approval by the Engineer upon delivery, and no broken, cracked, misshaped or otherwise damaged or unsatisfactory piping will be accepted.

G. It is to be noted that in the relatively small piping systems, the drawings do not necessarily show all fittings, offsets, unions, hangers, supports, etc. All such items shall be furnished and installed, however, as required for complete and satisfactory installation of the equipment shown.

H. All exposed interior and exterior, ductile iron pipe, fittings and exposed ductile iron specials, shall be painted. The Contractor may furnish pipe and fittings with the ductile iron pipe industry's standard exterior bituminous coating, or uncoated pipe and fittings, or pipe and fittings with a shop prime coat of paint. In any case, it shall be the Contractor's responsibility to provide a satisfactory final field finish painting job. Sealer coats (on bituminous

coated surfaces), thorough field cleaning (of uncoated surfaces), or shop primer which is compatible with field coats, shall be provided as required. Details of painting and materials to be used shall be as specified in **DIVISION 9, FINISHES**.

I. Where eccentric reducers are indicated to be used, the reducer shall be installed with its straight side at the top of the piping system, unless otherwise shown.

G. Contractor shall have the following qualifications:

1. Independent Inspection and Testing Agency:
   a. Ten years' experience in field of welding and welded pipe and fittings' testing required for this Project.
   b. Calibrated instruments and equipment, and documented standard procedures for performing specified testing.
   c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
   d. Testing Personnel: Qualified for nondestructive test methods to be performed.
   e. Inspection Services: Qualified welding inspector.
2. Welding Inspector: AWS certified, AWS QC1 qualified, with prior inspection experience of welds specified.
3. Welder and Welding Operator Qualifications:
   a. Qualified by accepted inspection and testing agency before starting Work in accordance with Section IX, Article III of the ASME Boiler and Pressure Vessel Code.
   b. Qualified to perform groove welds in Positions 2G and 5G for each welding process and pipe material specified.
   C Retesting: Upon Engineer's written request, retest qualified welder(s).
4. Certified Welding Inspector (CWI) for Shop Welding: In accordance with AWWA C200 and as follows:
   a. Responsibilities:
      1) Verify conformance to use of specified materials and their proper storage.
      2) Monitor conformance to approved WPS.
      3) Monitor conformance of WPQ.
      4) Provide 100 percent visual inspection before, during, and after shop welding.
      5) Maintain records and prepare report confirming results of inspection and testing.
5. Certified Welding Inspector (CWI) for Field Welding: In accordance with AWWA C206, AWS D1.1, and as follows:
   a. Responsibilities:

1) Verify conformance to use of specified materials and their proper storage.
2) Monitor conformance to approved WPS.
3) Monitor conformance of WPQ.
4) Provide 100 percent visual inspection before, during, and after field welding.
5) Maintain records and prepare report confirming results of inspection and testing.

1.06 VALVES - GENERAL

A. Valves specified herein shall have the type of ends specified or as indicated on the drawings or as required by equipment connections.

B. No valves shall be installed with stems in the vertical down position.

C. All valves on vertical pipes shall have their stems oriented to give maximum operational clearance, or shall be oriented as directed by the Engineer.

D. Each piece of equipment or appliance shall be separately valved so that supply and return services can be shut off and the piece of equipment or appliance removed if desired, without disturbing the piping systems. Valves shall be located so as to be easily accessible to operator of equipment. Valves shall be installed whether shown on the drawings or not.

E. All valves 2" and under which will be used for throttling services shall be globe type except as shown or specified otherwise. Gate valves shall be used for cutoff or stop service except as shown or specified otherwise.

F. Where extension stems are required, they shall be doweled or otherwise securely attached to the valve stem.

G. The valve and operator shall be the responsibility of the valve manufacturer.

H. All valves shall open left, counterclockwise.

I. All manually operated valves located 6 feet or higher above the floor shall have chain wheel operators with chains to the floor, unless otherwise shown on the drawings. This includes manual valves provided with the Membrane System Equipment package.

1.07 FITTINGS - GENERAL

A. All fittings shall be of the type indicated on the drawings unless otherwise specified. Ferrous piping shall be provided with ferrous fittings; copper

tubing shall be provided with bronze, wrought copper or brass fittings. In general, all fittings shall be as specified hereinafter in Article Pipe and Fittings Schedule.

B. Nipples shall be extra heavy and of same material as piping system in which they are installed. Close nipples are not acceptable.

C. Malleable iron ground joint unions, brass to iron seat, of approved make, shall be used on all connections, up to and including 3" in diameter, to risers, appliances and equipment. Flanged connections shall be used for piping larger than 3".

D. Wherever the sizes of pipes are reduced, fittings shall be used for reductions without the use of bushings.

E. All flanges shall come fairly face to face; the pipe in perfect line, the pipes shall not be sprung to make a joint. Gaskets for flanged joints shall be as specified under JOINTS. All joints shall be neatly made and with great care.

F. In general, soft copper tubing shall have flared type fittings, and hard copper tubing shall have soldered joint fittings, or "Swagelok" for 1" tubing or less.

G. Screwed type systems shall contain ample unions in piping at equipment and valving of the system to allow easy removal of the equipment or disassembly of the system.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS SCHEDULE

A. Pipe and fittings shall be as indicated on the drawings and as listed in the following schedule, which schedule is intended to serve as a general guide and is not necessarily a complete listing of every piping system. Systems which may not be listed shall be comprised of the same kind of pipe and fittings as in similar systems which are listed, or as directed by the Engineer. The following schedule describes pipe and fittings that are interior or exterior to a facility. Underground piping shall be as specified in **DIVISION 2, SITEWORK**.

FIRST GROUP					
SERVICE	PIPE		FITTINGS		TYPE
	Material	Spec. Ref.	Material	Spec. Ref.	JOINTS
a. Raw Sewage b. RAS c. WAS d. Scum e. Utility Water	Ductile Iron	ANSI A21.51	Ductile Iron	ANSI A21.10	Flanged

Notes for First Group

1. Pipe and fittings, shall be cement lined in accordance with ANSI Specifications A21.4 Section 4-10.1, with curing to be effected by application of a bituminous seal coating which shall cover and seal the cement mortar. The thickness of the cement lining shall be that specified in Section 4.8.2, Double Thickness.
2. Pipe shall be Class 53. Fittings 4" and larger shall be rated for minimum 150 psi.
3. For description of exterior surfaces, see Article Ductile Iron Pipe and Fittings.
4. Flanges shall be drilled and faced for ANSI B16.1, Class 125; mechanical joints shall conform to ANSI A21.11.

SECOND GROUP					
SERVICE	PIPE		FITTINGS		TYPE JOINTS
	Material	Spec. Ref.	Material	Spec. Ref.	
a. Grit	Ductile Iron	ANSI A21.51	Ductile Iron	ANSI A21.10	Flanged

Notes for Second Group

1. Pipe and fittings shall be glass lined as specified herein.
2. Pipe shall be Class 53. Fittings 4" and larger shall be rated for minimum 150 psi.
3. For description of exterior surfaces, see Ductile Iron Pipe and Fittings.

Third Group					
SERVICE	PIPE		FITTINGS		TYPE
	Material	Spec. Ref.	Material	Spec. Ref.	JOINTS
a. Potable water b. Utility Water, 3” and smaller	Copper Tube Type K Hard	ASTM B-88	Wrought Copper	ANSI 40.2	Soldered

Fourth Group			

SERVICE	PIPE		FITTINGS		TYPE
	Material	Spec. Ref.	Material	Spec. Ref.	JOINTS
a. Plumbing Drains and Vents within buildings	PVC	ASTM D2665 Sch. 40	PVC Drainage Pattern	ASTM D2665	Socket with Solvent Cement
b. Roof Drains and Roof Overflow Drains					

Fifth Group					
SERVICE	PIPE		FITTINGS		TYPE
	Material	Spec. Ref.	Material	Spec. Ref.	JOINTS
a. ALP – Exposed Outside	Stainless Steel	ASTM A312 Sch. 40	Stainless Steel	ASTM A774	Welded
b. Scum Spray Water	Stainless Steel	ASTM A312 Sch. 40	Stainless Steel	ASTM A774	Welded

Sixth Group					
SERVICE	PIPE		FITTINGS		TYPE
	Material	Spec. Ref.	Material	Spec. Ref.	JOINTS
a. Chemical (Interior)	P.V.C. pipe and fittings as specified hereinafter in this section of the specifications.				

2.02 DUCTILE IRON PIPE AND FITTINGS

A. Ductile iron pipe and fittings shall be suitable for the pressures, connections, and linings specified in the pipe schedule above.

B. Ductile iron pressure pipe shall be made of ductile iron of good quality and of such character as shall make the metal castings strong, tough and of even grain and soft enough to satisfactorily permit drilling, tapping and cutting. All piping shall be smooth, free from cold shuts, scale, lumps, blisters, and sand holes and defects of every nature which make it unfit for the use intended. All piping shall be straight and shall be true circles in section with

its inner and outer surfaces concentric. No plugging, filling, burning-in or welding shall be allowed.

C. Each piece of ductile iron pipe shall have the weight and class designation conspicuously painted on it as near as possible to flange end of the pipe and these designations shall be clearly legible.

D. Where required or shown, the Contractor shall provide ductile iron specials. Specials shall in general consist of spool pieces, less than standard lengths and nonstandard fittings. The specials shall conform in material, thickness and finish to the pipe in which they are installed. Tapped reinforced bosses shall be provided as an integral part of fittings, when shown or specified.

E. All gaskets for flanged pipe, valve and fitting joints shall be 1/8-inch thick, full faced or rubber ring gaskets in accordance with ANSI/AWWA C115/A21.15 Appendix A. Gaskets shall be suitable for pressures listed in pipe schedule. See additional requirements in Article Joints specified hereinafter.

F. Flange nuts and bolts shall be in accordance with ANSI/AWWA C115/A21.15 Appendix A. Nuts and bolts shall be suitable for pressures listed in pipe schedule. See additional requirements in Article Joints paragraph specified hereinafter.

G. Flanges may be cast integrally with the ductile iron pipe, or screwed on type flanges may be used. Threaded flanges shall be the same material as the pipe. Field installation of threaded flanges or the use of "uniflanges" shall not be permitted. Flanges shall be faced after the flange is installed on the pipe.

2.03 STAINLESS STEEL PIPE AND FITTINGS

A. Pipe: Schedule 40 ASTM A312, “as-welded” grade, Type 304L, pickled and passivated.

B. Joints: Butt-welded or flanged at valves and equipment.

C. Fittings: Butt-welded ASTM A774 Grade 316L Sch. 40.

D. Branch Connections: Butt-welding or reducing tee in accordance with fittings above.

E. Flanges: Van Stone Type with stainless steel rolled angle stub ends ASTM A240 Type 304 Class 125 stainless steel backing flange. Flanged end drilling pattern shall adhere to ASME B16.1 Class 125. Blind Flanges, exposed to the atmosphere and not buried nor immersed in liquid, may be either stainless steel or Class 125 ductile iron with gaskets as specified herein.

F. Unions: 2” and smaller: Threaded Forged: ASTM A182/A182M, Grade F316, 2,000-pound or 3,000-pound WOG, integral ground seats, AAR design meeting the requirements of ASME B16.11, bore to match pipe.

G. Bolting: Type 316 stainless steel, ASTM A320 Grade B8M hex head bolts and ASTM A194/A194M Grade 8M hex head nuts. Provide same on mating cast iron flange on valve or equipment with flat ring gasket.

H. Gaskets: Flanged, Hot Air Service: 1/8-inch thick, unless otherwise specified, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 300 degrees F, conforming to ASME B16.21 and ASTM D1330 Steam Grade. Blind flanges shall be gasketed covering entire inside face with gasket cemented to blind flange.

I. Thread Lubricant: 2” and smaller, Teflon tape.

2.04 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

A. Those piping systems listed in the preceding schedule and where noted on the drawings as being "PVC" shall be unplasticized polyvinyl chloride normal impact type, conforming to ASTM Specifications D-1784 and D-1785 for Class 12454-B. Pipe shall be Schedule Eighty (80). Pipe shall be that of the B.F. Goodrich Company, Grinnel Company, Inc., International Pipe and Ceramics Corporation, or equal, and each length shall be clearly labeled with the manufacturer's name, PVC Type, Schedule and Size. Pipe shall be extruded. Welded seams will not be permitted.

B. Fittings shall be PVC normal impact type for use with Schedule 80 pipe and shall be as manufactured by Chemtrol, Celanese Piping Systems, Inc., or equal. All fittings shall be solid molded. Welded seams shall not be permitted.

C. Generally, all PVC pipe and fittings shall have socket type joints with solvent cement. Joints shall be made in accordance with the manufacturer's instructions. Where specifically noted on the drawings, or where required for connections to equipment for special reasons, pipe and fittings shall have threaded ends, or flanged joints. Threaded joints shall be made using the pipe manufacturer's recommended thread lubricant joint compound. Flanges may be the socket type, and shall be complete with rubber gaskets and galvanized steel bolts and nuts.

D. Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds the requirements of ASTM F656 and as recommended by the pipe and fitting manufacturer, except solvent weld cement for PVC pipe joints in sodium

hypochlorite service shall be free of silica filler and shall be certified by the manufacturer to be suitable for that service. Certification shall be submitted.

E. The Contractor shall demonstrate to the full satisfaction of the Engineer that applicable personnel are adequately skilled in making the joints specified above, prior to installation of any PVC piping.

F. The Owner reserves the right to direct the Contractor to have tests conducted on PVC pipe and fittings. These tests, if required, shall be conducted at the manufacturer's plant and shall be at the Contractor's expense. Tests shall be sufficiently complete to prove conformance with the requirements of Commercial Standard CS-256-63, and the following additional quality requirements shall be similarly met:

1. A parallel plate flattening test to the extent that face to face contact of the interior wall surface is made. The formation of cracks shall be considered failure.
2. Immersion in a mixture of 15% by volume of dimethyl formamide in anhydrous acetone for twenty (20) minutes. The specimen shall exhibit no visible flaking upon completion of the test.
3. Fittings and couplings shall meet burst pressure requirements of Table 6 of ASTM Specification D1785 for pipe when tested with end plugs inserted to a distance no more than 1/3 of the socket depth.

2.05 GLASS LINING

Glass lined, ductile iron pipe and fittings shall be used in systems listed in the PIPE AND FITTING SCHEDULE. The lining shall be especially formulated for handling sludge and septage. The formulating shall consist of special glasses and inorganic materials applied to the parts by procedures recommended by the manufacturer. The glass lining shall be applied, in a minimum of two coats, to the interior surface which has been sand blasted to expose clean bare metal. The glass lining shall be fused bare to metal at a minimum temperature of 1400°F to provide a coating integrally molecularly bonded with the bare metal. The bond shall be sufficient to permit a strain in the metal of 0.001 inch/inch.

A. The finish coat shall conform to the following standards:

Thickness:	0.008 inches to 0.012 inches
Hardness:	5 to 6 on the MOHS scale or 400 on the Knopp scale
Density:	2.5 to 3.0 grams/cubic centimeter
Thermal Shock:	350 deg F without crazing, blistering, or spalling
Weight Loss:	Less than 3 milligrams/square inch when tested according to ASTM C-283-54

Surface Glass Loss:	No loss of surface glass in lining after immersion in an 8 percent sulfuric acid solution, at a temperature of 148 deg F for a period of 10 minutes

B. The glass lining shall be in accordance with the manufacturer's standard tolerances for coverage, continuity, and glass. Copies of these tolerances shall be submitted for the Engineer's approval before acceptance of the pipe and fittings is given. Pinholes, crazing or fishscales, which substantially expose the metal substrate, shall be cause for rejection of the piece. Sizes, details, handling, stacking, etc., shall be in accordance with the manufacturer's recommendations.

C. There shall be only one piece of glass lined pipe cut in the field per run of pipe and this shall be for closure purposes only. Field cut pipe shall not spall back from the cut section, greater than 1/8-inch. There shall be no fishscaling or crazing beyond this point. All field cutting shall be in accordance with the manufacturer's recommendations.

D. The glass lining for pipe and fittings shall Fast Fabricators Vitco SG-14 or equal.

2.06 VALVES SMALLER THAN 4 INCHES

A. All valves shall be provided with the type of ends indicated, unless otherwise specified. All valves of any one classification shall be of the same manufacturer.

B. Unless otherwise specified herein for specific items, valves shall be as follows.

1.	Gate, on ferrous piping smaller than 3”, threaded	Stockham No. B105(screwed ends) Crane, Kennedy, NIBCO, or equal.
2.	Gate, on non-ferrous piping, soldered	Stockham Cat. No. B124 Crane, Kennedy, NIBCO, or equal.
3.	Check, on ferrous piping, threaded	Stockham Cat No B319Y Crane, Kennedy, NIBCO, or equal.

4.	Check, on non-ferrous piping, soldered	Stockham Cat. No. B309Y Crane, Kennedy, NIBCO, or equal.
5.	Pressure regulating, 2½" and larger	Golden Anderson 43-D Spence Engineering Co. Type D34
6.	Pressure regulating, 2" and smaller	Golden Anderson 45-D Spence Engineering Co. Type D34
7.	Pressure reducing, 3" and smaller	Spence Engineering Co. Type D34 Cashco. Type 8310
8.	Pressure relief, air	Lunkenheimer Fig. 1226 or 1227 StraVal Rvi-05
9.	Pressure relief, liquid	Lunkenheimer Fig. 286 or 65B Crispin PL or AR Cla-Val CRL, or 55F
10.	Globe, on 2" and smaller non-ferrous piping, threaded	Stockham Cat. No. B-29 Crane , NIBCO, or equal
11.	Globe, on 3" and 2 ½" ferrous piping	Lunkenheimer No. 1021-PS Crane Co, NIBCO, or equal
12.	Ball Valve, Bronze Soldered, 2" and Smaller	Apollo Series 77-200 Stockham S-285
13.	Ball Valve, Bronze Threaded, 2 ½" and Smaller	Apollo Series 77-100 Stockham T-T285
14.	Ball Valve, Carbon Steel (Flanged), 2" thru 4"	Apollo Series 87-100
15.	Ball Valve, Stainless Smaller than 2”	Stockham 1802 Apollo Series 76F-100 Cla-Val CRL, or 55F
16.	Hose Valves	Croker Series 5000 Dixon Powhatan Guardian Series 5000

2.07 PVC BALL VALVES

A. PVC ball valves shall be PVC double-union type ball valves unless otherwise noted on the drawings.

B. Valves shall have socket welded union type ends. Valves shall be constructed of rigid, unplasticized, type I polyvinyl chloride, body and ball. Valves shall include Teflon ball seats and viton "O" ring seals.

C. PVC ball valves shall incorporate full flow ball port and shall be capable of withstanding 150 psi water service. Valves shall be compatible with Schedule 80 PVC piping. Each valve shall incorporate a lever type handle and be so arranged to indicate open or closed position.

D. PVC ball valves shall be the product of Chemtrol, similar of Spears, Hayward,, or equal.

E. Bleach ball valves for sodium hypochlorite application shall be designed to effectively vent sodium hypochlorite off gases to the pressure port and shall be the true union model-C of Chemtrol (Nibco), similar of Spears, Hayward, or equal.

2.08 PVC BALL CHECK VALVES

A. PVC ball check valves shall be provided and installed where shown on the Contract Drawings.

B. Ball check valves shall be PVC constructed with body and ball of the same material. Seals shall be viton "O" ring type seals, for ball seat and body seals. Except as otherwise shown on the drawings, valves shall be provided with socket ends for Schedule 80 PVC piping. Valves shall be capable of use in 150 psi cold water system service and shall be capable of installation in either horizontal or vertical line system. Unions shall be provided in the line at the check valve for ease of removal.

C. PVC ball check valves shall be the products of Chemtrol, similar of Spears, Hayward,, or equal.

2.09 SWING CHECK VALVES 4-INCHES AND LARGER

A. Swing check valves 4 inches and larger shall be in accordance with AWWA C-508, 175 psi water working pressure, cast iron body, rubber-faced cast iron clapper with stainless steel shaft rotating in bronze plugs, replaceable bronze-faced seats, class 125 flanged ends and outside lever and weight. Check valves shall be Figure 159 of M&H Valve Company, similar of Golden Anderson, Apco, Mueller, Pratt or equal.

B. The valve exterior surfaces shall be shop primed in accordance with **DIVISION 9, FINISHES**. All internal steel or iron surfaces shall have two coats of epoxy coating approved by NSF for potable water service, meeting the requirements of AWWA C-550 latest revision. All external steel or iron surfaces shall be primed in accordance with **DIVISION 9, FINISHES**.

2.10 ARMLESS SWING CHECK VALVES

A. Armless swing check valves 4 inches and larger shall be in accordance with AWWA C-508, 250 psi water working pressure, cast iron body, rubber-faced cast iron clapper with stainless steel shaft rotating in bronze plugs, replaceable bronze-faced seats, class 125 flanged ends and outside lever and weight. The seating surface shall be on a 45-degree angle to minimize disc travel. Check valves shall be Valmatic Swing-Flex or equal.

B. The valve exterior surfaces shall be shop primed in accordance with **DIVISION 9, FINISHES**. All internal steel or iron surfaces shall have two coats of epoxy coating approved by NSF for potable water service, meeting the requirements of AWWA C-550 latest revision. All external steel or iron surfaces shall be primed in accordance with **DIVISION 9, FINISHES**.

2.11 RESILIENT-SEATED GATE VALVES

A. Except as otherwise noted, all gate valves 4 inches and larger shall be resilient-seated, non-rising stem type, designed for a working pressure of 150 psi. Resilient-seated gate valves shall be shall be in accordance with the latest revisions of AWWA C509 and shall be suitable for wastewater service.

B. Resilient-seated gate valves shall have ASTM A126 Class B cast iron stuffing box, bonnet, and body with ANSI B16.1 Class 125 drilled flanges. Wedge shall be ASTM A126 Class B cast iron encapsulated in rubber with ASTM B138 bronze stem and triple O-ring shaft seals.

C. Resilient-seated gate valve exterior shall be shop primed in accordance with **DIVISION 9 FINISHES.** All valve internal steel or iron surfaces shall have two coats of epoxy coating, meeting the requirements of AWWA C-550 latest revision. All valve external steel or iron surfaces shall be painted in accordance with **DIVISION 9 FINISHES**.

D. Provide extension stems, stem guides, other misc. supports, handwheel operators as necessary as shown on Contract Drawings.

E. Resilient-seated gate valves shall be manually operated by handwheel or chainwheel, as appropriate (see Article Valves-General), and shall be Mueller Company Series A-2360, or equal model of American Flow Control, M&H Valve Company, or equal.

2.12 BUTTERFLY VALVE – LOW PRESSURE AIR SERVICE

A. The butterfly valve shall be lug style, cast-iron body, and lever operated. The valve body shall fit between ANSI Class 125/150 flanges. The disc shall be constructed of aluminum bronze. The stem shall be one-piece, constructed of Type 316 stainless steel. Disc seating shall be replaceable resilient EPDM, suitable for temperatures to 250 degrees F, 150 psi working pressure rating, bubble-tight at 50 psi differential pressure. The butterfly valve shall be as manufactured by Bray Controls, Series 31, similar of Henry Pratt or equal.

B. Where indicated on the Power Operated Valve Schedules, provide with a power operator as specified in Article Electric Operators for Facilities 8, 9, and 10, herein.

2.13 STRAINERS

A. General purpose strainers shall be of the Y-pattern type, with 20 by 20 mesh over the full pipe area. All strainers have 125 pound cast iron bodies. Strainers 1-1/2 inches and smaller, shall have screwed ends and screwed brass caps. Strainers 2 inches and larger shall have screwed or flanged ends, as required, and bolted iron caps. General purpose strainers shall be the No. 988-1/2 and 989-1/2 of the Crane Company, the equal of V.D. Anderson Company, or equal.

B. Strainers in PVC or CPVC piping systems shall be of all PVC construction.

2.14 JOINTS

A. All joints at equipment shall conform to the equipment requirements. No direct welded connections shall be made to valves or other equipment. Right and left couplings, long screws, or caulking of pipe threads or gasket joints will not be permitted. Mitered joints for elbows and notching straight runs of pipe for tees or elbows will not be permitted.

B. Soldered or brazed joints shall be made with solder and a noncorrosive paste flux. The solder mixture will be of 95-5 (tin-antimony) content. The use of acid core solder shall not be permitted. The application of excess heat shall be avoided to prevent undue softening or burning of the fittings or tubing when making connections. All soldering operations shall be performed in strict accordance with best accepted practices. Tubing shall be square cut and reamed to remove all burrs. The inside of the fittings and the outside of the tubing at each end shall be well cleaned immediately prior to soldering to remove all traces of oxidation, regardless of how clean the surfaces of the pipe and fittings may appear.

C. Threads shall be standard, clean-cut and tapered. All pipe shall be reamed free from burrs and kept free from scale and dirt. Unless otherwise specified,

threaded joints shall be made up with "Permatex" type 2, black, nonhardening pipe joint compound applied to the male thread only. The use of red lead or white lead will not be permitted. The complete threaded joint shall not have more than two threads exposed when made tight. Threads shall comply with ANSI B2.1.

D. Except where special couplings are indicated, piping requiring screwed connections shall be connected with screwed, malleable iron, ground joint, brass seat, 150 psi unions; for piping requiring flanged connections, flanged malleable iron unions shall be used. The finish of all unions shall match piping in which they are installed. Unions shall be provided at equipment and where required otherwise to facilitate removal of piping or equipment.

E. All gaskets between flanged connections and fittings shall be rubber ring gaskets 1/8 inch thick as specified herein.

F. Flanges shall be of the same material as the piping on which installed, and bolts, nuts and washers shall be of mild steel, with good sound well-fitting threads; the nuts shall be cold punched, hexagonal, trimmed and chamfered. Heads, nuts and threads shall be U.S. Standard sizes. Bolts shall be of such length as to project 1/4 inch beyond the nut when the flanged joint with gasket is assembled. All hardware shall be galvanized. For submerged or exterior, exposed flanged joints, all bolts and nuts shall be of 304 18-8 stainless steel. Hardware for connecting stainless steel flanges shall be stainless steel, compatible with the pipe material. All gaskets between flanges shall be full face rubber or ring gasket, 1/8 inch thick. The flange joint system (bolts, nuts, gaskets and installation) are to be suitable for the intended service and have a minimum pressure rating of 150 psi.

G. Welded joints, if required in the project, shall be made by the electric arc or oxyacetylene gas process. Only thoroughly experienced certified pipe welders shall be employed for the work. After being welded, the piping, when tested as specified hereinafter, shall show no indication of leakage, weakness, and other defects. Welding and welders shall be in accordance with the Article Certification of Welders specified hereinbefore.

H. Mechanical joints shall be made up with rubber gaskets conforming to ANSI A 21.11. Glands shall be bituminous coated and bolts and nuts shall be of high strength cast iron or high strength low alloy steel.

2.15 FLEXIBLE COUPLINGS

A. Unless specified or shown otherwise on the drawings, flexible couplings shall be the Style 38 of the Dresser Manufacturing Division, Models 411, 431, 912, or 913 of Rockwell International, similar of Romac or equal. Each shall be so

designed and constructed to withstand an internal line pressure equal to that of the pipeline in which it is to be installed. The various flexible couplings shall be suitable for the class and size of ductile iron pipe or steel pipe as required at the various locations, and shall be without pipe stops. The Contractor shall provide and install flexible couplings in addition to those shown, as required, for flexibility in installing the various piping systems. Locations of additional couplings shall be as directed by the Engineer.

B. Tie rods shall be provided across all flexible couplings unless otherwise specifically noted on the Contract Drawings to be omitted, and shall be as detailed on the Contract Drawings.

2.16 FLANGE ADAPTORS

A. Unless specified or shown otherwise on the drawings, flange adaptors shall be the Style 128 of the Dresser Manufacturing Division, similar models of Rockwell International, Romac, or equal. Each shall be so designed and constructed to withstand an internal line pressure equal to that of the pipeline in which it is to be installed. The flange adaptors shall be suitable for the class and size of ductile iron pipe or steel pipe as required at the various locations, and shall be without pipe stops. The Contractor shall provide and install flange adaptors in addition to those shown, as required, for flexibility in installing the various piping systems. Locations of additional adaptors shall be as directed by the Engineer.

B. Tie rods shall be provided across all flange adaptors unless otherwise specifically noted on the Contract Drawings to be omitted, and shall be as detailed on the Contract Drawings.

2.17 EXPANSION JOINTS

A. Expansion joints shall be able to remove stress from piping systems and handle corrosive abrasive slurries and domestic sewage and sludges. The assembly shall consist of two 150 LB drilled containing-ring type flanges and a natural rubber expansion joint. Expansion joints for sewage or other solids bearing liquids shall have filled arches to prevent obstruction and reduced flexibility.

B. Standard length shall be 6 inches. Approximate movement capabilities shall be 1/4 inch axial compression, 1/8 inch axial extension, 1/4 inch lateral deflection, 5 degrees angular movement and 2 degrees torsional movement. Maximum allowable working pressure shall be 165 psig. Rated temperature shall be 250 degrees F, minimum.

C. Tie rods shall be provided across all expansion joints unless otherwise noted, and shall be as detailed on the Contract Drawings.

D. Installation misalignment shall not exceed 1/8 inch in any direction. The expansion joint shall be located close to the stationary equipment or source of vibration and the other mating flange relatively close to an anchoring type support. Prior to installation all mating flanges shall be clean, dry and flat-faced.

E. Manufacturer of the expansion joint shall be Mercer style 500R, similar of Proco, General Rubber, Red Valve or equal.

2.18 WALL CASTINGS AND SLEEVES THROUGH WALLS AND FLOORS

A. Castings or sleeves shall be provided in walls and floors for the passage of all pipes.

B. Wall and floor sleeves for pipes smaller than 4 inches shall be schedule 40 galvanized steel pipe, conforming to ASTM A53, except where otherwise shown on the drawings. Sleeves passing through floors shall extend approximately 4 inches above the finish floor and sleeves extending through walls shall be flush. Chromium plated escutcheon plates, of a suitable pattern, shall be furnished and installed to conceal ends of all exposed pipe sleeves above the floors of finished rooms. Sleeves shall be of ample size to permit passage of pipe and insulation (where required) and allow for expansion. Space between pipe and sleeves shall be sealed with a modular mechanical type joint, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. The seal shall be watertight and provide electrical insulation between the pipe and the wall, thus reducing chances of cathodic reaction between these two members. The inside diameter of each wall or floor opening shall be sized as recommended by the manufacturer to fit the pipe and mechanical-seal to assure a watertight joint. Contractor shall familiarize his installation personnel with all manufacturer's recommendations and installation bulletins to assure a watertight assembly. Mechanical-seal shall be "Link-Seal" as manufactured by Thunderline Corporation, similar of Proco or equal. Where "Link-Seal" cannot be used, the space between pipe and sleeves shall be caulked, concrete grouted or other method as approved by the Engineer. Low melting point asphaltic materials will not be permitted for caulking.

C. Generally, except where otherwise noted on the drawings, wall castings shall be ductile iron or steel to match corresponding piping with the type of ends shown on the drawings, and shall be complete with water stop flange or thrust collar as indicated. The wall castings shall be of lengths shown Wall castings

with water stop collars shall be in accordance ANSI/AWWA C115/A21.15 Appendix C.

D. Generally, except where otherwise noted on the drawings, for pipes four (4) inches and larger passing through floors, sleeves shall be schedule 40 galvanized steel pipe conforming to ASTM A53. Except that no escutcheon plates will be required, these sleeves and their arrangement shall be as specified above for sleeves for pipes smaller than four (4) inches. Space between pipe and sleeves shall be sealed with mechanical seal as specified above.

E. The Contractor shall not be allowed to box-out the concrete for installation of any wall castings or sleeves, except with the Engineer's permission for each specific location involved. Castings or sleeves shall be securely fastened in place so that pouring of concrete will not disturb their position in any manner. The Contractor shall correlate with the other trades (particularly concrete work) to assure that all wall castings and wall and floor sleeves are properly set. When boxed-out sections are allowed, the boxed-out section shall be filled with non-shrink grout and treated in general as specified for "Construction Joints" in **DIVISION 3, CONCRETE**.

2.19 DRAINS AND VENTS

All piping systems (which do not include other convenient means of draining) shall include 3/4 inch hose valves at each low point to facilitate draining of the system. All piping systems, which do not include by nature of the systems a means of venting the air (for example, faucets at sinks are a means of venting), shall be provided with either a ½-inch manual ball valve or an automatic air vent valve, as directed by the Engineer, and located at each high point.

2.20 PIPE SUPPORTS

All supports shall conform to MSS SP-69. The following support models are based on Anvil International Catalog. Similar models from PHD, B-Line, Tolco, or equal are acceptable.

A. Clevis Hangers: Clevis hangers shall be of galvanized carbon steel construction. Hangers shall be adjustable and suitable for piping 4 through 24 inches. Clevis hangers for ductile iron or cast iron pipe shall be Figure 590. Clevis hangers for steel or plastic pipe shall be Figure 260.

B. Steel Yoke Pipe Roll Hanger: Yoke pipe rolls shall have cast iron rolls and carbon steel yoke, roll rod and hex nuts. All components shall have a galvanized finish. Rolls shall be suitable for piping 3 through 24 inches. Yoke pipe rolls shall be Figure 181.

C. Swivel Ring, Split Ring Hanger: Hangers shall have galvanized carbon steel construction. Split ring hangers shall be adjustable and suitable for piping ¾ through 8 inch. Swivel ring, split ring hangers shall be Figure 104.

D. Pipe Stanchion Saddle: Saddles for pipe 4 through 12 inches shall be cast iron with steel u-bolt and nuts. Saddles for pipe 14 through 36 inches shall be carbon steel saddle and u-bolt. All saddles shall have galvanized finish. Pipe stanchion saddles shall be Figure 259. Saddles shall be used with carbon steel stanchion with baseplate Figure 63P.

E. Adjustable Pipe Saddle: Saddles for pipe 4 through 12 inches shall be cast iron with steel u-bolt and nuts. Saddles for pipe 14 through 36 inches shall be carbon steel saddle and u-bolt. All saddles shall have galvanized finish, steel locknut nipple, and cast iron reducer. Adjustable pipe saddles shall be Figure 265. Adjustable saddles shall be used with carbon steel stanchion with threaded connection and baseplate Figure 63T.

F. Riser Clamps: Clamps shall be carbon steel construction with galvanized finish. Clamps shall be suitable for ¾ through 8 inch pipe and shall be Figure 261.

G. Offset Pipe Clamps: Clamps shall be galvanized carbon steel construction suitable for piping ¾ through 8 inch. Offset pipe clamps shall be Figure 103.

H. Wall Brackets: All brackets shall be galvanized carbon steel construction. Light duty brackets shall be suitable for maximum 750 pound load and shall be Figure 194. Medium duty brackets shall be suitable for maximum 1,500 pounds load and shall be Figure 195. Heavy duty wall brackets shall be suitable for maximum 3,000 pounds load and shall be Figure 199.

I. Ceiling Flanges and Plates: Ceiling flanges shall be malleable iron construction, suitable for 3/8 inch rod with minimum 450 pound load and ½ through ¾ inch rods with a minimum load capacity of 1,000 pounds. Flange shall have three mounting holes and provide 1 inch adjustment of hanger rod. Ceiling flanges shall be Figure 153. Ceiling plates shall be galvanized carbon steel construction suitable for 3/8 through 1 ¼ inch rod with corresponding maximum load of 730 and 9,500 pounds, respectively. Plates shall have either clevis attachment or rod attachment and shall be respectively Figures 49 or 52.

J. Concrete Inserts: Inserts shall be of galvanized malleable iron construction and shall be universal type allowing a minimum of 1 inch rod adjustment. Insert shall be suitable for 3/8 through 7/8 inch rods suitable for maximum

load of 730 pounds and 1,140 pounds, respectively. Inserts shall be Figure 282.

K. Beam Clamps: Clamps shall be either galvanized carbon steel construction suitable for beam flanges 4 through 12 inch, Anvil Figure 133, or equal, or malleable iron construction for beam flanges 2 3/8 through 7 inch, Anvil Figure 218 with Figure 157 extension piece, or equal.

L. Strut Channel: Strut channel shall be either galvanized steel or fiberglass as indicated on the Drawings. Channel size shall be selected to suit applied loads. Channels shall have a continuous slot to allow for insertion of pipe clamps, straps, and other support components Galvanized channel shall be hot dipped conforming to ASTM A123.

2.21 TANK DRAIN GATE VALVES

A. Ductile iron body, resilient seat, bronze stem and stem nut, ANSI Class 125 flanged ends, nonrising stem, in accordance with AWWA C515, minimum design working water pressure 200 psig, full port, fusion epoxy coated inside and outside per AWWA C550. Manufacturers and Products: American Flow Control; Series 2500. M&H; Style 7000 and C515 Large RW Valves.

B. Where indicated on the Power Operated Valve Schedules in the Drawings, provide with a power operator as specified in Article Electric Operators for Facilities 8, 9, and 10, herein.

2.22 SPRAY NOZZLES

A. Type 1. Nozzles shall have a flat spray pattern, with a nominal spray angle of 80 degrees at 40 psig supply. Body shall be cast iron. Flow capacity shall be 2 gpm at 40 psi. Connection size shall be 1/4-inch male NPT. Quantity provided shall be as shown on the Drawings plus two spares. The nozzles shall be manufactured by Spraying Systems Co. model VeeJet No. H-U-SS-8020, with adjustable ball fitting, or equal.

2.23 SERVICE SADDLE

A. Service saddles for metal piping shall be the double U-bolt type. Body shall be constructed of ductile iron. U-bolts shall be zinc plated steel and shall have a flat pipe bearing surface. Saddles shall be suitable for 150 psi operating pressure. Saddles shall be Ford F202, Mueller DR2A, Romac

202U, or equal.

B. Service saddles for plastic pipe shall use straps and shall provide full support around the circumference of the pipe and shall not distort, scratch, or damage the pipe when tightened. Saddles shall be manufactured specifically for plastic pipe. Saddle and clamps/straps shall be formed to meet the curvature of the pipe. U-bolt type straps shall not be acceptable. Saddles shall be suitable for 150 psi operating pressure. Saddles shall be Ford FS202, Mueller DR2S, Romac 202S, or Equal.

2.24 SEWAGE AIR RELEASE VALVES

A. The sewage air release valves shall be sized and installed as shown on the Contract Drawings. Air release valves shall be of the lever type and shall be capable of automatically releasing accumulated air from a sewage system while that system is in operation and under pressure.

B. To assure drop tight shut-off, a Viton or Buna-N orifice button shall be used to seal the valve discharge orifice when the valve is in a closed position. The orifice diameter will be sized for use within a given operating pressure range to insure maximum discharge capacity.

C. The materials of construction are as follows:

The body and cover shall be of cast iron, ASTM A126 Class B. The leverage mechanism, float and all other internal trim shall be of stainless steel. Valves shall be provided with flushing connections.

D. The stainless steel float shall be designed to and capable of withstanding a pressure in excess of 1,000 PSI.

E. The valves shall be Golden Anderson Figure 925, Model VM-48 Val-Matic, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF PIPING, HANGERS AND SUPPORTS

A. Proper and suitable tools and appliances for the safe and convenient handling of pipe and specials shall be used. All pipe and castings shall be carefully examined for defects before laying and no pipe or casting known to be defective shall be laid in the line.

B. During construction, the Contractor shall keep all ends of pipes, including those extending above the roof, and all drains and fixtures, closed with caps,

plugs or wooden flange covers, so as to prevent dirt, building material or other foreign matter from getting into pipe and traps.

C. All hangers, supports, and guides shall be of types as approved by the Engineer, arranged to maintain the required grading and pitching of lines, to prevent vibration and sagging, to provide for expansion and contraction, and to provide for complete support of the pipes. See paragraph 1.04 for additional requirements.

D. Unless shown otherwise on the Drawings, pipes shall be supported in accordance with the following:

1. Maximum support spacing and minimum rod size in accordance MSS SP-69 Table 3 and Table 4.
2. Soft copper tubing shall be supported at sufficiently frequent intervals to prevent sag or pockets.
3. Vertical lines shall be supported at their bases, using either a suitable hanger placed in the horizontal line near the riser or a base type fitting set on a pedestal, foundation or support. All vertical lines extending 6 feet or more shall be supported with riser clamps, offset clamps, pipe stanchion saddles, or adjustable pipe saddles.
4. All horizontal piping on vertical walls and all piping near walls for which ceiling anchorage is not practicable, subject to the Engineer's approval, shall be properly supported by steel brackets securely anchored into the wall construction. Horizontal pipe (or pipe covering) on vertical walls shall be held at a minimum of one inch from the walls to protect them from wall sweating.
5. Supports and anchor bolts subject to submergence or water spray shall be of Type 304 stainless steel.
6. All hangers shall be secured in unpainted inserts wherever practicable. Hangers and/or rod supports, inserted in the concrete slab, shall be capable of sustaining the hanger rod load.
7. All pipe supports and hangers attaching to block walls shall be anchored with Hilit Std. HIT Anchors for hollow masonry, ½-inch dia with 6-inches embedment or approved equal unless otherwise shown or specified. Anchor bolts shall be properly aligned with the work and shall not be bent to mate up with the opening.
8. Drilling of holes for anchors, supports, hangers, etc., in portions of the building which may affect the structural soundness of that portion will be done only after the Contractor has secured permission from the Engineer to do so.
9. All pipes, valves, fittings and equipment 6 inches in diameter and larger, and located relatively close to the various floors, shall be

supported by concrete or steel supports where shown on the Contract Drawings, or where directed by the Engineer.

10. Neoprene isolating mats shall be provided between concrete supports and metallic pipe, valves, fittings and equipment. Thickness of mats shall be not less than 1/8 inches.
11. Hangers which support galvanized pipe shall be galvanized and hangers which support copper pipe shall be copper-plated.
12. All piping connected to pumps shall be supported as near the pump as practicable such that the weight of the pipe is not supported by the pump casing.

3.02 MINIMUM SLOPES

Waste and drainage piping shall be sloped not less than 1/4-inch per foot in direction of flow unless otherwise indicated on the drawings.

3.03 CONNECTION AT DISSIMILAR METALS

Wherever pipes of dissimilar metals join, there shall be provided an insulating union, coupling or flange connector for corrosion control. Connectors shall include an approved type dielectric separator. Connectors shall be the product of Dresser Corporation, Capitol Manufacturing, EPCO, Watts, Central Plastics, Calpico, or equal. Stainless steel nuts, bolts, and washers shall be used at all places at which such dielectric separators are used.

3.04 IDENTIFICATION OF PIPING SYSTEMS

A. Painting of the various piping systems shall be as specified under **DIVISION 9, FINISHES**.

B. All piping systems listed shall be stenciled with the name of the service to indicate the use of that particular pipe, and an arrow showing the normal direction of flow. Stencils shall be plain block letters of the size indicated hereinafter. Stenciled names shall be located near each branch connection, near each valve and at least every 50 feet on straight runs of pipe. All stenciled names shall be so located as to be legible from the floor. Generally, letters on light colored pipes shall be either black or red; on dark colored pipes letters shall be white. Stenciled names shall be applied after the piping has been tested, covered (if required) and painted. Color coding and names are as specified herein. Any system inadvertently not listed shall be stenciled as directed by the Engineer. Paint all valves and operators the same color as the piping. Paint equipment the same color as the piping.

C. All materials shall be applied in accordance with the manufacturer's recommendation.

D. Data Plates, bright metal parts such as stainless steel, chrome plate, etc., shall not be painted. Nor is it intended to paint stainless steel, copper, brass, or aluminum pipes. Pipes of these metals, however, shall be color coded, banded with colors indicated below with 6 inch wide bands not less than 8 feet on centers. PVC and CPVC piping shall be painted.

E. The various systems shall be either painted or color banded as follows:

Service and Identification	Pipe or ID Band Color	Letter and Flow Arrow Color
1. All Sewage Systems	Brown	Yellow
2. Non Potable Water	Lt. Green	Black
3. Cold Water/Potable	Blue	White
4. Hot Water	Crimson	Black
5. Drains	Black	White
6. Vents	Buff	White
7. Chemical	Safety Yellow	Black
8. Natural Gas	Yellow Ochre	Black
9. Roof Drains	Black	White
10. Roof Overflow Drains	Black	White
11. Sanitary Drains	Brown	Yellow
12. Utility Water	Purple	Yellow
13. Tempered Water	Indian Red	Black
14. Fire Water	Red	Blue
15. Heating Water	Crimson	Black

Pipe Covering Outside Diameter (in.)	Stencil Letter Size (in.)
Under 3/4	(Use Hand Lettering)
3/4 to 1-1/4	1/2
1-1/2 to 2	3/4
2-1/2 to 6	1-1/4
8 to 10	2-1/2
Over 10	3-1/2

F. All valves shall be provided with identification tags. Valve tags shall be 3/32 inch thick engraved plastic, 2 inches in diameter, with black engraved lettering on a white background. Lettering and/or numbering shall be 3/4 inches high, shall be on both sides of the tag and shall correspond to the valve designations required by the Engineer. Valve tags shall be fastened to each valve with 4 ply wire passing through a small predrilled angular hole through the valve tag and secured with a metal seal. Valve tags shall be as

manufactured by the Seton Name Plate Corporation, or equal. Contractor shall coordinate valve tag identification with the Owner. In general valve abbreviation identification shall as shown on the Contract Drawings, unless directed otherwise.

3.05 TESTING OF PIPES

A. Engineer shall be notified in advance of all tests and all tests shall be conducted to his entire satisfaction. All tests shall be made prior to insulating piping as applicable.

B. Repairs to the various systems shall be made with new materials. No caulking of threaded joints, cracks or holes will be acceptable. Where it becomes necessary to replace pieces of pipe, the replacement shall be the same material and thickness as the defective piece. Tests shall be repeated after defects disclosed thereby have been made good or the work replaced.

C. All piping shall be adequately braced and supported during the tests so that no movement, displacement or damage shall result from the application of the test pressure. Relief devices in the various systems shall be capped or plugged during the tests.

D. All equipment used in testing shall be subject to the approval of the Engineer, and shall be such as to properly develop, maintain and measure test procedures. Test pressure shall be developed and maintained by means of a hydraulic force pump.

E. The test pressure shall be maintained for at least two hours with no pressure drop. All gravity flow piping systems, inside or under the various structures, shall be filled with water and there shall be no drop in level after two hours. Piping systems shall be tested in accordance with the following schedule:

System	Symbol	Testing Medium	Test Pressure
Raw Sewage	RS	Water	150 psig
Sump Pump Discharge	SPD	Water	50 psig
Grit	GT	Water	150 psig
Utility Water (Plant Effluent)	UT	Water	150 psig
Scum	SC	Water	50 psig
Return Activated Sludge	RAS	Water	50 psig
Waste Activated Sludge	WAS	Water	50 psig
Low Pressure Air	ALP	Air	20 psig

System	Symbol	Testing Medium	Test Pressure

3.06 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 for Pressure Piping, if recommended by piping or fitting manufacturer, and as may be specified in herein.

B. Weld Identification: Mark each weld with symbol identifying welder.

C. Pipe End Preparation:

1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removed by chipping or grinding.
3. Beveled Ends for Butt Welding: ASME B16.25.

D. Surfaces:

1. Clean and free of paint, oil rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:

1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1-inch, whichever is greater.

F. Climatic Conditions:

1. Do not perform welding if there is impingement of any rain, snow, sleet, or high wind on the weld area, or if the ambient temperature is below 32 degrees F.
2. Stainless Steel and Alloy Piping: If the ambient temperature is less than 32 degrees F, local preheating to a temperature warm to the hand is required.

G. Welded Pipe Joints:

1. Shop Welded:
   a. Fabricate in accordance with AWWA C200 (steel pipe) and AWWA C220 (stainless steel pipe) as modified herein.
   b. Complete joint penetration (CJP) butt joints shall be used for longitudinal, girth, and spiral welds, unless otherwise indicated.
   c. Lengths of pipe shall not be shop-joined using lap joints.
2. Preparation of Joints for Field Welding:
   a. Butt Joint Welded" Plain ends beveled as required by AWWA C200, AWWA C220, and Contractor's field WPS.
   b. Lap Joint Welded:
      1) Double fillet lap joints in preparation for field welding shall be in accordance with AWWA C200.
      2) For pipe 42 inches in diameter and larger, tack weld four metal tabs at equal intervals around inside circumference of bell ends to indicate location at which the spigot end has reached maximum penetration into bell. Remove stops after welding of joint.
      3) Double welded lap joints and butt-strap joints shall be tapped and drilled for testing in accordance with AWWA C206.

H. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

I. Surface Defects: Chip or grind out those affecting soundness of weld.

J. Weld Passes: As required in welding procedure.

K. Weld Quality: Free of cracks, incomplete penetration, weld undercutting, excessive weld reinforcement, porosity slag inclusions, and other defects in excess of limits shown in applicable piping code.

L. Field Welding of Pipe and Fittings:

1. Conform to AWS D1.1, AWWA C220, AWWA C206, approved welding procedure, and referenced welding codes. In case of conflict, AWS D1.1 shall govern.

2. Preheat and Interpass temperature requirements for unlisted base metals shall be determined according to ASME Boiler and Pressure Vessel Code, Section IX.
3. Rejectable weld defects shall be repaired or redone, and retested until sound weld metal has been deposited in accordance with appropriate welding codes.
4. Field connections to Existing Welded Steel Pipe:
   a. Where welded connection to existing is shown on the Drawings, remove coatings and linings in area of joint, cut and prepare existing pipe for field welding to new pipe.
   b. Connection joint shall be a butt-strap joint as specified herein.
   c. Repair joint coatings and linings as specified herein.

END OF SECTION 15060

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SECTION 15080

MECHANICAL INSULATION

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SECTION 15080

MECHANICAL INSULATION

PART 1 - GENERAL

1.01 SCOPE

Provide all labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the mechanical insulation as specified herein.

1.02 SUBMITTALS

Shop drawings shall be submitted for all items specified herein as specified under **DIVISIONS 0 AND 1**.

PART 2 - MATERIALS

2.01 MATERIALS

A. Insulation shall have a fire and smoke hazard rating as tested by procedure ASTM E-84, NFPA 255 and UL 723 not exceeding:

Flame Spread	25
Smoke Developed	50

Accessories, such as adhesives, mastics, cements and tapes for fittings shall have the same component ratings as listed above.

B. All products or their shipping cartons shall bear a label indicating that flame and smoke ratings do not exceed above requirements.

C. Any treatment of jackets or facings to impart flame- and smoke-safety shall be permanent. The use of water-soluble treatments is prohibited.

2.02 QUALITY

Surfaces of insulation shall be smooth and even, with jackets drawn tight and smoothly cemented down at all longitudinal and end laps. Adhesive shall be resistant to vermin and mold, and shall be durable. No scrap pieces of covering shall be used where a full length section will fit. All covering shall be non-combustible and shall meet Factory Mutual requirements in this respect.

2.03 ELASTOMERIC TUBE INSULATION

A. The materials specified in this paragraph apply to the following piping systems.

1. Potable water – ¾ inch thick
2. Utility water - 3/4 inch thick.
3. Refrigerant. – 3/4 inch thick.
4. Condensate drain. – 3/4 inch thick.

B. Elastomeric tube insulation shall be the closed cell type suitable for temperatures between minus 297 to plus 220 degrees F. Insulation shall not contain CFCs or formaldehyde. Insulation shall have a minimum thickness indicated and shall be Armaflex as manufactured by Armacell, Inc., similar of Aeroflex, Nomaco, or equal.

C. Insulation for exterior piping systems shall also have a weather protective jacket constructed of 0.016 inch thick aluminum. Aluminum jackets shall be sealed and made watertight.

2.04 FIBERGLASS PIPE INSULATION

A. The materials specified in this paragraph apply to the following above ground piping systems.

1. Low Pressure Air Piping – 1-1/2-inch minimum thickness, on interior intake and discharge piping.

B. Fiberglass pipe insulation shall have minimum thickness as indicated and shall comply with the requirements of ASTM C 547 and meet ASTM C 585 for sizes required in the particular system. It shall be glass fibers bonded with a thermosetting resin suitable for installation on piping systems. Product shall include a vapor retarding facing and a factory applied, longitudinal acrylic adhesive closure system. Insulation shall have operating temperature limits of 0 to 850 deg F.

C. Insulation for exterior piping systems shall also have a weather protective jacket constructed of 0.016 inch thick aluminum. Aluminum jackets shall be sealed and made watertight.

D. Fiberglass pipe insulation shall be Johns-Manville Micro-Lok® series, similar of Owens Corning, CertainTeed, Knauf, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All insulation shall be installed by trained qualified personnel showing a minimum of 1 year experience with the specified product.

B. Systems and equipment specified herein and systems noted on the Contract Drawing to be insulated shall be cleaned and insulated. This includes piping in furred spaces, trenches, wall chases, and piping in toilet rooms, except chromium plated piping.

C. All exterior or interior piping to be heat traced shall be insulated.

D. Insulated piping shall be supported by hangers on the outside of the covering. Galvanized iron or galvanized steel shields shall be installed between the hanger or support and the insulation. Shields shall be formed to fit the insulation and shall extend up to the centerline of the pine and not less than 4 inches on each side of the hanger or support. For trapeze hangers or roller supports where the load bears at a line or a point, shields for pipe sizes under 3 inches shall be No. 16 gauge; and for pipe sizes 3 inches and larger, shields shall be No. 14 gauge.

E. Insulation shall be applied over clean, dry surfaces only after tests to the covered systems have been completed.

F. The insulation shall be stored in a dry place prior to application. Installation of wet or very damp insulation shall not be permitted.

G. Insulation on all cold surfaces must be applied with a continuous unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold surfaces, and all valves, fittings, flanges, and unions on water piping must be adequately insulated and vapor sealed to prevent condensation. Insulation shall not be continuous through all openings and sleeves. Insulation must be readily removable and replaceable where valve packing nuts are insulated. Valves not subject to sweating shall be insulated only up to packing nuts. Where pipe insulation rests on hangers or supports, it shall be of a rigid nature, equal in thickness to adjoining pipe insulation and sized to carry load without crushing. Handholes, manholes, cleanouts, ASME stamp, catalog number, manufacturer's name, rupture discs, etc., shall be left exposed. Insulation shall be neatly beveled in these areas.

H. The insulation shall be neatly terminated at each end of unions so that they will be accessible. Fittings and valves shall be insulated per insulation manufacturer’s recommendations. Standard oversizing practices shall be

used. When indicated on the drawings, plenum insulation liner shall also be protected with double wall plenum construction.

END OF SECTION 15080

SECTION 15114

PLUG VALVES

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SECTION 15114

PLUG VALVES

PART 1 - GENERAL

1.01 DESCRIPTION

Provide all coordination, labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the equipment as shown or specified and in accordance with the requirements of the Contract Documents.

1.02 SUBMITTALS

A. Furnish detailed shop drawings for all items specified herein in accordance with Division 1.

B. Furnish detailed Operation and Maintenance manual for all items specified herein in accordance with Division 1.

1.03 EQUIPMENT DESIGN

A. Mechanical equipment design, workmanship, testing and operation shall be as specified herein and in accordance with Section 15000, General Mechanical Requirements.

B. Electrical and Instrumentation equipment design, workmanship, testing and operation shall be as specified herein and in accordance with Division 16 and 17.

1.04 QUALITY CONTROL

A. The equipment manufacturer shall have a minimum of 10 years experience in manufacturing equipment similar, equal or larger size, to that specified.

B. The Equipment Manufacturer shall provide a list of at least 10 exclusively different U.S. installations where equipment identical to that proposed to be provided has been in successful operation. The term "installation" shall mean individual projects/contracts. Multiple equipment units for a project shall be considered as 1 installation toward meeting the experience requirements. Installation information shall include, but not be limited to, the following:

1. Name and location of the installation.
2. Name of person in direct responsible charge for the equipment.
3. Address and phone number of person in direct responsible charge.
4. Month and year the equipment was placed in operation.
5. Capacity of Equipment

C. The equipment provided shall conform to all applicable requirements of the governing bodies listed in Section 15000 General Mechanical Requirements

1.05 DELIVERY, STORAGE AND HANDLING

A. The equipment shall be packaged to minimize possible damage from moisture, temperature variations and impact due to shipping conditions. Exposed threads shall be protected with tape or caps, openings shall be closed by caps or plugs. Detailed installation instructions shall accompany the equipment.

B. The Contractor shall inspect the equipment when it is delivered to ensure that it is not damaged. Store the equipment in a dry location and maintain the equipment per Manufacturer's recommendations.

C. Dispose of packing materials in accordance with state and federal regulations.

D. Delivery, storage and handling shall be in accordance with Division 1.

1.06 MANUFACTURER'S INSPECTION AND START-UP

A. The Contractor shall furnish the services of the equipment manufacturer's qualified field representative to inspect the equipment after installation, provide startup services, and supervise all initial start-up operations and functional testing as specified herein for a minimum of two (2) eight (8) hour days. Services shall be provided as required to ensure complete and operational equipment.

B. In the event that the equipment does not perform as specified, the Contractor, at no additional expense to the Contract, Owner or the Owner's representative, shall make provisions for the field representative to stay on site until all problems are resolved to the Owners satisfaction.

1.07 MANUFACTURER'S CERTIFICATE

The Contractor shall furnish the Engineer with a Manufacturer's Certificate, signed by an authorized representative of the Manufacturer, certifying that the equipment is installed in a complete and satisfactory manner and has been functionally tested such that it is ready for operation.

1.08 TRAINING

Provide the service of a qualified manufacturer's representative to thoroughly train Owners personnel in the operation and maintenance of the equipment installed. Training shall be provided by as required to ensure Owner's personnel understanding of equipment for a minimum of two (2) hours.

1.09 WARRANTY AND GUARANTEE

Contractor shall warrant and guarantee to the Owner that all work will be in accordance with the Contract Documents and that the equipment, material, workmanship, performance and installation will not be defective for (2) two years from the date the system is placed in operation which shall be upon completion of operation tests.

PART 2 - PRODUCTS

2.01 PLUG VALVES

A. Plug Valves shall be non-lubricated, eccentric, resilient-faced plug type and shall be furnished with end connections as shown on the Contract Drawings. Flanged valves shall be provided with Class 125 drilled flanges in accordance with ANSI B16.1. Mechanical joint ends shall be in accordance with AWWA Standard C111. All plug valves shall be furnished by one manufacturer.

B. Valve bodies shall be of cast iron in compliance with ASTM A126 Class B and AWWA C-507, Section 5.1 Standards. All exposed nuts, bolts, springs and washers shall be 316 stainless steel. Valve plug shall be ductile iron with integral upper and lower shaft. The plug shaft seal shall utilize a stuffing box and split pull-down packing ring. Resilient plug facing shall be of neoprene and shall be compliant with ASTM D429 method B. Port areas of plug valves shall be nominal 100 percent of full pipe area. Ports shall be rectangular in design for all sizes.

C. Valves shall be furnished with corrosion resistant seats of a welded in and machined overlay of at least 90 percent pure nickel which comply with AWWA C507, Section 3. Valves shall be furnished with replaceable 316 stainless steel sleeve type bearings in upper and lower journals. These bearings shall comply with AWWA Standard C504, Section 3.6. Valve shaft packing seals shall comply with AWWA Standard C504, Section 4.5.7.4 and shall be of buna(vee). Nowhere in the valve or actuators shall the valve shaft be exposed to iron on iron contact. The valve shall be repackable without removing the bonnet or operator. Repacking shall be able to done while valve is still in service.

D. Valve pressure ratings shall be as follows and shall be established by hydrostatic tests as specified by ANSI Standard B16.1. Pressure ratings shall be 175 psi for valves through 12 inches and 150 psi for valves 14 inches and larger. Valves shall provide drip tight shut off up to the full pressure rating with the pressure applied to the valve from either direction.

E. Unless otherwise noted, plug valves 4 inch and larger shall be furnished with manual, geared operators. All plug valves 6 feet or higher above floor, regardless of valve size, shall have geared operators with chain wheel. All plug valves utilizing stem extensions shall have geared operators. All hand wheel operated valves shall open with counter-clockwise rotation of the hand wheel. The diameter of the hand wheels or chain wheels shall under no conditions be greater than twice the diameter of the gear sector, and the gears shall be made of bronze or be mounted on bronze bearings. Buried valves shall be supplied with a valve box and stem extensions to grade with a 2 inch operating nut. Each buried operator shall have external valve position indicator. Valve boxes shall be in accordance with Division 2. Operators for non buried valves shall have an integral position indicator.

F. Manual operators shall be designed to produce the required torque with a maximum pull of 80 lb. on the hand wheel or chain wheel, and a maximum input of 150 ft. lb. on operating nuts. Geared valve operators shall be of the worm gear type and shall be enclosed in cast iron housing suitable for running in oil and with sets on all shafts to prevent dirt or water entry. Operator shaft and quadrant shall be supported on permanently lubricated bronze bushings. Operators without bronze bushings are not acceptable. Operators shall clearly

indicate valve position and shall be provided with an adjustable stop to set closing position. Operators for submerged or buried service shall have seals on all shafts and cover gaskets to prevent entry of dirt and water. All exposed bolts, nuts, springs and washers shall be stainless steel.

G. Certain plug valves require powered actuators as identified on the Contract Drawings. Refer to other DIVISION 15 specifications for requirements. These valves shall be provided ready to accept specified powered actuator.

H. Plug valves shall be coated with two-part epoxy, conforming to AWWA C210. Coating shall be self-priming system. Coating shall be 16 mils dry film thickness. Coating shall have a minimum surface preparation to SSPC-SP10 standards. Coating shall be Tnemec Series 46H-413 or equal.

I. Plug valves shall be DeZurik Series PEC, or approved equal.

2.02 SPARE PARTS

Provide the following spare parts for each size valve provided.

A. Plug
B. Bearings
C. V-Type packing
D. Cover Seal
E. Grit guard
F. Thrust Bearings
G. Key

2.03 ELECTRIC MOTOR ACTUATORS

Electric motor actuators shall be as specified in Section 15056.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install the equipment and appurtenances in accordance with the manufacturer's recommendations.

B. Installation of the equipment shall not be attempted until the equipment manufacturer has provided detailed installation manuals to the Contractor and the Contractor and manufacturer have instructed key field personnel in detail regarding installation of the equipment.

3.02 LUBRICATION

A. Lubricate the equipment in accordance with manufacturer’s recommendation prior to startup and refill as necessary until the operation of the equipment is turned over to the Owner.

B. Provide premium lubrication and lubrication schedule in accordance with Division 15.

3.03 PAINTING

A. All exposed metal parts of the equipment shall be cleaned, primed and finished with the manufacturer's paint system that is in accordance with Division 9. All field touch-up painting shall be in accordance with Division 9.

B. All internal steel or cast iron surfaces, except finished or bearing surfaces, shall be shop-painted with two coats of asphalt varnish conforming to Federal Specification TT-C-494C.

3.04 FUNCTIONAL TESTS

A. When the pumps, instrumentation, electrical controls and all related piping have been installed and are in working order, the Contractor shall conduct a field test of the valves in the presence of the Engineer.

B. The functional tests shall demonstrate that the valves are operating properly and in a satisfactory manner in accordance with the Contract Documents in such a manner to make possible the issuance of the "Manufacturer's Certificate" as described above.

3.05 CLEANING

Clean the equipment and work area from all construction debris in accordance with Division 1. The equipment provided shall be free from debris prior to placing into service.

3.06 TOOLS

The Contractor shall provide all special tools and devices necessary for installation, operation, maintenance and removal of the valves in accordance with Section 15000.

END OF SECTION

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SECTION 15410

PLUMBING FIXTURES

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SECTION 15410

PLUMBING FIXTURES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide all labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the plumbing fixtures as specified herein and as shown on the Contract Drawings.

B. The work includes, but is not limited to the following:

1. All domestic hot and cold water piping.

2. All plumbing fixtures and floor drains.

3. Pipes, valves, fittings, insulation and painting shall be as specified in other sections of the specifications.

4. All items of equipment specified herein.

1.02 SUBMITTALS

Shop drawings shall be submitted for all items specified herein as specified **DIVISIONS 0 AND 1**.

1.03 EQUIPMENT DESIGN

Equipment design, workmanship, testing and operation shall be as specified under **SECTION 15000, GENERAL MECHANICAL REQUIREMENTS**.

1.04 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

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

C. Regulatory Requirements: Comply with requirements in Americans with Disabilities Act for plumbing fixtures for people with disabilities.

D. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

PART 2 - PRODUCTS

2.01 SERVICE SINK

A. Service sink shall be designed for heavy duty industrial use and shall be made of enameled cast iron. Service sink shall be wall mounted with coved corners and rolled rim, shall have a 10 inch high backsplash, and shall be equipped with service sink faucet. Basis-of-Design Product: Service sinks shall be Kohler Bannon Series K-6716 or a comparable product of American Standard, Eljer, Crane Plumbing, or equal.

B. Service sink faucet shall have vacuum breakers, threaded spout, pail hook, valve units, and internal thread couplings. Faucet shall be Model K-8905 of Kohler, or equal.

C. Service sink shall be 24 by 20 inch overall with 13 inch deep bowl, cast iron P-trap with floor flange, 3 inch waste outlet, strainer, clean-out plug, and suitable supports.

2.02 CLEAN-OUTS AND DRAINS

A. FD-1, Floor Drain: Drains shall be of the high capacity, bottom outlet type and of the size indicated. Area drains shall be of cast iron with 6" Nikaloy strainer, double drainage flange, adjustable flashing collar, and primer tap. Floor drains shall be the Series 30000A of the Josam Manufacturing Company, Inc., similar of Zurn, Jay R. Smith or equal.

B. FD-2, Floor Drain with Funnel: Drains with funnels shall be of the high capacity, bottom outlet type with sizes as shown on Contract Drawings.

Drains shall be coated cast iron with 7" Nikaloy strainer with 4" funnel, double drainage flange, adjustable flashing collar, and primer tap. Floor drains with funnels shall be Series 30000-E2 of Josam Manufacturing, similar of Zurn, Jay R. Smith or equal.

C. FD-3, Floor Drain:

1. Materials: Cast-iron body and grate.

2. Options: Sediment bucket, Jay R. Smith Mfg. Co.; Model 2696, trap primer connection, vandalproof screws.

3. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 2210T-U, similar of Josam, Zurn or equal.

D. FCO-1, Floor Cleanout: Cleanout plugs and test tees in finished walls and floors shall be provided with polished bronze cover plates securely fastened with countersunk screws. Floor cleanout shall be adjustable type, Series 56000 of the Josam Manufacturing Company, the Model Z1415-3 of Zurn Industries, Inc., similar of Jay R. Smith or equal and all cleanouts shall be properly sized for service intended.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION

A. No plumbing fixture or device shall be installed in such a manner as to make a cross connection between the potable supply and polluted water system or drainage system.

B. All plumbing fixtures or devices requiring water, drainage or electrical connections shall have such connections made, complete in all respects.

C. The work shall be carefully laid out in advance, and any excess cutting of construction will not be permitted. Damage to building, piping, wiring or equipment, as a result of cutting for installation, shall be repaired by mechanics skilled in the trade involved.

D. Fixtures and devices shall be tightly covered and protected against dirt, water and chemical or mechanical injury. Upon completion of the work, fixtures and devices shall be cleaned, adjusted and operated.

E. In the execution of the work, the Contractor shall comply with the State of Delaware Plumbing Code.

F. All plumbing fixtures, equipment or devices with waste discharging to the sanitary drainage system shall be equipped with approved 'P' traps of the appropriate size and vented as shown on the Contract Drawings.

G. The Contractor shall give the required notice relative to the work when inspections are required, shall obtain and pay for all permits, and shall make all deposits necessary for the work to be performed.

H. Plumbing Specialties:

1. Water Hammer Arresters:
   a. Install PDI-certified and rated water hammer arresters, sized and located in accordance with PDI WH-201 and as shown on Drawings.
   b. Install adjacent to equipment wherein quick closing valves are installed.
   c. Install at each emergency safety shower.
   d. Water hammer arresters shall have access panels or shall be otherwise accessible.

2. Drain P-Trap Priming:
   a. Pipe: Type K, soft copper.
   b. Trap and prime floor drains, trench drains and hub drains, unless shown otherwise on the Drawings. No attempt has been made to show trap primer valve locations or trap primer pipe routing.
   c. Field route trap primer piping during installation of floor drains, trench drains and hub drains, and install trap primer valves in mechanical rooms, janitor rooms, or other locations acceptable to Engineer.
   d. Priming System: Complete with connection to serving utility water system.

3. Trap Priming Valves:
   a. Floor drain traps primed with priming valves, 1/2-inch copper to floor drain.
   b. Two traps maximum primed from one priming valve or as recommended by manufacturer. Locate in mechanical spaces or janitor’s rooms and as indicated on Drawings.
   c. Provide shutoff valve ahead of priming valves.

END OF SECTION 15410

SECTION 15440

PLUMBING EQUIPMENT

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SECTION 15440

PLUMBING EQUIPMENT

PART 1 - GENERAL

1.01 SCOPE

Provide all labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the plumbing equipment as specified herein and as shown on the Contract Drawings.

1.02 SUBMITTALS

Shop drawings shall be submitted for all items specified herein as specified **DIVISIONS 0 AND 1**.

1.03 EQUIPMENT DESIGN

Equipment design, workmanship, testing and operation shall be as specified under **SECTION 15000, GENERAL MECHANICAL REQUIREMENTS**.

1.04 QUALITY ASSURANCE

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

B. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

PART 2 - PRODUCTS

2.01 BACKFLOW PREVENTER

A. (3/4” to 2”)

Backflow preventer shall be Watts Series 909, Wilkins (Zurn) Model 375, or equal reduced pressure type. Backflow preventer shall be all bronze construction with stainless steel internal parts. It shall be a complete assembly including tight-closing shut off ball valves before and after the device. The design shall include test cocks, a pressure differential relief valve located between two positive seating check valves. It shall meet the requirements of

ASSE 1013 and AWWA C511. Preventers shall be supplied with a matching air gap.

B. (2 ½" to 10")

Backflow preventer shall be Watts Series 909, Wilkins (Zurn) Model 375A, or equal reduced pressure type. Backflow preventer shall be cast iron or ductile iron construction with stainless steel internal parts. It shall be a complete assembly including tight-closing shut off gate valves before and after the device. The design shall include test cocks, a pressure differential relief valve located between two positive seating check valves. It shall meet the requirements of ASSE 1013 and AWWA C511. Preventers shall be supplied with a matching air gap.

2.02 PIPING ACCESSORIES

A. Water hammer arrestors shall be Josam Manufacturing Company, Series No. 750006, similar of Zurn, Watts or equal, properly sized for service intended.

C. Pipe Traps: Trap material shall match piping. Unless otherwise noted, traps shall be deep seal type as indicated. Traps shall be provided for all fixtures that do not have integral traps.

2.03 HOSES

A. Hose, of the size, type and length specified herein, shall be furnished for use at the various hose bibb, hose valve, and wall hydrant locations shown. Hose shall be furnished in ¾", 1" and 1 ½" diameter. The hose shall be multi-ply synthetic cord reinforced type with rubber tube and cover, and shall be Goodyear Sureline series, or equal. The hose shall be furnished in fifty (50) foot lengths at EACH location shown on the drawings.

B. Couplings shall be furnished for each hose. They shall be of cast brass and shall have American Standard thread for hose diameters specified above.

C. One hose nozzle shall be furnished for each (50) foot length of hose. The nozzles shall be of cast brass with adjustable spray pattern.

D. Hose racks shall be wall-mounted type, designed to hold a minimum of 50 feet of hose and shall be installed where indicated on the Contract Drawings.

The rack shall be made of polished stainless steel rod as manufactured by Strahman Valves, Inc., Model HR-100 or HR-100L, or equal.

2.04 HOSE BIBBS

A. Interior hose bibbs shall be cast bronze ASTM B584 with neoprene elastomers and stainless steel fasteners. Interior hose bibbs shall be Wilkins (Zurn) Model 195, similar of Watts, Woodford, or equal, size as indicated on Contract Drawings.

B. A vacuum breaker shall be installed on each interior hose bib. Vacuum breakers for ¾" bibbs shall be Woodford Model 34H, similar of Zurn, Watts or equal.

2.05 HOSE VALVES

Hose valves shall be cast brass, angle body globe valves. Valves shall have replaceable seats and discs. Connections shall be female by male NPT. Valves shall be actuated by a minimum 3.5 inch hand wheel. Hose valves shall be Croker 5000 Series, similar model of Dixon Powhatan, or equal.

2.06 WALL HYDRANTS

Wall hydrants shall be non-freeze design, sized as shown on the drawings. Wall hydrant shall be of cast bronze construction with backflow preventer, pressure relief valve and integral vacuum breaker, Josam Series 71050, similar of Zurn, or equal.

2.07 YARD HYDRANTS

A. Yard hydrants shall be of non-freeze, heavy duty design. Hydrants shall have a ¾" NPT inlet and a 1" NPT outlet hose connection. Hydrant head shall be cast iron construction with brass hose outlet and cam type operating handle. Yard hydrants shall be Josam series 71450, similar of Zurn, or equal.

B. A vacuum breaker shall be installed in accordance with manufacturer's recommendations for the exterior yard hydrants. Vacuum breakers shall be the Anti-Siphon Vacuum Breaker as manufactured by Watts Regulator Company, similar of Zurn, Woodford or equal.

2.08 AIR ADMITTANCE VALVES

A. Stack Admittance Valve

Stack admittance valves shall conform to ASSE 1050 and shall be sized to suit piping indicated on Contract Drawings. Valves shall be manufactured by Durgo, Studor, or equal.

B. Fixture Admittance Valve

Fixture admittance valves shall conform to ASSE 1051, Type A for single fixture or Type B for branch piping. Valve shall be sized to suit connected fixture or branch vent piping. Valves shall be manufactured by Durgo, Studor, or equal.

2.08 INSTANTANEOUS WATER HEATERS

Instantaneous water heaters shall be UL listed, thermostatically controlled systems. The heater shall be suitable for the electrical service and provide the temperature rise as shown on the Contract Drawings. Heaters shall have replaceable, cartridge Ni-Chrome heating elements and shall have a high temperature limit switch. Unit inlet connection shall have a replaceable filter. The instantaneous water heaters shall be manufactured by Eemax Inc., Keltech Inc., or equal.

2.10 EMERGENCY SHOWER AND EYEWASH

The shower shall be free-standing with epoxy-coated brass 1-1/4" stay open shower ball valve operated by a stainless steel pull rod with triangle handle. The Eye/Face wash unit shall be an epoxy-coated brass 1/2" ball valve, operated by foot-treadle or push-flag handle. The shower head and eye wash bowl shall be ABS plastic. The entire assembly shall be bright yellow. Unit connections shall be 1-1/2" supply, and floor support flange. The emergency shower and eyewash unit shall be Sch. 80 hot-dipped galvanized inside and out with an exterior corrosion-resistant epoxy coating. Emergency showers and eyewash shall be connected to a tempering valve in order to comply with ANSI standard Z358.1-2004. Emergency Shower and Eyewash shall be Encon Safety Products Model 01-0502-10, similar model of Speakman Company, or equal.

2.11 TEMPERING VALVES

A. Tempering valves shall employ two fully independent control mechanisms which split the flow in half, blend each half to the design temperature and then integrate each stream at the outlet. The valve shall control outlet temperature over a wide range of flow and shall be suitable for deluge shower or eyewash applications in order to comply with ANSI standard Z358.1-2004. The valve shall include three thermometers to measure the temperature of each stream and the merged flow. Temperature adjustment shall be vandal-resistant.

B. Each independent control mechanism shall employ a liquid-filled thermostatic motor to drive the valve without additional power requirements. Each control mechanism shall employ a stainless steel sliding piston control device with reverse seat closure and both fixed and variable cold water bypass.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION

A. No plumbing equipment shall be installed in such a manner as to make a cross connection between the potable supply and polluted water system or drainage system.

B. All plumbing equipment requiring water, drainage or electrical connections shall have such connections made, complete in all respects.

C. The work shall be carefully laid out in advance, and any excess cutting of construction will not be permitted. Damage to building, piping, wiring or equipment, as a result of cutting for installation, shall be repaired by mechanics skilled in the trade involved.

D. Equipment shall be tightly covered and protected against dirt, water and chemical or mechanical injury. Upon completion of the work, equipment shall be cleaned, adjusted and operated.

E. In the execution of the work, the Contractor shall comply with State and Local Plumbing Codes.

F. All plumbing equipment with waste discharging to the sanitary drainage system shall be equipped with approved 'P' traps of the appropriate size and vented as shown on the Contract Drawings.

G. The Contractor shall give the required notice relative to the work when inspections are required, shall obtain and pay for all permits, and shall make all deposits necessary for the work to be performed.

3.02 WATER HAMMER ARRESTOR INSTALLATION

A. Install PDI certified and rated water hammer arresters, sized and located in accordance with PDI WH-201 and as shown on Drawings.

B. Install adjacent to equipment wherein quick closing valves are installed.

C. Install at each emergency safety shower.

D. Water hammer arresters shall have access panels or shall be otherwise accessible.

END OF SECTION 15440

SECTION 15442

SUMP PUMPS

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SECTION 15442

SUMP PUMPS

PART 1 - GENERAL

1.01 SCOPE

Provide all labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the sump pumps as specified herein and as shown on the Contract Drawings.

1.02 SUBMITTALS

A. Shop drawings shall be submitted for all items specified herein as specified under **DIVISIONS 0 AND 1**.

B. Complete Operation and Maintenance Manuals shall be submitted for all items specified herein as specified under **DIVISIONS 0 AND 1**.

1.03 EQUIPMENT DESIGN

Equipment design, workmanship, testing and operation shall be as specified under **SECTION 15000, GENERAL MECHANICAL REQUIREMENTS**.

1.04 MANUFACTURER'S INSPECTION AND START-UP

The Contractor shall furnish the services of the equipment manufacturer's qualified field representative to inspect the equipment after installation, instruct plant personnel in its operation and maintenance, and supervise its initial operation as specified under **SECTION 01300, SUBMITTALS**.

1.05 MANUFACTURER'S CERTIFICATE

The Contractor shall furnish the Engineer with a Manufacturer's Certificate, as specified under **SECTION 01300; SUBMITTALS** certifying the miscellaneous equipment has been installed in a complete and satisfactory manner ready for operation.

1.06 WARRANTY

The respective manufacturers shall warrantee the equipment, both in material and workmanship for a period of one year from the day of final acceptance.

PART 2 - PRODUCTS

2.01 SIMPLEX SUMP PUMP

A. Type 1 sump pumps shall be of the heavy duty, non-clog, submersible type with an approximate capacity as scheduled on the Contract Drawings. Pump shall be constructed of cast iron with the Manufacturer's standard finish. The pump shall be equipped standard with dual shaft seals. Each pump shall have not less than a 1½-inch NPT discharge and shall be capable of passing a 1/2 inch solid.

B. Sump pump motors shall be sized as shown on the Contract Drawings. Motors shall be oil-filled with permanently lubricated ball bearings and thermal overload protection. Each motor shall be supplied with immersible power cord to suit.

C. Encapsulated vertical mechanical float type switches shall be suspended from a pump mounted bracket as required for pump control levels. Switches shall be suitable for a temperature range of 32 deg F to 120 deg F with a rating of 13 AMPS at 115 volts, AC. Switch shall be sealed in a solid polypropylene float that is leakproof, shockproof and corrosion resistant. Switch shall be weighted to give floatation stability, repeatable, and accurate operation. Switch shall be supplied with a piggy back switch/plug arrangement to allow automatic operation of pump.

D. Sump pumps shall be Model V-A1 as manufactured by Hydromatic, similar of Zoeller, Goulds, Aurora, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

Install the sump pumps and appurtenances in accordance with the manufacturer's recommendations.

3.02 FIELD TESTING

When the pumps and electrical controls and all related piping have been installed, the Contractor shall conduct a field test of the pumping units in the presence of the Engineer. The tests shall demonstrate that the pump units are operating in a satisfactory manner, in accordance with the requirements of these specifications and in such a manner to make possible the issuance of the "Manufacturer's Certificate" described in **DIVISIONS 0 AND 1**.

END OF SECTION 15442

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SECTION 15741

UNITARY AIR SOURCE UNITS

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SECTION 15741

UNITARY AIR-SOURCE UNITS

PART 1 - GENERAL

1.01 DESCRIPTION

Provide all labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the ductless split air conditioner and heat pump equipment as specified herein and as shown on the drawings.

1.02 QUALITY ASSURANCE

A. Codes and Standards: Provide units conforming to the following:

1. Air Movement and Control Association, Inc. (AMCA): Comply with applicable AMCA standards including AMCA 210, “Laboratory Methods of Testing Fans for Rating Purposes.”

2. American National Standards Institute (ANSI): Comply with applicable ANSI standards including S1.23, “Method for Designation of Sound Power Emitted by Machinery and Equipment”.

3. National Electrical Manufacturers Association (NEMA): Comply with applicable NEMA standards including MG1, “Motors and Generators”.

4. National Fire Protection Association (NFPA): Construct terminals using acoustical and thermal insulations complying with NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems”.

1.03 SUBMITTALS

A. Shop Drawings shall be submitted for items specified herein as specified under Section 01300 SUBMITTALS.

B. Complete Operation and Maintenance Manuals shall be submitted as specified under Section 01300 SUBMITTALS.

PART 2 - PRODUCTS

2.01 DUCTLESS SPLIT AIR CONDITIONER

A. General:
1. Ductless split system with , wall mounted, low profile, cassette style, indoor units, complete with DX coil, fan, louvers, expansion valve, fan motor, piping connectors, electrical controls, condensate pump, washable filter, and hanging brackets.
2. Outdoor unit shall be capable of serving more than one indoor unit when indicated.
3. Indoor units shall be of the same manufacturer as the associated outdoor unit.
4. See schedules on the Contract Drawings for system requirements.
5. Indoor unit shall include a fresh air inlet when indicated in the schedule.

B. Indoor Unit Cabinet:
1. Fully insulated.
2. Discharge and inlet grilles.

C. Evaporator Fan:
1. Direct-drive blower type with air intake and discharge.
2. Adjustable air louvers.
3. Motors: Totally enclosed and permanently lubricated with inherent protection.

D. DX Evaporator Coil:
1. Copper tube with aluminum fins and galvanized steel tube sheets.
2. Fins bonded to tubes by mechanical expansion.
3. Condensate Drip Pan: Locate under coil with drain connection to remove condensate.

E. Internal Condensate Pump:
1. To remove condensate from drain pan when gravity drainage cannot be used.
2. Lift capability of condensate pump shall be 18 inches.

F. Controls:
1. Factory installed refrigerant metering device.
2. Electronic expansion valve.
3. Heat Pump Applications: Reverse flow bypass refrigerant metering device with internal check valves.
4. Wired wall-mounted thermostat with setpoint adjustment only, with lockable cover.
5. Thermostat shall be wired and shall not require batteries.

6. Automatic restart after power failure at same operating conditions as at failure.
7. Float control in condensate sump to shut unit down in case of pump malfunction.
8. Evaporator coil freeze protection.

G. Air Filters: Filter tracks and cleanable filters, accessible from below

H. Outdoor Unit:
1. Space saving, slim, unit meeting the dimensional requirements indicated in the schedule.
2. Refrigerant: R410A.

I. See schedule on drawings for additional specifications

J. Manufacturers: The following manufacturers are allowed if the units meet all specifications:
1. Sanyo, Samsung, Mitsubishi, Carrier or equal.

PART 3 - EXECUTION

3.01 INSPECTION AND ACCESS

General: Inspect and verify the following items:

1. Verify access before equipment delivery

2. Verify structural supports and bases

3. Confirm clearance, head room and arrangement before installation

3.02 INSTALLATION OF EQUIPMENT

A. General: Install equipment in accordance with the manufacturer's installation instructions and where indicated on the Contract Drawings.

B. Support Bases: Provide concrete pad and concrete bases as indicated.

C. Start-Up: Verify rotation, adjust belts, lubricate and start-up in presence of manufacturer's representative.

D. For Ductwork, Air Devices, and all appurtenances, see SECTION 15810, DUCTWORK.

3.03 TESTS

A. Preparation for Tests: Before the scheduled tests, the Contractor shall have prepared the fans and the associated air handling systems (supply, return, and/or exhaust) in accordance with the contract requirements and ready for operation. All architectural openings and mechanical systems shall be in their normal operation positions during the tests.

B. Capacity Test: The fan system must be tested to deliver the specified capacity under the specified conditions as listed in the equipment schedule, on the Contract Drawings, or in the specifications. Requirements for air system test are specified in SECTION 15950, TESTING, ADJUSTING, AND BALANCING

END OF SECTION

SECTION 15775

ELECTRIC HEAT TRACE EQUIPMENT

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SECTION 15775

ELECTRIC HEAT TRACE EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

Provide all coordination, labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the equipment as shown or specified and in accordance with the requirements of the Contract Documents.

1.02 SUBMITTALS

A. Furnish detailed shop drawings for all items specified herein in accordance with Division 1.

B. Furnish detailed Operation and Maintenance manual for all items specified herein in accordance with Division 1.

1.03 EQUIPMENT DESIGN

A. Mechanical equipment design, workmanship, testing and operation shall be as specified herein and in accordance with Section 15000, General Mechanical Requirements.

B. Electrical and Instrumentation equipment design, workmanship, testing and operation shall be as specified herein and in accordance with Division 16 and 17.

1.04 QUALITY CONTROL

A. The equipment manufacturer shall have a minimum of 10 years experience in manufacturing equipment similar, equal or larger size, to that specified.

B. The equipment provided shall conform to all applicable requirements of the governing bodies listed in Section 15000 General Mechanical Requirements.

1.05 DELIVERY, STORAGE AND HANDLING

A. The equipment shall be packaged to minimize possible damage from moisture, temperature variations and impact due to shipping conditions. Exposed threads shall be protected with tape or caps, openings shall be

closed by caps or plugs. Detailed installation instructions shall accompany the equipment.

B. The Contractor shall inspect the equipment when it is delivered to ensure that it is not damaged. Store the equipment in a dry location and maintain the equipment per Manufacturer's recommendations.

C. Dispose of packing materials in accordance with state and federal regulations.

D. Delivery, storage and handling shall be in accordance with Division 1.

1.06 MANUFACTURER'S INSPECTION AND START-UP

A. The Contractor shall furnish the services of the equipment manufacturer's qualified field representative to inspect the equipment after installation, provide startup services, and supervise all initial start-up operations and functional testing as specified herein. Services shall be provided as required to ensure complete and operational equipment.

B. In the event that the equipment does not perform as specified, the Contractor, at no additional expense to the Contract, Owner or the Owner's representative, shall make provisions for the field representative to stay on site until all problems are resolved to the Owners satisfaction.

1.07 MANUFACTURER'S CERTIFICATE

The Contractor shall furnish the Engineer with a Manufacturer's Certificate, signed by an authorized representative of the Manufacturer, certifying that the equipment is installed in a complete and satisfactory manner and has been functionally tested such that it is ready for operation.

1.08 TRAINING

Provide the service of a qualified manufacturer's representative to thoroughly train Owners personnel in the operation and maintenance of the equipment installed. Training shall be provided by as required to ensure Owner's personnel understanding of equipment for a minimum of two (2) hours.

1.09 WARRANTY AND GUARANTEE

Contractor shall warrant and guarantee to the Owner that all work will be in accordance with the Contract Documents and that the equipment, material, workmanship, performance and installation will not be defective.

PART 2 - PRODUCTS

2.01 ELECTRIC HEAT TRACE

A. Provide electric heat tape where shown on the Contract Drawings and/or as specified herein. Each system shall be complete with the thermostats, contactors as required and all necessary components, attachments and controls necessary for a complete and satisfactory operation. The adjustable temperature controller with appropriate contactor shall be installed in a NEMA 4X enclosure with closed cell neoprene gasket and fastening method to provide weather tight and dust tight seal. Temperature controller shall be ambient sensing type suitable for either hazardous or non-hazardous environments as shown of the Contract Drawings.

B. Heating tape shall be provided on all free standing piping lines located outside subject to freezing or as shown on the Contract Drawings. All tape shall be UL approved. Electric heating tape and controls shall be suitable for operation on 120 volts, single phase service. Heat tape shall be insulated as recommended by the manufacturer and as specified in Division 15.

C. Electric materials and wiring methods shall conform to standards established in Division 16. Application and installation of the systems shall be in accordance with the recommendation and instructions of the manufacturer of the respective system and/or component parts. Heat tape, thermostats and all associated controls used on the various systems shall be suitable for the service voltage as hereinbefore specified. Thermostats shall have ratings of not less than 125 percent of the full load current of the circuit that is controlled, at the operating voltage. Thermostats shall be rigidly mounted as indicated or required. Heat tape shall be a minimum of 8 watts per foot and be of the self-limiting heating type immune to burnouts with copper conductors, conductive/resistive core of graphite and polymers and insulated jacket. Heating tape shall be spiral mounted or straight-run mounted in accordance with manufacturers' recommendations. Heating tape shall have power indication light at the end of the pipe as well as on the control box.

D. Heating tape shall be as manufactured by Raychem, Chemelex Auto trace type BTV with AMC-1A series controller, similar model of Chromolox, or approved equal.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The electric heat trace systems shall be installed in accordance with manufacturer's recommendations.

B. Installation of the equipment shall not be attempted until the equipment manufacturer has provided detailed installation manuals to the Contractor and the Contractor and manufacturer have instructed key field personnel in detail regarding installation of the equipment.

3.02 CLEANING

Clean the equipment and work area from all construction debris in accordance with Division 1. The equipment provided shall be free from debris prior to placing into service.

END OF SECTION 15775

SECTION 15810

DUCTWORK

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SECTION 15810

DUCTWORK

PART 1 - GENERAL

1.01 SCOPE

A. Types of low pressure ductwork required for this project include the following:

1. Exhaust ductwork.
2. Supply air ductwork.
3. Attenuation Silencer Packs

B. Types of ductwork accessories required for project include the following:

1. Dampers.
   a. Back-draft dampers
   b. Motor-operated dampers.
2. Turning vanes.
3. Duct hardware.
4. Duct access doors.
5. Flexible connections.
6. Penetration seals.

C. Related Sections:
1. 15850 Air Inlets and Outlets
2. 15950 Testing, Adjusting, and Balancing

1.02 QUALITY ASSURANCE

A. Installer: A firm with a minimum of five (5) years of successful installation experience on projects with low pressure ductwork systems similar to that required for project.

B. SMACNA Standards: Comply with SMACNA "HVAC Duct Construction Standards - Metal and Flexible" for fabrication and installation of ductwork.

C. ASHRAE Standards: Comply with ASHRAE Standards for fabrication and installation of low pressure ductwork.

D. ASTM/ANSI Standards: Comply with applicable ASTM and ANSI standards for material, fabrication, and installation of ductwork.

E. NFPA Compliance: Comply with ANSI/NFPA 90A "Standard for the Installation of Air-Conditioning and Ventilating Systems" and ANSI/NFPA 90B "Standard for the Installation of Warm Air Heating and Air-Conditioning Systems."

F. Field Reference Manual: Have available at project field office, copy of SMACNA "HVAC Duct Construction Standards-Metal and Flexible."

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's specifications on manufactured products and factory-fabricated ductwork used for work of this section in accordance with **DIVISIONS 0 AND 1**.

B. Ductwork Shop Drawings: Submit dimensioned layouts of ductwork showing both the accurately scaled ductwork and its relation to space enclosure. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced.

C. Accessories Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components.

D. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual.

E. Record Drawings: At project closeout, submit record drawings of installed ductwork, duct accessories, and outlets and inlets.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.

B. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.01 ALUMINUM DUCT

A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains and discolorations, and other imperfections, including those which would impair painting.

B. Where indicated on drawings, fabricate ductwork from sheet aluminum complying with ANSI/ASTM B209, Alloy 3003, Temper H14.

C. Shop fabricate ductwork in 4, 8, 10 or 12-foot lengths, unless otherwise indicated or required to complete runs. Preassemble work in shop to greatest extent possible, so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Matchmark sections for reassembly and coordinated installation.

D. Shop fabricate ductwork of gauges and reinforcement complying with SMACNA "HVAC Duct Construction Standards."

E. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with centerline radius equal to one and one-half times the associated duct width; and fabricate to include turning vanes in elbows.

F. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible.

G. Low pressure rectangular ductwork, fittings, etc., shall be constructed, installed and supported in accordance with current SMACNA Standards

H. Miscellaneous Ductwork Materials

1. General: Provide miscellaneous materials and products of types and sizes indicated. Provide type and size required to comply with ductwork system requirements, including proper connection of ductwork and equipment.

2. Duct Insulation: As specified in **SECTION 15080, MECHANICAL INSULATION**.

3. Duct Sealant: Nonhardening, non-migrating mastic or liquid elastic sealant (type applicable for fabrication/installation detail) as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork.

4. Duct Cement: Nonhardening migrating mastic or liquid neoprene based cement (type applicable for fabrication/installation detail) as compounded and recommended by manufacturer specifically for cementing fitting components, or longitudinal seams in ductwork.

5. Ductwork Support Materials: Except as otherwise indicated, provide aluminum fasteners, anchors, rods, straps, trim and angles for support of ductwork.

2.02 FIBERGLASS REINFORCED PLASTIC (FRP) DUCT

A. General

1. FRP Duct and all accessories shall be designed and constructed to meet the following requirements:

Description	Quantity
Hydrogen Sulfide Exposure	25-50 ppm
Duct Pressure	2" W.C. Positive & Negative
Air Temperature	40 to 110F
pH Range	3 to 10.5
Operation	Continuous

2. All FRP Ductwork shall be shop fabricated to the largest extent possible to minimize field joints. Flanged connections shall be provided at each damper, expansion joint, and equipment connection, except where otherwise noted, to facilitate disassembly.

B. Materials of Construction

1. Resin: Resin used shall be premium, corrosion resistant, vinyl ester type such as Hetron FR 922, similar type of Derakane, or equal.

2. Reinforcement:

   a. Surface veiling shall be Type C chemical grade, Nexus 1012, or equal.

   b. Chopped strand mat shall be Type E electrical grade 1-1/2 ounces per square foot with silane finish and styrene soluble binder.

c. Continuous glass roving for chopper gun spray-up applications shall be Type E electrical grade with silane coupling agent.

d. Woven roving shall be Type E electrical grade with 24 ounces per square yard.

3. Visual defects shall be better than Level II on the inside of the duct and better than Level III on the outside in accordance with ASTM D 2563.

4. Components shall be preassembled at the point of fabrication. Preassembly shall not require all joints to be factory assembled, but all joints shall be prepared for field fabrication.

C. Construction

1. FRP Ductwork and Fittings shall be contact molded in accordance with ASTM D 3982. The duct shall be designed for a 10:1 safety factor for internal pressure loadings, and shall be designed for a 5:1 safety factor for external and vacuum loadings. Contact molded components and accessories, including turning vanes, shall be fabricated in accordance with ASTM D 3982 and (BNS) PS 15-69. The ductwork and fittings will be exposed continuously to hydrogen sulfide gas.

2. Layers

a. Interior Layer: shall consist of an interior surface and an internal corrosion barrier.

i. Interior surface shall be resin rich (90% content) and reinforced with surface veiling of nominal 10 mils thickness.

ii. Internal corrosion barrier shall be resin rich (80% content) and reinforced with either 2 layers of chopped strand mat or continuous glass roving using chopper gun spray-up with ½ to 2 inch length glass fiber. Interior corrosion layer shall have nominal 90 mils thickness.

b. Structural Layer: Shall consist of alternating layers of chopped strand mat and woven roving. Structural layer shall have sufficient thickness to conform with minimum physical property and dimensional requirements as delineated by

ASTM and SMACNA.

c. Exterior Layer: shall consist of a single ply of surface veiling with exterior surface coat of white gel coat containing resin, pigment, and ultraviolet light inhibitor such as UV-9. Exterior surface shall contain sufficient resin to ensure relatively smooth surface free from exposed glass fibers or glass projections.

D. The minimum properties of contact molded laminate shall comply with ASTM and SMACNA standards.

E. Nominal thickness of ductwork shall be in accordance with ASTM and SMACNA standards and as follows:

FRP Duct I.D. (in.)	Minimum Wall Thickness(in.)
2-16	0.125
18-30	0.187
32-60	0.250

F. All FRP ductwork and fittings shall have Class 1 rating with a minimum flame speed rating of 25 or less and a smoke developed rating of 50 or less based on ASTM E 84 unless otherwise indicated on the Contract Drawings.

G. FRP ductwork supports shall be as shown on the Contract drawings. FRP and metal surfaces shall be separated by a ¼" neoprene pad to prevent damage to duct.

H. FRP duct shall be as manufactured by Augusta Fiberglass, Composites USA, Belco, or equal.

2.03 BACKDRAFT DAMPERS

Backdraft dampers shall be of the weatherproof balanced type and shall be installed as shown on Contract Drawings. Damper shall be constructed of not less than 0.09-inch 6063-T6 extruded aluminum alloy frames. Blades shall have a maximum width of 8 inches and shall be fabricated of 0.025-inch aluminum. Axles shall be full-length 3/16 inch diameter galvanized steel, with self-lubricating heavy duty nylon bearings. Damper blades shall be equipped with vinyl seals. Backdraft damper shall be Model BD2/A1 of Ruskin, similar of Greenheck, American Warming, PennBarry, or equal.

2.04 MOTOR OPERATED DAMPERS

Motor operated dampers shall be of parallel blade type construction and shall be furnished with motor and all appurtenances necessary for successful operation, such as jack-shafting, etc.

A. Frames shall be not less than 0.125-inch 6063T5 aluminum hat channel type suitable for interior duct or wall mounting. Mounting baffles shall be provided where it is necessary to increase damper dimensions for tight fit in wall opening. Damper blades shall be of parallel design, not less than 0.125-inch 6063T5 aluminum.

B. Blades shall be edged with extruded vinyl for minimum leakage and quiet operation. Damper blades shall not exceed 6 inches in width. Blades shall turn on zinc-plated steel shafts, not less than 1/2 inch in diameter, in synthetic bearings. Blade linkage hardware shall be corrosion-resistant and readily accessible after installation. Dampers shall have side seals of flexible metal, spring loaded. Leakage and flow characteristic data shall be supplied by the damper manufacturer for all dampers. Dampers, seals, motors and hardware shall be suitable for operation at ambient temperatures from -20°F to 200°F at specified leakage.

C. Dampers shall be Ruskin Model CD51, similar of Greenheck, Honeywell, American Warming or equal.

D. Damper motors shall be electric, NEMA 3 rated, powered as shown on the Contract Drawings for proper operating sequence. Damper motor shall be of the two-position (fixed 90 deg stroke), spring return, normally closed, type, Honeywell MS4110 or equal. Dampers for generator systems shall be spring open, normally open type. Damper motors shall be suitable for operation at 120 volts, 60 Hertz power and shall be capable of generating 88 lb-in of torque. Damper motors shall be furnished with auxiliary position contacts to suit controls as shown on Contract Drawings.

2.05 VOLUME CONTROL DAMPERS

A. Volume control dampers in the FRP ductwork shall be the size shown on the drawings, having same construction as duct with stainless steel locking quadrant and neoprene blade seals. Flanges shall be suitable for field drilling. Dampers shall have same class/flame rating as duct. Dampers shall be the style #300 FF of Composites USA, similar models of Augusta Fiberglass, or equal.

B. Volume dampers in aluminum ductwork shall be factory fabricated, with required hardware and accessories. Dampers shall comply with SMACNA “HVAC Duct construction Standards.”

2.06 TURNING VANES (SHEET METAL DUCTWORK)

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch wide, single vane, curved blades of sheet aluminum set 2-inch on centers (O.C.); support with bars perpendicular to blades set 2 inches O.C.; and set into vane runners suitable for duct mounting.

2.07 DUCT HARDWARE

Test Holes: Provide duct test holes in ductwork at fan inlet and outlet, and elsewhere as indicated, consisting of slot and cover, for instrument tests.

2.08 DUCT ACCESS DOORS

A. General: Provide duct access doors where required for access and as shown on Contract Drawings. Doors shall be manufactured by Nailor Industries, Kees Inc., or equal.

B. Construction: Construct of same or greater wall thickness as ductwork served and provide insulated doors for insulated ductwork. Provide flush frames for un-insulated ductwork and extended frames for externally insulated duct. Provide one side hinged and other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.

2.09 FLEXIBLE CONNECTIONS

A. General: Provide flanged flexible duct connections wherever ductwork connects to vibration isolated equipment and as shown on Contract Drawings. Flexible connections shall have adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment.

B. Materials and Construction

1. Flexible connections shall be manufactured in W-design configuration with a minimum two piles of asbestos-free reinforcement of neoprene-coated flameproof fabric vulcanized into a homogeneous product ¼" nominal thickness. The flanges shall be an integral part of the flexible connections. Flexible connections shall be manufactured by Mercer Rubber Company, or equal.

2. Flexible connections shall be constructed with compound curve molded corners with the arch premolded. The arch shall continue

throughout the corner and shall be fully developed when in the neutral installed position. Pre-compression or tucking of the corner to form the arch shall not be permitted.

3. The corners on rectangular expansion joints shall be completely molded and free of splices.

4. Flexible connections shall be designed to accept the system movements without imposing any significant forces on the ductwork.

5. Flexible connections shall utilize a set-back configuration.

6. Dimensions of flexible connections will be 12-inch flange to flange unless shown otherwise.

7. Materials shall be suitable for the temperature and environment where it will be in service.

2.10 GENERATOR PLENUMS

A. Generator plenums shall be constructed of ***[select one: aluminum duct, stainless steel duct]*** and shall conform to SMACNA 4 inch pressure class construction and reinforcement.

B. Provide air tight, hinged access doors for the generator exhaust plenum. Doors shall have viewports and locking latches and shall be nominal 36 inch wide by 72 inch high. Access doors shall be manufactured by Nailor Industries, Kees Inc., or equal.

PART 3 - EXECUTION

3.01 INSTALLATION OF DUCTWORK

A. Low Pressure: Assemble, install and support ductwork in accordance with recognized industry practices which will achieve air tight (2% leakage) and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling.

B. Seal all ductwork, after installation, to seal class recommended, and method described in SMACNA "HVAC Duct Construction Standards."

C. Install concrete inserts as required, for support of ductwork in coordination with formwork, as required to avoid delays in work.

D. Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

E. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of building. Limit clearance to 2" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1” clearance outside of insulation. Coordinate layout with lighting layouts and similar finished work.

F. Electrical Equipment Spaces: Do not run ductwork through transformer vaults or electrical equipment spaces and enclosures unless otherwise specifically indicated.

G. Where ducts pass through interior partitions and exterior walls, conceal space between construction opening and duct or duct-plus-insulation with sheet metal flanges of same gauge as duct. Overlap opening on 4 sides by at least 1-1/2".

H. Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

I. Support ductwork in manner complying with SMACNA "HVAC Duct Construction Standards" hangers and supports section.

3.02 INSPECTION

Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.03 INSTALLATION OF DUCTWORK ACCESSORIES

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Install balancing (volume) dampers where indicated.

C. Install turning vanes in square or rectangular 90º elbows in supply, return and exhaust air systems, and elsewhere as indicated.

D. Install airtight access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.

E. Install silencers in accordance with manufacturer's recommendations. Provide crimped or button punched continuous metallic nosings between adjacent modules. Provide galvanized steel support rack and flanged and gasketed duct connections.

3.04 FIELD QUALITY CONTROL

Operate installed duct and accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty duct and accessories, as required to obtain proper operation and leakproof performance.

3.05 CLEANING, PROTECTION AND ADJUSTING

A. Clean ductwork internally, unit-by-unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or where ductwork is to be painted, might interfere with painting or cause paint deterioration.

B. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

C. Adjusting: Adjust ductwork accessories for proper settings. Final positioning of manual dampers is specified in **SECTION 15950, TESTING, ADJUSTING, AND BALANCING**.

3.06 BALANCING

Refer to **SECTION 15950, TESTING, ADJUSTING, AND BALANCING** for air distribution balancing of low pressure ductwork. Seal any leaks in ductwork that became apparent in balancing process.

3.07 PAINTING

Painting shall be in accordance with **DIVISION 9, FINISHES**.

END OF SECTION 15810

SECTION 15830

FANS

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SECTION 15830

FANS

PART 1 – GENERAL

1.01 DESCRIPTION

Provide all labor, materials, equipment and services necessary for and incidental to, the complete and satisfactory installation of the Fans as specified herein and as shown on the Contract Drawings.

1.02 SUBMITTALS

A. Shop Drawings including dimensioned drawings, descriptive literature capacity performance data, electrical characteristics and materials of construction shall be submitted for all items specified herein as specified in **DIVISIONS 0 AND 1**.

B. Provide operation and maintenance manuals in accordance with **DIVISIONS 0 AND 1**.

1.03 EQUIPMENT DESIGN

Equipment design, workmanship, testing and operation shall be as specified under **SECTION 15000, GENERAL MECHANICAL EQUIPMENT**.

1.04 QUALITY ASSURANCE

Codes and Standards. Provide units conforming to the following:

1. Air Movement and Control Association, Inc. (AMCA): Comply with applicable AMCA standards including AMCA 210, Laboratory Methods of Testing Fans for Rating Purposes."

2. American National Standards Institute (ANSI): Comply with applicable ANSI standards including S1.23, "Method for Designation of Sound Power Emitted by Machinery and Equipment".

3. National Electrical Manufacturers Association (NEMA): Comply with applicable NEMA standards including MG1, "Motors and Generators".

4. National Fire Protection Association (NFPA): Construct terminals using acoustical and thermal insulations complying with NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.05 MANUFACTURER'S INSPECTION AND START-UP

The Contractor shall furnish the services of the equipment manufacturer's qualified field representative to inspect the equipment after installation, instruct Owner personnel in its operation and maintenance, and supervise its initial operation as specified in **DIVISIONS 0 AND 1**.

1.06 MANUFACTURER'S CERTIFICATE

The Contractor shall furnish the Engineer with a Manufacturer's Certificate, as specified in **DIVISIONS 0 AND 1**. certifying the equipment has been installed in a complete and satisfactory manner ready for operation.

PART 2 - PRODUCTS

2.01 FANS GENERAL

A. Fans shall be guaranteed to deliver the specified quantity of air and pressure when tested in accordance with the applicable AMCA Test Code. Fans shall bear the AMCA Certified Rating Seal. Fans shall be quiet operating and vibration free. Each fan shall be suitable for the space available. Each unit shall have moving parts statically and dynamically balanced. Capacities shall be as shown on the Contract Drawings.

B. Substitution of fans other than those specified shall require the Contractor to correlate the fan with proper installation and ductwork connections. See **SECTION 15810, DUCTWORK**.

C. Fan wheels and impellers shall be accurately formed and assembled to operate at all speeds up to 1.5 the maximum cataloged speed without static or dynamic unbalance, eccentricity, or wobble. Wheels shall be rigidly braced to resist stresses due to air pressure, motion and rapid acceleration.

D. Each centrifugal fan shall be provided with a motor having a nameplate rating not less than the actual fan horsepower. Motors shall meet the other requirements of **SECTION 15000, GENERAL MECHANICAL REQUIREMENTS** and shall be copper wound construction suitable for operation on service as indicated on the Contract Drawings. All motors will be 1750 rpm maximum. Where noted on motor control diagrams, thermal switches (thermistors) shall be furnished in motor windings.

E. Motor sheaves shall be the adjustable pitch type, selected so the specified capacities will be delivered with the sheaves at the approximate mid-position. All drives shall be protected by suitable OSHA guards.

2.02 PROPELLER FANS

A. Electric motor driven propeller fans shall be provided where shown on the Contract Drawings. Fans shall be direct driven or belt driven and shall have capacities and electrical characteristics as indicated in the equipment schedules shown on the Contract Drawings.

B. General Service Fans

Fans shall have a heavy gauge motor mounting platform supported by formed integral stiffening flanges and welded onto a coated steel fan panel with welded corners, pre-punched mounting holes, and a deeply spun venture. Statically and dynamically balanced propellers shall be heavy gauge steel. Shafts shall be turned, ground, polished and rust protected. Pulleys shall be adjustable, cast iron, machined, keyed, securely attached and sized for 150% of the horsepower at its rated maximum speed.

C. Heavy Duty Fans

Fans shall have a heavy gauge motor mounting platform supported by heavy gauge structural channel framework laterally supported and fastened onto a galvanized steel fan panel featuring toggle lock corners, pre-punched mounting holes, and a deeply spun venture. Statically and dynamically balanced propellers shall be coated heavy gauge steel utilizing a fully welded coated heavy gauge steel spider. Shafts shall be turned, ground, polished and rust protected. Pulleys shall be adjustable, cast iron, machined, keyed, securely attached and sized for 150% of the horsepower at its rated maximum speed.

D. Motors shall be permanently lubricated and shall be resiliently mounted. Bearings shall be heavy duty rated for minimum L50 life of 200,000 hours. Motors shall be suitable for operation on electrical service as indicated on the Contract Drawings.

E. Each fan shall be provided with a wire guard located on the motor side.

F. Propeller fans shall be the Breezeway series as manufactured by Penn Barry Company, Greenheck SB series, similar of Loren Cook, or equal.

2.03 THERMOSTATS

Ventilation thermostats and freezestats shall be the cooling type (close on rise in temperature) suitable for operation on 120 volt control circuits. The thermostat shall be the heavy duty type with a single pole, double throw switch, an adjustable set point with removable knob and a set point range of 35 deg F to 110 deg F. In

NEMA-7 rated areas, thermostats shall have a remote capillary. The thermostats shall be Honeywell Model T6054A, or equal.

2.04 SPARE PARTS

Each fan shall be provided with one spare set of bearings. Each belt driven fan shall be provided with one spare belt.

2.05 VENTILATION CONTROLS

For ventilation controls, see Contract Drawings and DIVISION 17.

PART 3 – EXECUTION

3.01 INSPECTION AND ACCESS

A. General: Inspect and verify the following items

1. Verify access before fan delivery
2. Verify structural supports and bases
3. Confirm clearance, head room and arrangement before installation.

3.02 INSTALLATION OF FANS AND VENTILATORS

A. General: Install fans and ventilators in accordance with the manufacturer's installation instructions, where indicated on the drawings.

B. Support Bases: Provide concrete pad and concrete bases as indicated.

C. Roof Curbs: Furnish roof curbs to roofing installer for installation.

D. Isolation: Mount on vibration isolators specified.

E. Flexible Connections: Provide flexible connections.

F. Motor Connections: Provide flexible liquid tight motor connections.

G. Start-Up: Verify rotation, adjust belts, lubricate and start-up in presence of manufacturer's representative.

3.03 TESTS

A. Preparation for Tests: Before the scheduled tests, the Contractor shall have prepared the fans and the associated air handling systems (supply, return, and/or exhaust) in accordance with the contract requirements and

ready for operation. All architectural openings and mechanical systems shall be in their normal operation positioning during the tests.

B. Capacity Test: The fan system must be tested to deliver the specified capacity under the specified conditions as listed in the equipment schedule, on the Contract Drawings, or in the specifications. Requirements for air system test are specified in **SECTION 15950, TESTING, ADJUSTING AND BALANCING**.

END OF SECTION 15830

SECTION 15850

ELECTRIC UNIT HEATERS

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SECTION 15850

ELECTRIC UNIT HEATERS

PART 1 - GENERAL

1.01 DESCRIPTION

This section covers the requirements for furnishing all labor materials, equipment and appurtenances for the complete and satisfactory installation of all electric unit heaters, as shown on the Drawings and as required for a complete installation as specified.

1.02 SUBMITTALS

A. Submit the following Shop Drawings in accordance with Section 01300:

1. Catalog cuts and detailed specifications for all equipment which indicate physical dimensions, performance and materials of construction.

2. Wiring diagrams clearly indicating wiring termination points for all electrical items.

B. Submit Operation and Maintenance Manuals in accordance with Section 01900 for the unit heaters.

1.03 QUALITY ASSURANCE

A. Requirements of Section 15000, entitled GENERAL MECHANICAL REQUIREMENTS, shall apply to this section.

B. All electrical work associated with the equipment specified in this section shall be in accordance with DIVISION 16 - ELECTRICAL.

PART 2 - PRODUCTS

2.01 GENERAL

A. Electric unit heaters shall be provided as shown on the Drawings. Heaters shall be installed complete and shall be ready for operation. Heaters shall have sizes and capacities as shown on the Contract Drawings.

2.02 GENERAL SERVICE ELECTRIC UNIT HEATERS

A. General service electric unit heaters shall be of the capacity and service ratings described and scheduled on the Contract Drawings. All general service unit heaters shall be as described herein.

B. Unit heaters shall be UL listed and meet the requirements of the National Electrical Code and shall have capacities as shown on the Contract Drawings. Cabinets shall be of 18-gauge steel with adjustable louvers. All metal surfaces shall be factory finished to prevent corrosion. Unit heaters shall be provided with brackets suitable for wall or ceiling mounting.

C. The heating elements shall consist of metal sheath fin tube. Operating elements shall have automatic reset thermal overheat protection wired for instantaneous pilot operation of built-in control contactor holding coil.

D. The motors shall be totally enclosed, continuous fan-duty sleeve bearing type equipped with built-in thermal overload protection. Each unit shall be equipped with a combination fan guard/motor support resiliently mounted.

E. Fans shall be aluminum, directly connected to the fan motor. Fans shall be statically and dynamically balanced.

F. Unit heaters shall be suitable for electrical service as shown on the Contract Drawings. Heaters shall have integral, heavy duty magnetic contactors and integral thermostats and disconnect switches.

G. Unit heaters shall be Chromalox Type LUH or approved equal.

2.03 WASHDOWN ELECTRIC UNIT HEATERS

A. Electric unit heaters shall be horizontal discharge type.

B. Heaters shall have heavy gauge anodized aluminum case. Heating elements

shall be the fin tube design of monel construction. Elements shall be protected from overheating by automatic thermal overload protection.

C. Heaters shall be suitable for operation on either a single or three phase, 60 Hertz service, of the voltage indicated in the schedule herein. Heaters shall be supplied with integral electric starters. Heaters shall be supplied with a normal open auxiliary contactor which closes when the heater is energized.

D. Fan motors shall be totally enclosed with permanently lubricated ball bearings.

E. Heaters shall be provided with adjustable outlet louver grille, heavy gauge protective rear grille and factory pre-wired wall-mounted swivel bracket. All hardware shall be of stainless steel construction, and the junction box shall be of fiberglass reinforced polyester construction.

F. All unit heaters shall be U.L. listed and provided by the same manufacturer. Electric unit heaters shall be the type HD3D as manufactured by Chromalox, Inc., or equal.

G. Heaters shall capable of being controlled from a remote wall mounted thermostat.

2.04 CONTROLS

The unit heaters shall be controlled by integral thermostats in a 120VAC control circuit. The thermostats shall be initially set for 50°F. Heaters controlled by remote thermostats, shall be supplied with at least one normally open auxiliary starter contact, for use in heater control circuitry.

2.05 FACTORY FINISH

Unit heaters shall receive the manufacturer's standard finish.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install electric unit heaters as shown on the Drawings and in accordance with manufacturer's recommendations.

B. Orient heater discharge direction as indicated on the Drawings. Install heaters with a minimum 7-foot clearance above the finished floor (AFF) unless indicated otherwise.

C. For multiple heaters controlled form a common thermostat, connect a single heater to the common thermostat and the remaining heaters in that group, shall be started using the auxiliary starter contacts in a 'daisy-chain' mode of operation.

3.02 TESTING

Verify the automatic operation of all unit heaters.

3.03 SCHEDULE

Refer to the Drawings for a Unit Heater Schedule.

END OF SECTION

SECTION 15950

HVAC TESTING, ADJUSTING AND BALANCING

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SECTION 15950

HVAC TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.01 SCOPE

Contractor shall provide all labor, materials, equipment and services necessary for and incidental to the complete and satisfactory testing, adjusting and balancing of the HVAC equipment and ductwork as specified herein.

1.02 SUBMITTALS

A. Conform to the requirements of **DIVISION 0 AND 1**.

B. Test Reports: Provide certified test reports, signed by the test and balance supervisor who performed the work. In addition, have the reports certified by a Professional Engineer who is familiar with testing and balancing and the project, and is registered in the jurisdiction where testing is being conducted. The final reports shall include identification and types of instruments used, and their most recent calibration date.

C. Standards: The Contractor shall deliver a copy of either NEBB or AABC standards for testing and balancing work associated with the project. This document shall serve as specific guidance to construction engineers as to minimum requirements.

D. Maintenance Data: Include, in maintenance manuals, copies of certified test reports and identification of instruments.

E. Qualifications: The Contractor shall submit the certified individual qualifications of all persons responsible for supervising and performing the actual work, the name of the certifying engineer, and the qualifications of the independent Registered Professional Engineer certifying the report.

1.03 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.04 SUMMARY

A. Systems: Testing, adjusting and balancing specified in this Section includes the following systems.

1. Supply and Exhaust HVAC systems

B. Related Sections: Refer to other Division 15 sections.

1.05 QUALITY ASSURANCE

A. Tester's Qualifications: A specialist certified by the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) with at least 3 years of experience in those testing, adjusting and balancing requirements similar to those required for this project, who is not the installer of the system to be tested and is otherwise independent of the project.

B. Codes and Standards: Provide testing, adjusting and balancing conforming to American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), American National Standards Institute (ANSI), and either NEBB or AABC the following:

1. American National Standards Institute (ANSI): Comply with the following:

a. S1.4 Specification for Sound Level Meters
b. S1.11 Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters

2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Comply with ASHRAE recommendations pertaining to measurements, instruments, and testing, adjusting, and balancing.

3. NEBB or AABC: Comply with NEBB'S "Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems" or comply with AABC MN-1 "National Standards," as applicable to mechanical air distribution systems, and associated equipment and apparatus.

C. The Contractor shall submit the name of the organization he proposes to employ for approval within [30] days after contract award. If the Contractor

fails to submit the name of an acceptable agency within the specified time, a firm may be selected to accomplish the work, and this selection shall be binding upon the Contractor at no additional cost.

D. Calibration of Testing Instruments: All measurement instruments used for testing, adjusting, balancing, and commissioning shall be calibrated. The time between the most recent calibration data and the final test report date shall not be over 1 year.

1.06 AGENDA

A. Agenda: A preliminary report and agenda shall be submitted and approved prior to the start of testing and balancing work.

1. Review plans and specifications prior to installation of any of the affected systems, and submit a report indicating any deficiencies in the systems that would preclude the proper adjusting, balancing, and testing of the systems.

2. The agenda shall include a general description of each air system with its associated equipment and operation cycles for heating, ventilation, odor control and cooling as applicable.

3. The agenda shall include a list of all air flow and air terminal measurements to be performed.

4. The agenda shall incorporate the proposed selection points for sound measurements, including typical spaces as well as sound sensitive areas like offices and conference rooms, if applicable.

5. The agenda shall also include specific test procedures and parameters for determining specified quantities (e.g. flow, drafts, sound levels) from the actual field measurements to establish compliance with contract requirements. Samples of forms showing application of procedures and calculations to typical systems shall be submitted.

6. Specific test procedures for measuring air quantities at terminals shall specify type of instrument to be used, method of instrument application (by sketch) and factors for:
   a. Air terminal configuration.
   b. Flow direction (supply or exhaust).
   c. Velocity corrections.

d. Effective area applicable to each size and type of air terminal.
e. Density corrections.

7. The agenda shall include identification and types of measurement instruments to be used, and their most recent calibration date.

1.07 JOB CONDITIONS

A. General: Do not proceed with testing, adjusting and balancing work until the following conditions have been met:

1. Work has been completed and is operable. Ensure that there is no latent residual work yet to be completed on the tested equipment.

2. Work scheduled for testing, adjusting and balancing is clean and free from debris, dirt and discarded building materials.

3. All architectural openings (doors, windows, and other openings) which may affect the operation of the system to be tested, adjusted, and balanced shall be positioned at their normal states.

4. All related mechanical systems which may affect the operation of the system to be tested, adjusted, and balanced shall be at their normal operating conditions.

PART 2 - PRODUCTS

2.01 PATCHING MATERIALS

A. Material: Seal, patch and repair ductwork, piping and equipment drilled or cut for testing purposes.

1. Plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.

2. Piping shall be capped with materials the same as the piping system.

3. Insulation shall be neatly hemmed with metal or plastic edging, leaving test points visible for future testing.

2.02 TEST INSTRUMENTS

A. Standards: Utilize instruments and equipment of type, precision, and capacity as recommended in the following standards:

1. NEBB "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

2. AABC Manual MN-1.

B. Test Instruments: All instruments used for measurements shall be accurate and calibration histories for each instrument shall be available for examination. Each test instrument shall be calibrated by an approved laboratory or by the manufacturer. The Owner or Engineer has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable.

C. Additional Instruments: Permanently installed measuring instruments, such as temperature and pressure gauges, shall be verified with standard portable instruments. Any instrument which does not meet specification requirement shall be replaced or recalibrated.

D. Cone Instruments: The Contractor shall employ manufactured enclosure type cones, capable of air volume direct readings, for all diffuser air flow measurements, as applicable. The readout meters shall meet calibration requirements.

PART 3 - EXECUTION

3.01 PROCEDURES AND INSTRUMENTS, GENERAL

A. Requirements: All systems and components thereof shall be adjusted to perform as required by drawings and specifications.

B. Test Duration: Operating tests of Heating and Cooling Terminal Units, fans, and other equipment shall be of not less than four hours duration after stabilized operating conditions have been established. Capacities shall be based on temperatures and air and water quantities measured during such tests.

C. Instrumentation: Method of application of instrumentation shall be in accordance with the approved agenda.

1. All instruments shall be applied in accordance with the manufacturer's certified instructions.

2. All labor, instruments, and appliances required shall be furnished by the Contractor. Permanently installed instruments used for the tests (e.g., flow meters) shall not be installed until the entire system has been cleaned and ready for operation.

3.02 AIR SYSTEM PROCEDURES

A. Adjustments: Adjust all air handling systems to provide approximate design air quantity to or through each component, and to maintain stable and comfortable interior temperatures, free of drafts or stagnant conditions. Adjusting and balancing of all systems shall be conducted during periods of the year approximating maximum seasonal operation, with all other ancillary systems in simultaneous operation.

B. Equalizers: Equalizing devices shall be adjusted to provide uniform velocity across the inlets (duct side for supply) of terminals prior to measuring flow rates.

C. Balance: Flow adjusting (volume control) devices shall be used to balance air quantities (i.e., proportion flow between various terminals comprising system) to the extent that their adjustments do not create objectionable air motion or sound (i.e., in excess of specified limits).

1. Balancing between runs (submains, branch mains, and branches) generally shall be accomplished by flow regulating devices at, or in, the divided-flow fitting.

2. Restriction imposed by flow regulating devices in or at terminals shall be minimal. Final measurements of air quantity shall be made after the air terminal has been adjusted to provide the optimum air patterns of diffusion.

D. Fan Adjustment: Total air system quantities, generally, shall be varied by adjustment of fan speeds in accordance with air system data. Damper restriction of a system's total flow may be used only for systems with

direct-connected fans (without adjustable pitch blades), provided system pressure is less than ½-inch W.G. and sound level criteria is met.

E. Air Measurement: Where air quantity measuring devices are specified in other sections such systems shall be used as a cross-check of portable measuring equipment.

1. Except as specifically indicated herein, pitot tube traverses shall be made of each duct to measure air flow therein. Pitot tubes, associated instruments, traverses, and techniques shall conform to the ASHRAE "Handbook Fundamentals Inch Pound Edition."
2. Where the duct design velocity and air quantity are both less than 1000 (fpm/cfm), air quantity may be determined by measurements at terminals served.

F. Test Holes: Test holes shall be in a straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence generating devices, to optimize reliability of flow measurements.

G. Air Motion: Air motion and distribution shall be as specified and indicated on drawings. The Contractor at no additional cost shall, in addition to air motion measurements, make smoke tests wherever requested to demonstrate the air distribution from air terminals.

3.03 CERTIFIED REPORTS

A. Submittals: Three copies of the reports described herein, covering air system performance, air motion (fpm) shall be submitted prior to final tests and inspection.

B. Instrument Records: Types, serial numbers, and dates of calibration of all instruments shall be included.

C. Reports: Reports shall conspicuously identify items not conforming to contract requirements, or obvious mal-operation and design deficiencies.

D. Certification: The reports shall be certified by an independent Registered Professional Engineer who is versed in the field of air balancing and who is not affiliated with any firm involved in the design or construction phases of the project. Certification shall include checking of adherence to agenda, of calculations, of procedures, and evaluation of final summaries.

3.04 AIR SYSTEM DATA

A. Report: The certified report shall include, for each air handling system, the data listed below.

1. Equipment:

a. Installation data

(1) Manufacturer and model
(2) Size
(3) Arrangement, discharge and class
(4) Motor Hp, voltage, phase, cycles, and full load amps
(5) Location and local identification data

b. Design data

(1) Data listed in schedules on drawings and specifications.

c. Fan recorded (test) data
(1) cfm
(2) Static pressure
(3) rpm
(4) Motor operating amps, motor operating bhp

2. Duct Systems:

a. Duct air quantities (maximum and minimum) - main, submains, branches, outdoor (outside) air, total air, and exhaust

(1) Duct size(s)
(2) Number of Pitot tube (pressure measurements)
(3) Sum of velocity measurements (Note: Do not add pressure measurements)
(4) Average velocity
(5) Recorded (test) cfm vs. design cfm

b. Individual air terminals

(1) Terminal identification supply or exhaust, location and number designation

(2) Type, size, manufacturer and catalog identification applicable factor for application, velocity, area, etc., and designated area

(3) Design and recorded velocities - fpm (state "core," "inlet," etc., as applicable)

(4) Design and recorded quantities - cfm deflector vane or diffusion cone settings

3.05 FINAL COMMISSIONING TESTS, INSPECTIONS AND ACCEPTANCE

A. Scope: Tests shall be made to demonstrate that capacities and performance of air and water systems comply with contract requirements.

1. At the time of final inspection, the Contractor shall recheck a random selection of data (air quantities and air motion) recorded in the certified report.

2. Points and areas for recheck shall be selected by the Engineer.

3. Measurement and test procedures shall be the same as approved for work forming basis of certified report.

4. Selections for recheck (specific plus random), in general, will not exceed 25 percent of the total number tabulated in the report, except that special air systems may require a complete recheck for safety reasons.

B. Retests: If random tests show a measured flow deviation of 10 percent or more from, or a sound level of 2 db or more greater than, that recorded in the certified report listings, for 10 percent or more of the rechecked selections, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new certified reports submitted, and new inspection tests made, all at no additional cost.

C. Marking of Settings: Following final acceptance of certified reports, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the Contractor so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

END OF SECTION 15950

SECTION 16010

ELECTRICAL GENERAL PROVISIONS

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SECTION 16010

ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General Provision of the Contract, including General and Supplementary Conditions, General Requirements and Division 1, apply to work specified in Division 16.

B. This section describes General Provisions for electrical work included in Division 16. This section applies to sections of Division 16.

1.02 SCOPE

A. Provide labor, materials, equipment and perform operations for complete installation of electrical work and related systems indicated or required ready for continuous and complete operation.

B. Provide labor and materials, although not specifically mentioned, but necessary for the completion of work and operation of the system, as if specifically called for at no additional cost to Owner.

1.03 GENERAL DESCRIPTION

A. Work includes, but not be limited to, providing the following:

1. Primary and/or secondary service feeders as indicated.
2. Switchboard, motor control center, and electrical distribution system to panelboards, motor control center(s), and as indicated.
3. Complete wiring system, including branch circuits and panelboards for lighting, power, receptacles and other special connections.
4. Internal (and external) lighting fixtures, switches, receptacles, pull boxes, outlets, conduit, wiring, lamps, ballasts and accessories.
5. Exit and Emergency lighting.
6. Telephone raceway system.
7. Grounding system.
8. Equipment connections for heating, ventilating and cooling systems.
9. Equipment connections for other equipment specified under other divisions.
10. Lightning Protection.

1.04 WORK OF OTHERS

A. For work specified in other divisions, cooperate and coordinate with other trades as if work were specified in this division.

B. The following items of labor, materials related to or incidental to the installation of the electrical work will be provided under other divisions:

1. Telephone and computer cables and related equipment, which will be provided by others under direct negotiations with Owner.
2. Equipment indicated as "N.I.C." (not included in contract).
3. Motors and motor driven equipment.
4. Temporary power and lighting which is provided under Section 01510 - TEMPORARY UTILITIES.
5. Flashing of raceways through roof.

C. Application for permanent electrical power and telephone utility connections and service wiring installation, will be made by Owner. Provide arrangements for installation of such service. Charges for permanent service made by utility will be paid by Owner.

1.05 REFERENCES AND DEFINITIONS

A. Following are definitions of terms and expressions used in Electrical Sections:

1.	OWNER	-	Sussex County
2.	ARCHITECT	-	Whitman, Requardt and Associates, LLP
3.	ENGINEER	-	Whitman, Requardt and Associates, LLP
4.	PROVIDE	-	"furnish and install completely"
5.	DIRECTED	-	"directed by Owner"
6.	INDICATED	-	"indicated in Contract Documents"
7.	CONCEALED	-	"hidden from normal sight"
8.	EXPOSED	-	"not concealed"
9.	WIRING	-	includes wire, fittings, conduit boxes and other accessories which comprise system
10.	APPROVAL	-	Owner's acceptance of particular shop drawing, material and method providing subject matter is in conformance with design concept and standard practice
11.	OR EQUIVALENT	-	a product, material or system with same general attributes as item specified and meeting Contract Documents as to capacity, performance, dimensions, general construction, and must be submitted to Owner for review

B. References to catalogs, standards, codes, specifications, and regulations are latest edition in effect at date of invitation to bid.

1.06 CODES, REGULATIONS AND PERMITS

A. Secure and pay for required permits and inspections required by local authorities, and make applications required.

B. Materials furnished and work installed shall comply with latest issue of codes, rules, regulations, and recommendations of the following bodies, unless otherwise noted:

1. American National Standards Institute (ANSI)
2. American Society of Testing and Materials (ASTM)
3. BOCA Basic Building Code
4. Electrical Testing Laboratories (ETL)
5. Factory Mutual (FM)
6. Insulated Cable Engineer Association (ICEA)
7. Institute of Electrical and Electronics Engineers (IEEE)
8. Illumination Engineering Society (IES)
9. National Board of Fire Underwriters' (NBFU)
10. National Electrical Codes (NEC)
11. National Electrical Manufacturers Association (NEMA)
12. National Fire Protection Association (NFPA)
13. National Electrical Safety Code (NESC)
14. Occupational Safety and Health Agency (OSHA)
15. Underwriters Laboratories, Inc. (UL)
16. Local Power Company
17. Local Telephone Company
18. Applicable City, County, State and Federal Codes

C. Electrical installation shall be inspected and approved by the authority having jurisdiction and certificates documenting approval shall be furnished to Owner before requests for final payment. Allow inspections at any time. Impedance or interference with inspections shall not be permitted.

1.07 MATERIALS LIST AND SHOP DRAWINGS

A. Within 15 days after award of contract, submit to Owner for approval list of manufacturer's names for proposed material and equipment. In the event any item of material or equipment contained in the list fails to comply with specification requirements, such item will be rejected. If prior to expiration of 15-day period or any duly authorized extension thereof, failure to submit schedule of acceptable material or equipment covering items occurs, Engineer will select items and such selection shall be final and binding as a condition of contract. Rejected items shall be resubmitted within 15 days of receipt of notice of rejection.

B. After receiving approval of equipment manufacturers and prior to delivery of any material to job site, submit for approval detailed dimensioned shop drawings, together with descriptive specifications, engineering data sheets and catalog cuts showing construction size, arrangement, operating clearances, performance characteristics and capacity of electrical materials, equipment and systems. Each

item of equipment proposed shall be a standard catalog product of approved manufacturer, unless otherwise noted.

C. Shop drawings, specifications, catalogs, and pamphlets, and other documents submitted for approval shall be properly labeled indicating specific service for which material or equipment is to be used, section and article number of specifications governing, and Contractor's name, name of job, and date submitted.

D. Shop drawings, specifications, catalogs, pamphlets and other documents submitted for approval describing items shall contain detailed and specific information which shall demonstrate fully that the material, equipment or system conforms to contract documents. Each shop drawing, specification, catalog and pamphlet shall be clearly marked in ink to identify item submitted. Data of general nature is not acceptable.

E. If material or equipment is installed prior to receipt by Contractor of pertinent shop drawings marked "Approved" or "Approved as Noted," material or equipment shall be removed, and approved material or equipment provided at no extra charge to Owner.

F. Acceptance of shop drawings shall not relieve Contractor from responsibility to provide labor, material, equipment and systems required by contract documents. Owner and Engineer will not be responsible for errors or omissions on shop drawings furnished by Contractor, even though such drawings containing errors or omissions are inadvertently accepted.

G. Engineer will not act as coordinator between suppliers and subcontractors. Coordination shall be responsibility of Contractor. See other sections of these specifications for additional detailed requirements for wiring diagrams, schematic diagrams, interconnection diagrams and similar shop drawings for systems and equipment such as:

1. Motor Control Center(s)
2. Lighting Control System

H. Provide shop drawings for following:

1. Lighting Fixtures
2. Panelboards
3. Switchboards
4. Motor Control Center(s)
5. Transformer(s)
6. Safety Switches
7. Motor Starters and Controls
8. Surge Protective Devices
9. Wiring Devices
10. Wire Splicing Kits and Schedule

11. Framing Channels
12. Relays and Timers
13. Terminal Panels
14. Wire and Cable
15. Cabinets and Enclosures
16. Raceway and Fittings
17. Pull Boxes
18. Lightning Protection Components
19. Fuses
20. Variable Frequency Drives
21. Explosionproof Equipment
22. Grounding System
23. Underground Distribution System Components

I. Provide spare parts and tools for electrical equipment indicated. Submit list of spare parts and tools as part of shop drawing requirements.

J. No materials or equipment shall be released for shipment or installed until suitable action has been taken by Engineer as indicated by stamp and signature.

1.08 OPERATING AND MAINTENANCE MANUALS

A. Assemble six sets of Operating and Maintenance Manuals for electrical systems and equipment to be delivered to Engineer upon completion of work and prior to occupancy by Owner. Owner reserves right to withhold final payment until Operating and Maintenance Manuals are delivered.

B. Bind each copy of Operating and Maintenance Manual in durable, hardback binder, with data sheets individually punched and entered. Provide loose leaf 3-ring type with black plastic coated covers.

C. Data sheets shall have an identifying label on front cover and shall include following:

1. Index.
2. One copy of approved materials list.
3. One copy of each approved shop drawing and associated data.
4. One copy of nameplate data for each motor and overload protection device.
5. One copy of each system or equipment manufacturer's recommended preventive maintenance, if any.
6. One copy of each panelboard directory typed on separate sheets.
7. One copy of time-current characteristic curve for each type of fuse, overload device, circuit breaker and protective relay.
8. One copy of each system and component operating instruction (where applicable).

D. Refer to Section 01300 - SUBMITTALS.

1.09 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Upon completion of work and tests, instruct Owner's representative in operating, adjustment and maintenance of electrical systems and equipment furnished. Provide instruction as directed by Owner and divided into four 4-hour sessions, each at time directed by Owner.

B. Instructor shall be factory trained and thoroughly familiar with all parts of system and equipment on which instruction is given.

C. Instructions shall include name or label, location and general description of each system together with specific instructions describing operating modes, routine and emergency procedures required of building personnel for operating and maintaining each system. Listing of names, addresses, and phone numbers of service organizations for each item of equipment and typewritten maintenance schedule for each item of equipment shall be included.

1.10 RECORD DRAWINGS

A. Maintain at construction site one set of prints, carefully record actual locations of each piece of electrical equipment, control devices, switches, outlets, wires, cables, conduits, and accessories, including dimensions to locate, where different from contract drawings. Upon completion of work, deliver this "as built" set of prints to Owner. Owner reserves right to withhold final payment until "as built" drawings are received.

B. Refer to Section 01300 - SUBMITTALS.

1.11 SITE VISIT

A. Prior to preparing bid visit site and become familiar with existing conditions, make necessary investigations as to locations of existing structures, equipment, ductwork, piping, utilities, work to be removed, and matters which can affect work under Contract. No additional compensation will be paid as a result of failure to be completely familiar with existing conditions under which work must be performed. Notify Owner of discrepancies prior to bidding.

B. Base measurements, both horizontal and vertical, from established lines and levels. Work shall agree with these established lines and levels. Verify conditions at site.

C. See instructions to Bidders.

1.12 DRAWINGS

A. Drawings are diagrammatic and indicate general arrangement and manner of connections. They do not show all details of construction or exact location of work.

B. Carefully examine contract documents and ensure proper fitting of materials and equipment, as indicated.

C. Although location of materials and equipment may be indicated in a certain place, construction may develop conditions that render this location inaccessible or impractical. In such cases, before fabricating and installing work, call condition to attention of Engineer for further direction. When requested by Engineer detailed drawing of proposed departure due to field conditions, and their causes, shall be submitted for approval. Engineer shall make all final written decisions as to conditions which require changing of work.

D. Minimal shifting in locations of outlets, before installation, is to be expected and shall be done at no increased cost to Owner.

E. Conflicting points in contract documents shall be called to attention of Owner prior to execution of work to a point where changes will effect additional cost to Owner.

1.13 WARRANTY

A. Unless otherwise indicated in Division 1, materials and equipment provided under this Division shall be free from defects in workmanship and materials for a period of one year after date of certification of completion and acceptance of work. Correct defects in workmanship, materials and performance which appear within warranty period on notice from Owner, without cost to Owner. In default thereof, Owner may have such work done and charge cost of same to Contractor.

B. During warranty period, make proper adjustments, calibrations and service to electrical systems, equipment and apparatus installed and do all work necessary to ensure efficient and proper functioning of systems and equipment.

C. Warranties shall be strictly adhered to, and Contractor shall be responsible for any service and replacement required in connection with warranty of items. Warranties shall commence after date of certification of completion and acceptance of work.

D. Contractor shall be responsible for electrical systems and related damages possible and hold harmless Owner, and consultants from malfunctions of systems and equipment installed under this contract, as defined by State laws pertaining to real property for period of time as defined by law.

E. During guarantee period, adjust, calibrate and service equipment provided under this contract.

PART 2 - MATERIALS

2.01 GENERAL

A. Electrical materials and equipment shall be new, carry U.L. label when such material, equipment or system are of type or class listed by Underwriters Laboratories, Inc., and shall be suitable for conditions and duties imposed on them at site. If U.L. label is not available from manufacturer, when requested or required by local authority having jurisdiction, equipment shall be tested by an approved electrical testing company in accordance with NEC at no additional cost to Owner. Submit data indicating compliance with standards prior to installation. Description, characteristics, and requirements of materials to be used shall be in accordance with qualifying conditions established in following sections.

B. Component parts of each item of equipment and device shall bear manufacturer's nameplate, giving name of manufacturer, description, size, type, serial number, model number, and electrical characteristics, in order to facilitate maintenance or replacement. Nameplate of subcontractor or distributor is not acceptable.

C. In specifying materials, the following general procedures are used:

1. Where material or equipment is specified by name or other identifying information and one name brand only is used, it is considered that use of that particular item is essential to project, and Contractor shall base proposal on cost of that item.
2. Where material or equipment is specified by brand name and other identifying information and two or more brand names are given, it is considered that any one of brands named will perform as desired, and Contractor shall base proposal on one of named brands.
3. Where material or equipment is specified with phrase "...or equivalent..." after a brand name and other identifying information, it is intended that brand name used is for purpose of establishing minimum acceptable standard of quality and performance, and Contractor may base proposal on any item which is in all respects equal to that specified and presents essentially same appearance, size, operation and performance.
4. Where material is specified as complying with requirements of published "Standard Specification" of trade associations, ANSI, ASTM, and government specifications, Contractor shall base proposal on any item which can be shown to comply in all respects with referred "Standard Specification."

D. Acceptable materials, equipment and methods:

1. Engineer will determine whether any materials, equipment and methods offered for approval as an equal are equal to those specified and will fit space available.
2. Decision of Engineer on questions of equality is final.
3. Provide acceptable material, equipment and methods at no increase in cost to Owner.

E. Upon receipt of written notice from Engineer, that material, equipment and methods have been reviewed and accepted ("Approved" or "Approved as Noted"), Contractor may precede with accepted equal material, equipment and methods, providing Contractor assumes full responsibility for and makes, at no cost to Owner, any change or adjustment in construction that may be required by use of such materials, equipment or methods including services provided under other divisions. In event of any adverse decisions by Engineer, no claim of any sort shall be made or allowed against Owner.

2.02 CONCRETE WORK

A. Unless otherwise indicated, concrete work for electrical equipment foundations and pads shall conform to requirements of other sections of specifications.

2.03 EQUIPMENT SUPPORTS, FOUNDATIONS AND STANDS

A. Provide supports, foundations and stands required for electrical equipment and provide and set all necessary anchor bolts.

B. Concrete pads shall not be less than 4 inches high, unless otherwise indicated and shall extend 2 inches beyond equipment base. Chamfer edges and corners, and finish smooth exposed surfaces. Pads shall rest on rough concrete floor slabs.

C. Where equipment is indicated as floor-mounted, construct stands of structural steel sections (or steel pipe and fittings braced and fastened with flanges) bolted to floor.

D. Where equipment is indicated as hung from ceiling or roof construction, provide necessary hanger rods of size and number required by equipment and necessary supplemental structural steel sections, securely fastened to building construction.

E. Where equipment is indicated to be wall-mounted, provide brackets, constructed of structural steel shapes suitable for application, securely anchored to building construction.

F. Motor-operated equipment, transformers and other vibrating equipment shall be mounted on rubber-in-shear vibration isolators suitable for application, unless otherwise specified.

2.04 LABELS AND NAMEPLATES

A. Provide switchboards, panelboards, circuit breakers, motor control centers, motor starters, safety switches, control equipment, pilot lights, pushbuttons, switches, panels, transformers, and instrumentation with engraved laminated phenolic nameplates (white background with black letters) with beveled trim. Data and installation shall be approved by Engineer. Provide nameplates with minimum 1/4-inch high etched letters. For indoor applications, fasten nameplates with screws. For

outdoor applications, attach to equipment enclosure with silicone and stainless steel machine screws, washer, and nuts on inside. Labels shall include:

1. EQUIPMENT DESIGNATION
2. VOLTAGE
3. SERVED FROM (equipment designation)
4. CIRCUIT (number), LOCATED (location)

B. Mount typewritten schedule of circuits, with legend as indicated in suitable frame on inside of lighting and appliance panel cabinet doors under clear plastic. Provide nameplates for distribution panelboard circuits.

C. Space or Pole Numbers (SOPN) for panelboards indicated are for purpose of clarifying grouping of wiring into circuits. Where panelboards are not marked with SOPN locations, provide permanent label on each device in panelboard.

D. Junction boxes and pull boxes, except those directly located at fixture or equipment to which system is connected, shall be identified with 1" high stenciled lettering to indicate voltage and circuiting on which installed.

E. Identify raceways at points not more than 20 feet on center by means of plastic identification labels. Apply labels within one foot of penetration wherever conduits leave and enter switchboards, panelboards, switchgear, junction boxes, pull boxes and similar items and at each side of penetrations of walls, partitions and floors. Labels shall indicate system voltage and type of service (i.e., Control Circuits, Power, Lights). Install labels in accordance with manufacturer's instructions, with label sizes to match conduits to which they are applied.

F. Provide wire identification marking on each phase, neutral, and ground wire at each accessible point along its length (i.e. panelboards, junction boxes, pull boxes, outlet boxes, and other enclosures.) Labels shall indicate circuit numbers, terminal numbers, and pole numbers of each conductor. Mark wire identification code on back cover of each pull and junction box to indicate phase, neutral, and ground wires enclosed by box.

G. Wire identification shall be permanent black letters and numerals on white background (printed plastic pressure sensitive strips wrapped around wire, hot stamped PVC sleeves slipped on or split and tied around wire, or other equivalent methods). Write-on tags are not acceptable.

PART 3 - EXECUTION

3.01 COORDINATION OF WORK

A. Continually check, layout, and superintend installation of work indicated. Provide information regarding locations and sizes of chases and openings and be responsible

for accuracy of information. Lay out and superintend installation of hangers, inserts, sleeves and other work in masonry and concrete in advance of and during construction, coordinating work of other trades to prevent interference in location of other equipment.

B. Coordinate exact locations of electrical equipment, outlets, and conduits with all other trades so that there will be no interference with material and equipment by other trades. Where conflicts between trades result, resolve to Engineer's satisfaction and at no expense to Owner.

C. Remain completely informed of progress of general construction at all times, and install work that is to be concealed without delay to work of other trades. During wall construction, install conduit and outlet boxes indicated as concealed in masonry construction.

D. Examine work of other trades insofar as their work comes into contact with or is covered by work installed under this specification section. In no case attach to, cover up or finish against any defective work, or install work in a manner which will prevent proper installation of work of other trades.

E. Coordinate spacing and arrangement of lighting fixtures, diffusers, grilles, and other ceiling mounted equipment, where ceiling patterns may be set up, so as to be symmetrical and centered in individual tiles. Equipment, fixtures, devices, and accessories, installed in or on ceilings shall be compatible with ceiling system.

3.02 HANDLING AND STORAGE OF MATERIALS

A. Proper and suitable tools, equipment and appliances for safe and convenient handling and placing of materials and equipment shall be used. During loading, unloading and placing, care shall be taken in handling equipment and materials so that no equipment and materials, including Owner furnished and existing, are damaged.

B. Electrical material and equipment delivered to job site shall be stored under roof or other approved covering, on pedestals above ground. Enclosures for material and equipment shall be weatherproof.

C. Materials and equipment, which are damaged or affected as a result of improper handling or storage, shall be subject to removal at direction of Owner and replaced with new materials, at no cost to Owner.

3.03 DAMAGE TO OTHER WORK

A. Contractor shall be held responsible for any damage to work already in place due to work or negligence of workers. Patching and repairing of damaged work shall be done by trade, which originally installed work at expense of Contractor under this Division.

3.04 MOUNTING HEIGHTS

A. In general, use mounting heights indicated however, field conditions may dictate changes. Where these special conditions occur, final mounting height shall be brought to attention of Engineer for further direction.

B. Coordinate final location of outlets with respect to proximity of architectural material and avoid conflicts in location prior to rough-in. Relocate outlets in conflict with above items as indicated.

3.05 EQUIPMENT CONNECTIONS

A. Equipment requiring electrical service shall be installed and connected in accordance with approved methods and in accordance with manufacturer's recommendations.

B. Equipment connections indicated shall be considered diagrammatic. Actual connections shall be approved for each case and minimized space used.

C. Conduit, outlets, wiring, fittings and accessories for connections to electrical equipment shall be provided. Should equipment of different ratings be furnished, adjust circuit components accordingly, at no expense to Owner, after approval by Engineer. Confirm proper size and location of equipment connections before fabrication and installation of work.

D. Contractor shall reach an agreement as to limits of responsibility of various trades where connecting to outlets provided by others, and where providing outlets to receive connections by others, so that work and equipment will be provided with proper services connected and ready for use.

3.06 COMBINING CIRCUITS INTO COMMON RACEWAY

A. Circuits may be combined into common raceways in accordance with the following requirements:

1. Analog control circuits from devices in same general area to same destination.

    a. No power or AC discrete control circuits shall be combined in same conduit with analog circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
    c. Analog circuits shall be continuous from source to destination. Do not add TJB, splice, or combine into a multi-pair cable without authorization of Engineer.
    d. Raceways shall not exceed 40 percent.

2. Discrete control circuits from devices in the same general area to the same destination.

    a. No analog control circuits shall be combined in same conduit with discrete circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
    c. Raceways shall not exceed 40 percent.

3. Power circuits from loads in same general area to same source location (such as: panelboard, low voltage motor control center).

    a. Lighting Circuits: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
    b. Receptacle Circuits, 120-Volt Only: Combine no more than three circuits to a single raceway. Provide a separate neutral conductor for each circuit. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
    c. All Other Power Circuits: Do not combine power circuits unless shown on the Contract Drawings or without authorization of Engineer.

4. All changes to the Contract Documents shall be documented on record drawings.

3.07 WATERPROOFING

A. Waterproofing and dampproofing of building shall be held unharmed by installation of work under this Division. Wherever any work or conduits under this Division pierce waterproofing or dampproofing including outside walls, such penetration shall be made only when approved by Owner and pierced surface shall be made watertight. Replace waterproofing damaged or destroyed at no expense to Owner.

3.08 CUTTING, PATCHING AND PAINTING

A. Cutting, patching and painting necessary for installation of electrical work shall be done under this Division. Any damage done to work already in place shall be repaired at no cost to Owner. Patching shall be uniform in appearance and shall match existing finish and paint.

B. Holes and openings created as a result of demolition work shall be patched uniformly and shall match existing finish and paint.

C. Exposed equipment, including conduit installed under this Division, shall be cleaned and left in condition ready for painting under other Divisions. Items not provided with corrosion-resistant finish shall be painted. Electrical panels, control equipment, and supporting framework except as otherwise indicated, shall have light gray enamel finish which may be manufacturer's standard gray, if acceptable to the Engineer. Touch-up or repaint scratched or marred finishes, to match original finish as directed by Engineer. Particular caution shall be exercised not to obscure nameplate data.

3.09 SLEEVES AND PLATES

A. Provide sleeves for installation of raceways. Carefully locate in advance of construction of walls and floors where new construction is involved. Provide cutting and patching to set sleeves which are not placed prior to construction.

B. Provide sleeves for raceways passing through concrete, masonry, plaster and gypsum wallboard construction. Caulk annular space of sleeves with an elastic fire resistant caulking compound to make installation fire, air and water tight.

C. Fasten sleeves securely in construction to prevent displacement when concrete is poured and when other construction is built around them. Take precautions to prevent concrete, plaster and other materials being forced into space between raceway, and sleeve during construction.

D. Sleeves required in existing concrete or masonry walls shall be set and secured with mortar grout and fast drying bitumastic sealant.

E. At sleeves where objectionable noise can be transmitted, at smoke barriers, at walls above ceilings that extend to underside of structure of floor above, and at fire rated separations, seal openings between raceways and corresponding sleeves to prevent sound transmission and to maintain fire rating. Use UL approved resilient sealant for penetration seals. Submit method of sealing for approval.

F. Where watertight sleeves are indicated, or required, to suit installation on above grade raceway penetrations, provide Link Seal rubber seals, as manufactured by Thunderline Corporation, between pipe and sleeves. Where watertight sleeves are indicated, or required, to suit installation on below grade wall and floor raceway penetrations, provide OZ/Gedney Type WSK and Type FSK fittings.

G. Where conduit motion due to expansion and contraction can occur, make sleeves of sufficient diameter to permit free movement of conduit. Check construction to determine proper length for various locations; make actual lengths to suit following:

1. Terminate sleeves flush with walls, partitions and ceilings.
2. Terminate sleeves 2 inches above finished floor in equipment rooms, kitchen and wet floor areas.

3. In other areas, terminate sleeves 1 inch above finished floors, unless otherwise indicated or directed.

3.10 EXCAVATING AND BACKFILLING

A. Provide excavation and backfill necessary to install underground electrical work included in this Division. Establish lines and grades required for proper location of work, and shall be responsible for correctness thereof. Check elevations of utilities before starting work. Excavation and backfill shall be performed in accordance with other Divisions.

1. Trenches shall be excavated to width and depth required by NEC or as indicated. Trench subgrade shall be such as to allow bedding of conduit or duct with uniform and continuous bearing on solid, undisturbed earth for full length of each run.
2. Trenches in fill areas shall not be excavated until embankment construction has been completed to minimum 2 feet above top of conduit or duct being placed.
3. Any part of trench excavated below specified subgrade shall be backfilled at no cost to Owner, using approved bedding materials. Wherever wet or otherwise unstable subgrade is encountered below elevation of original ground surface which existed prior to time of construction, soil shall be removed to depth and extent directed by Engineer and trench backfilled with approved bedding material. Reimbursement for extra work shall be in accordance with General Conditions. Wherever removal of wet or otherwise unstable subgrade from fill material previously placed by Contractor is required by Engineer, cost of removal of unstable soil and backfilling of the trench, shall be done at no cost to the Owner.

3.11 FLOOR MATTING

A. Any walkway areas in front of electrical and instrumentation panels shall be covered with an 18 inch wide, 1/2 inch thick minimum safety matting with appropriate voltage rating rubber meeting ANSI and ASTM standards. Installation of matting shall be in conformance with manufacturers' requirements.

3.12 PLACING IN SERVICE

A. At completion of work a thorough test, as indicated, shall be made in presence of Owner with equipment, machinery and appliances in operation and entire electrical system proven satisfactory for operation and free from defects.

B. After building is in full operation by Owner, provide continuously recorded voltmeter and ammeter readings for period of one week at such feeder and service points, as directed by Owner.

C. Gather in one place and at one time loose equipment, keys, record drawings, and spare parts to be turned over to Owner. Label items and provide typed list ready to be signed by an authorized representative of Owner.

END OF SECTION 16010

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SECTION 16055

SHORT-CIRCUIT/COORDINATION STUDY/ARC FLASH HAZARD ANALYSIS

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SECTION 16055

SHORT-CIRCUIT/COORDINATION STUDY/ARC FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.01 SCOPE

A. The contractor shall furnish short-circuit and protective device coordination studies.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
6. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):

1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
5. ANSI C37.5 – Methods for Determining the RMS Value of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage, and for Simplified Calculation of Fault Currents

C. The National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code, latest edition
2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.03 SUBMITTALS FOR REVIEW/APPROVAL

A. The short-circuit and protective device coordination studies shall be submitted to the Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the Engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

B. Submit to power company setting of overcurrent protective devices in Main Incoming Switchgear/Switchboard and obtain approval.

1.04 SUBMITTALS FOR CONSTRUCTION

A. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies, where required, shall be provided on CD in PDF format.

B. The report shall include the following sections:

1. One-line diagram showing protective device ampere ratings and associated designations, cable size & lengths, transformer kVA & voltage ratings, motor & generator kVA ratings, and switchgear/switchboard/panelboard designations
2. Descriptions, purpose, basis and scope of the study
3. Tabulations of the worst-case calculated short circuit duties as a percentage of the applied device rating (circuit breakers, fuses, etc.); the short circuit duties shall be upward-adjusted for X/R ratios that are above the device design ratings
4. Protective device time versus current coordination curves with associated one line diagram identifying the plotted devices, tabulations of ANSI protective relay functions and adjustable circuit breaker trip unit settings
5. Fault study input data, case descriptions, and current calculations including a definition of terms and guide for interpretation of the computer printout
6. Incident energy and flash protection boundary calculations
7. Comments and recommendations for system improvements, where needed

8. Executive Summary including source of information and assumptions made

1.05 QUALIFICATIONS

A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical Engineer shall be a full-time employee of the Engineering Services Organization. The study shall be performed by an independent agency or by the equipment manufacturer.

PART 2 - MATERIALS

2.01 STUDIES

A. Contractor to furnish short-circuit and protective device coordination studies. The coordination study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and include the largest feeder circuit breaker in the 480 Volt power distribution switchboards and panelboards. The study shall also include variable frequency drives, harmonic filters, power factor correction equipment, transformers and protective devices associated with variable frequency drives, emergency and standby generators associated paralleling equipment and distribution switchgear.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

2.02 DATA COLLECTION

A. Contractor shall obtain all data as required by the power system studies. The Contractor shall expedite collection of the data to eliminate unnecessary delays and assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future utility supplies, motors, and generators.

C. Load data utilized may include proposed loads obtained from Contract Documents.

D. Include fault contribution of existing motors in the study, with motors < 50 hp grouped together.

2.03 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standards 141, latest edition.

B. Transformer design impedances and standard X/R ratios shall be used when test values are not available.

C. Provide the following:

1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram of the system being evaluated with available fault at each bus, and interrupting rating of devices noted
4. Source impedance data, including electric utility system and motor fault contribution characteristics
5. Typical calculations
6. Tabulations of calculated quantities
7. Results, conclusions, and recommendations

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric utility's supply termination point
2. Low voltage switchboard
3. Motor Control Center
4. Branch circuit panelboards
5. Other significant locations throughout the system
6. Variable Frequency Drives

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, switchboards, power distribution units, and panelboard bus bracing to withstand short-circuit stresses
3. Adequacy of transformer windings to withstand short-circuit stresses
4. Cable and busway sizes for ability to withstand short-circuit heating

2.04 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.

B. Include on each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the curve sheets, where applicable:

1. Electric utility's protective device
2. Low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
3. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
4. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
5. Conductor damage curves
6. Ground fault protective devices, as applicable
7. Pertinent motor starting characteristics and motor damage points
8. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

G. Recommend setting of all non overcurrent protective devices.

2.05 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

B. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, panelboards, power distribution units, busway and splitters) where work could be performed on energized parts.

D. The Arc-Flash Hazard Analysis shall include all 480V locations and significant locations in 208 Volt systems fed from transformers.

E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm^2.

F. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

G. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.

H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

2.06 REPORT SECTIONS

A. Input Data:

1. Utility three-phase and line-to-ground available contribution with associated X/R ratios
2. Short-circuit reactance of rotating machines with associated X/R ratios
3. Cable type, construction, size, # per phase, length, impedance and conduit type
4. Transformer primary & secondary voltages, winding configurations, kVA rating, impedance, and X/R ratio
5. Reactor inductance and continuous ampere rating

B. Short-Circuit Data:

1. Source fault impedance and generator contributions
2. X to R ratios
3. Asymmetry factors
4. Motor contributions
5. Short circuit kVA
6. Symmetrical and asymmetrical fault currents

C. Recommended Protective Device Settings:

1. Phase and Ground Relays:

a. Current transformer ratio.
b. Current setting.
c. Time setting.
d. Instantaneous setting.
e. Specialty non-overcurrent device settings.

2. Circuit Breakers:

a. Adjustable pickups and time delays (long time, short time, ground).
b. Adjustable time-current characteristic.
c. Adjustable instantaneous pickup.

D. Incident energy and flash protection boundary calculations.

1. Arcing fault magnitude
2. Device clearing time
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard Risk Category

PART 3 - EXECUTION

3.01 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion. The same procedure shall be followed for all non-overcurrent relays.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies at no additional cost to Owner.

C. Notify Owner in writing of any required major equipment modifications.

D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the equipment manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

3.02 ARC FLASH WARNING LABELS

A. The vendor shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. The label shall have an orange header with the wording, “WARNING, ARC FLASH HAZARD”, and shall include the following information:

1. Location designation
2. Nominal voltage
3. Flash protection boundary
4. Hazard risk category

5. Incident energy
6. Working distance
7. Engineering report number, revision number and issue date

C. Labels shall be machine printed, with no field markings

D. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.

1. For each 480 and applicable 208 volt panelboards and disconnects, one arc flash label shall be provided
2. For each low voltage switchboard, one arc flash label shall be provided
3. For each motor control center, one flash label shall be provided
4. For each variable frequency drive one arc flash label shall be provided.

3.03 ARC FLASH TRAINING

A. The equipment vendor shall train personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). Maintenance procedures in accordance with the requirements of NFPA 70E, Standard For Electrical Safety Requirements For Employee Workplaces, shall be provided in the equipment manuals.

END OF SECTION 16055

SECTION 16060

GROUNDING AND BONDING

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SECTION 16060

GROUNDING AND BONDING

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. Provide all labor, materials, equipment and services necessary for the installation of a complete ground system.

B. The ground system shall consist of all required ground rods, cold water pipe grounds, and copper conductors, including all necessary connections to control centers, substations, building steel, etc.

C. The grounding systems are comprised of two wired systems. One is each neutral wire which is grounded at the transformer. The second is a "Green Wire" system which is isolated from the neutral wire system (except at transformers) and serves as an equipment grounding (safety) conductor.

D. There is a single point (the earth ground reference point) connection for each system.

E. Provide ground for service neutral, neutrals of each separately derived alternating-current system, metallic structures, enclosures, devices, and utilization equipment permanently and effectively in accord with requirements of the National Electrical Code, and as shown and required. All grounding and bonding connections shall be solderless. Welding of conduit and fitting will not be allowed for bonding purposes.

F. The neutrals of each separately derived alternating-current system shall be connected grounded at one point only. Service ground shall be extended from this single point of connection to the electrode system as indicated on the drawings.

1.03 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 GROUND CONDUCTORS

A. Wire between the grounding electrode system and other points of the system shall be uninsulated copper with conductor properties, as required, by the National Electrical Code. The minimum size wire for connection to the grounding electrode system shall be 4/0.

2.02 GROUND RODS

A. Ground rods shall be copper-clad steel as manufactured by Copperweld Steel Company, or equivalent, 3/4-inch minimum diameter and 10-foot minimum length.

2.03 HAND BOXES

A. Handboxes shall be as shown on the drawings.

2.04 EXOTHERMIC WELD

A. All cable to ground rod connections and all connections elsewhere herein specified or shown on the drawings shall be accomplished by the exothermic welding process.

B. Furnish all materials and molds necessary to properly perform all required exothermic welds.

C. Furnish exothermic welding systems from the Cadweld Division of Erico Products, Inc., or Burndy Corporation.

PART 3 - EXECUTION

3.01 GENERAL

A. Conduits, switchboard, motor control centers, panels, metal boxes, cabinets, dry-type transformers, fixtures, outlets and other metal enclosures surrounding or containing electrical equipment, motors or apparatus with metal frames shall be securely grounded in accordance with the National Electrical Code.

B. An equipment ground conductor shall be run with all three-phase branch circuits as shown in schedules on the drawings; the ground conductor shall be connected to the ground bus at the control centers and to the motor frame or equipment frame at the load. The new grounding system shall be provided as shown on the drawings and/or as specified herein.

3.02 INSTALLATION

A. Provide bare copper wire and connections to ground all transformer secondary neutral terminals as required by the NEC. Wire shall be sized as required by the NEC, but shall not be sized smaller than #6 AWG.

B. The electrical continuity of all metal raceways shall be insured by means of properly installing locknuts, bonding straps or other approved means. Provide a separate green conductor in all circuits installed in flexible conduit and bond the conductor to the cabinet, outlet box, etc., at each end of the run. Ground connections shall be made by means of welded or bolted ground clamps or grounding-type bushings.

C. Equipment grounding conductors shall be provided with green colored insulation in accordance with the National Electrical Code.

D. The service shall be grounded in accordance with Article 250 of the National Electrical Code. The size of the grounding conductor shall be in accordance with paragraph 250-94 of the Code and/or as noted on the drawings.

E. Ground rods shall be installed after the finished grade is in place. Ground rods shall be placed no closer to a structure than two (2) feet nor any farther away than ten (10) feet. Locations for ground rods shall be adjusted to avoid interdiction of underground piping, services or structures.

F. All connections to ground rods shall be by exothermic welding only.

G. Splices in ground grid cable and any connections which will be concealed by earth or construction shall be by exothermic welding only.

H. Measure resistance to ground. If the valve is more than 5 ohms, provide additional ground rods until the ground resistance is 5 ohms or less at no additional cost to Owner.

END OF SECTION 16060

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SECTION 16120

WIRE, SPLICES AND TERMINATIONS (600V OR LESS)

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SECTION 16120

WIRE, SPLICES AND TERMINATIONS (600V OR LESS)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - apply to work specified under this section.

1.02 SCOPE

A. Work includes labor, materials, equipment and services for installation of complete system of conductors for the electrical installation as indicated.

1.03 SUBMITTALS

A. Submit manufacturer's product data in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Submit detailed sheets of kits, materials, splicing and terminating methods and instructions. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 INSULATED SINGLE CONDUCTOR CABLES

A. Secondary wiring within buildings shall be soft drawn copper with 600 volt insulation rated for 90 degrees C, and shall be manufactured in accordance with requirements of the NEC, UL, ASTM, NEMA, and ICEA.

B. Wire and cable shall be delivered to job site in full coils or reels, each bearing a tag containing UL approval stamp, name of manufacturer, trade name, code, type of wire, and month and year of manufacture.

C. Conductor insulation shall be NEC type "THWN-2", "THHN", "XHHW", or "XHHW-2", adequately color coded for identification, unless otherwise indicated. Conductor size shall be as defined by standard American Wire Gauge (AWG) numbers or circular mils where indicated.

D. Conductors #8 and larger shall be stranded.

E. Minimum size for power and lighting circuits shall be #12. Minimum size for 120 Volt control circuits shall be #14.

F. For vibrating equipment, wiring shall be stranded.

2.02 BARE SINGLE CONDUCTOR CABLES

A. Bare copper ground wire shall be soft drawn copper and shall conform to ASTM B-3.

B. All conductors #2 and smaller shall be solid. Conductors #1 and larger shall be stranded and shall conform to ASTM B-8.

2.03 MULTICONDUCTOR VARIABLE FREQUENCY DRIVE CABLE

A. Conductors:

1. Stranded tinned copper.
2. Insulation: 600 volt cross linked polyethylene, UL Type XHHW-2.
3. Grounding Conductors: Three symmetrical BC grounds.

B. Sheath:

1. UL 1277 Type TC, 90 degrees C.
2. Spiral copper tape shields, 100 percent coverage.

C. Outer Jacket: Polyvinyl Chloride (PVC) per UL 1277.

D. Manufacturer:

1. Belden Series 29500
2. Service Wire Co.
3. Approved equal

2.04 TERMINATION AND SPLICING FITTINGS

A. Fittings for termination or splicing stranded wire shall be solderless and designed for stranded wire circumferential compression type fittings. Thomas and Betts, Brundy, Square D, or equivalent.

B. Splices (junctions which occur below grade (including those in NEMA 4 junction boxes)) shall be 3M "Scotch-cast" insulated.

C. Splices in branch circuit and control wiring #10 and smaller shall be made with insulated spring connectors, Ideal "Wirenuts" or equivalent.

2.05 PULLING COMPOUND

A. Pulling compound shall be UL approved, "Y-ER-EASE", or equivalent. Soap, grease or any substance other than specified shall not be permitted.

PART 3 - EXECUTION

3.01 GENERAL

A. All wire shall be installed in raceways.

B. Multi-conductor variable frequency drive power cable, UL Type XHHW-2 shall be provided between variable frequency drive and motor.

3.02 INSTALLATION

A. Grounding, neutral, and phase conductors shall be pigtailed for connection to receptacles so that any receptacle may be disconnected without interrupting connections to other receptacles on same multiwire branch circuit.

B. No wiring shall be installed until building is under roof.

C. Do not install wire in raceways until after concrete work or plastering is completed. Raceways, in which moisture has collected, must be swabbed out before pulling in wire.

D. Wiring exposed to temperatures higher than 30 degrees Celsius shall have insulation properly rated for temperatures it must withstand (i.e., wiring in lighting fixtures or electric heating equipment, unless provided by fixture or equipment manufacturer shall be type THHN, AVB, or other).

E. Phase wires shall be color coded. Phase wires #8 AWG and smaller shall be color coded throughout entire length. Phase wires larger than #8 AWG may be color coded by applied sleeves or taped at each splice and termination, and at maximum 3 feet intervals for any accessible segment and within 2 inches of wire terminations. Color coding shall be as follows:

PHASE	208Y/120V	480V	480Y/277V
PHASE A	BLACK	BROWN	BROWN
PHASE B	RED	ORANGE	ORANGE
PHASE C	BLUE	YELLOW	YELLOW
NEUTRAL	WHITE	---	GRAY
GROUND	GREEN	GREEN	GREEN

F. Green colored insulated equipment grounding "Green Wire" conductors shall be provided for feeders and for branch circuits. "Green Wire" grounding and neutral wires shall be color coded throughout entire length. Provide "Green Wire" grounding conductor, in addition to grounding provided by raceway system enclosing branch circuit or circuits. Size of "Green Wire" grounding conductor shall conform to NEC requirements. Ground conductor shall interconnect grounding terminal of each receptacle, lighting fixture or equipment enclosure containing circuit and grounding bus or terminal at point of origin of respective circuit. "Green Wire" grounding conductor shall be run with each respective feeder and branch circuit conductor group and with each multiwire branch circuit conductor group. At each receptacle location, connect "Green Wire" system to receptacle enclosure using separate pigtail.

G. Branch circuits shall be provided only as single or combined wiring groups, as follows:

1. One section of raceway shall not enclose more than one branch circuit or multiwire branch circuit, unless otherwise indicated.
2. Where more than one branch circuit or multiwire branch circuit share common enclosure (i.e., pull box or junction box or wiring trough). Wiring comprising each branch circuit and multiwire branch circuit shall be secured as group by "ties" or other grouping devices at intervals not to exceed 3 inches, where accessible.
3. Where branch circuits and multiwire branch circuits are routed in wireway, increase wiring size, as required, to comply with derating requirements of NEC.

H. Wire sizes for 20 ampere, 120 volt or 277 volt lighting or receptacle branch circuits shall be based on circuit total lengths (measured horizontally and vertically along path from Panelboard to load), as follows:

Wire Size	120V to Ground Max Total Length	277V to Ground Max Total Length
#12	75' or less	150' or less
#10	100'	250'
# 8	over 100'	over 250'

1. Where wire size is specifically indicated and voltage drop is in accordance with NEC, length restrictions noted above do not apply (i.e., motor branch circuits).
2. Where wire size is increased only to accommodate length relationships noted above, taps (i.e., pigtails to devices) up to 10' long may be made with #12 at utilization points.

3.03 WIRE IDENTIFICATION

A. Provide wire identification in accordance with Section 16010 - ELECTRICAL GENERAL PROVISIONS.

3.04 SPLICES AND TERMINATIONS

A. Screw-on "Wirenut" type fittings shall not be used for connecting stranded wiring, unless strands are twisted for each conductor before installing "Wirenut".

B. Aluminum fittings shall not be used for wire connections.

C. Where stranded wires are terminated in screw pressure connection, approved fittings and installation methods shall be used to avoid separating strands.

D. No splices or joints will be permitted in either feeders or branches, except at outlets and accessible junction boxes. Joints in branch-circuit shall be mechanically and electrically secure with solderless connectors as listed by UL, as pressure type, 600-volt rating, compression or indent type. Connectors shall be insulated by approved preformed type with integral or separate cover, or by means of taping with approved plastic or rubber and friction tapes to provide insulating value equal to that of conductors being joined. In making of splice, connectors shall be brought up securely upon the conductor, ensuring conductors are equally engaged, the insulation is not ruptured, no bare wires are exposed or have "back-off" due to application of pressure and connector will not loosen due to cycling or vibration, in order to insure an efficient splice. Number, size and combinations of conductors permitted by UL, as listed on manufacturer's packaging of connector, shall be strictly complied.

E. Splice connectors shall be manufactured and installed so that conductor insulation will not be reduced when conductor is positioned in final location. Tools used to compress fittings shall be type which requires proper compression before tool can be released.

F. Insulating materials for splices and connections such as rubber, friction, glass and synthetic tapes, putties, resins, splice cases, compositions, and other materials shall be approved for that particular use, location, voltage, and installed in accordance with manufacturer's recommendations.

END OF SECTION 16120

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SECTION 16130

RACEWAYS

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SECTION 16130

RACEWAYS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - apply to work specified under this section.

B. Requirements of this section of specification apply to and form part of individual electrical sections of the specification.

1.02 SCOPE

A. Work includes labor, materials, equipment and services for installation of complete raceway system.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Refer to Section 03300 - CAST-IN-PLACE CONCRETE

B. Refer to Section 16120 - WIRE, SPLICES AND TERMINATIONS (600V OR LESS)

C. Refer to Section 16190 - FIRE SPREAD PREVENTION

D. Refer to Section 16411 - UNDERGROUND RACEWAYS AND DUCTBANKS

1.04 SUBMITTALS

A. Submit shop drawings and manufacturer's product data, in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications, installation instructions and general recommendations for each type of raceway required. Include data substantiating that proposed materials comply with specified requirements for each type of raceway.

B. Submit dimensioned shop drawings of raceway systems showing layout of raceways, fittings and spatial relationships to associated equipment and adjoining raceways. Show connections to electrical panels, feeders, and motors.

PART 2 - MATERIALS

2.01 GENERAL

A. Raceways shall be UL listed and bear the UL label, unless otherwise indicated.

B. Raceways for hazardous locations shall be specifically approved by UL or Factory Mutual, for its intended application.

2.02 RIGID METAL CONDUIT (RMC) RACEWAY

A. RMC raceway shall also be known as galvanized rigid steel raceway (GRS). RMC raceway shall be steel, zinc coated for corrosion protection and shall comply UL 6, Federal Specification WWC-581 and ANSI Specification C80.1. Threads shall be protected from corrosion as soon as possible after they are cut by plated or painted finish.

B. Polyvinylchloride (PVC) coated RMC raceway shall be steel, hot-dipped galvanized inside and out prior to application of protective coating. PVC coated RMC shall comply with UL 6, ETL PVC-001, NEMA, , ANSI Specification C80.1 and shall bear the UL listing mark #E-65583, and ETL PVC-001. Exterior coating shall be applied with nominal thickness of 40 mils to raceway, which has been treated with primer before coating is applied. Urethane coating shall be applied to interior of raceway to nominal thickness of 2 mils. The exterior and interior coatings shall be continuous, except for threads, and shall be made in accordance with NEMA Standards Publication RN1.

2.03 LIQUID TIGHT/FLEXIBLE METAL CONDUIT (LT/FMC) RACEWAY

A. LT/FMC raceway for feeder and branch circuits of general wiring systems shall be constructed of galvanized steel core with thermoplastic jacket and integral copper ground wire, and shall comply with UL 360 and Federal Specification WWC-566, Type 1. Liquid tight jacket shall conform to NEMA RN1. Provide Anamet or equivalent.

B. In hazardous areas, LT/FMC shall have stainless steel braid covering with flexible stainless steel inner core and wire duct liner. LT/FMC shall comply with UL 886. Provide Crouse-Hinds Couplings, or equivalent.

2.04 COUPLINGS AND FITTINGS FOR STEEL RACEWAYS

A. Couplings shall be steel finished with coatings inside and outside of zinc or cadmium.

B. Couplings for RMC, except where encased in concrete or in hazardous locations, shall be threaded (solid or split). Where encased in concrete or within masonry, couplings for RMC raceway shall be solid (not split in half or down one side) threaded steel fittings only.. In hazardous locations, couplings for RMC raceway shall be solid (not split in half or down one side) threaded steel fittings only.

C. Provide type "A" insulating bushings by OZ/Gedney, or equivalent, on RMC raceway terminations.

D. Box connectors for LT/FMC raceway shall comply with Federal Specification WF 406B and shall be liquid tight with insulated throat as manufactured by Sepco, or equivalent. Provide straight or 90 degree connectors suitable for use in its intended application.

E. Fittings shall be compatible with raceway and box accommodated. Fittings for RMC shall be threaded and shall conform to Federal Specification W-C-408. Fittings for PVC coated raceway shall be of same manufacturer as raceway, and shall conform to same standards. Fittings for LT/FMC shall meet Federal Specification W-F-406, Type I, Class 3, style as required.

F. Fittings for use in hazardous locations shall conform to UL 886, and shall be specifically approved by UL or Factory Mutual, as suitable, for its intended application.

G. Expansion fittings for use with RMC raceway shall be type AX or EX by OZ/Gedney, or equivalent. Expansion/deflection fittings for use with RMC shall be type DX by OZ/Gedney, or equivalent. Type of fitting shall be properly chosen for type of movement anticipated.

2.05 CONDUIT OUTLET BODIES FOR STEEL RACEWAYS

A. Conduit outlet bodies shall conform to UL 514, Federal Specification W-C-586b and ANSI Specifications C80.4 and C33.84.

B. Conduit outlet bodies shall be hot-dipped zinc galvanized iron alloy where used with RMC, galvanized steel raceway, and shall have factory applied PVC jacket where used with like coated raceway.

C. Conduit outlet bodies for RMC conduit systems shall be provided complete with threaded hubs, neoprene gaskets and cast covers.

2.06 POLYVINYLCHLORIDE RIGID NONMETALLIC CONDUIT (PVC) RACEWAY

A. PVC raceway shall be heavy wall polyvinylchloride type 40 conforming to NEMA TC-2 and Federal Specification WC-1094. PVC raceway shall be suitable for concrete encased or direct burial underground applications. PVC raceway shall have reduced emissions of smoke and HCL under fire conditions.

B. PVC raceway for telephone and communications applications shall be heavy wall polyvinylchloride conforming to NEMA TC-10, NEMA GT8343 and other applicable local telephone company standards. PVC raceway shall be suitable for concrete encased underground applications. Telephone duct installed above grade shall be suitable for exposed applications.

C. PVC raceway for power circuits shall be suitable for use with 90 degree C. conductors.

2.07 COUPLINGS AND FITTINGS FOR PVC RACEWAYS

A. Couplings and fittings for PVC raceway shall conform to NEMA TC-3.

B. Couplings and fittings for PVC raceway encased in concrete, for direct burial applications or within masonry shall provide watertight connections and shall be suitable for encasement in concrete.

2.08 WIREWAY

A. Wireway raceway shall be steel with all surfaces finished with coating to protect against corrosion,. Wireway raceway shall be complete with covers and associated assemblies, (including: adapters, elbows, three-way junction, four-way junction, and telescopic hangers to accommodate installation of wiring using "Lay-in" methods.

B. Oil-tight, dust-tight, watertight wireway raceway (NEMA 4X) shall conform to UL 870, and shall be not less than 14- gauge 304 stainless, except that end flanges shall not be less than 10-gauge 304 stainless steel. Wireway shall be gasketed and provided with quick release screw clamps. Hoffman or equivalent.

C. Oil-tight, dust-tight wireway (NEMA 12) shall conform to UL 870, and shall not be less than 14-gauge steel, except that end flanges shall not be less than 10-gauge steel. Wireway shall be constructed without knockouts, and shall be provided with corrosion-resistant phosphatizing primer and ANSI-49 grey epoxy finish. Wireway shall be gasketed and provided with quick release cover latches. Square D or equivalent.

2.09 ELBOWS AND OFFSETS

A. Preformed elbows and offsets shall conform to same standards as respective raceway.

2.10 MISCELLANEOUS

A. Cable Supports shall be OZ/Gedney type "S", or equivalent.

B. Wall entrance seals shall consist of hot-dipped galvanized sealing gland assembly capable of providing seal around conduit to withstand 50-foot head of water without leakage. Shell of seal shall have at least two cast collars at right angle to sleeve that is embedded in concrete. Entrance seals shall be OZ/Gedney. Suitable for use with new or existing construction as applicable.

C. Conduit seals shall be as manufactured by Crouse-Hinds, Appleton, or equivalent.

PART 3 - EXECUTION

3.01 GENERAL

A. Install wiring in raceways, unless otherwise indicated.

B. Provide labeling in accordance with Section 16010 - ELECTRICAL GENERAL PROVISIONS

3.02 RACEWAY METHODS

A. PVC coated rigid steel raceway shall be used throughout, except where LT/FMC is required. RMC shall be used in the Dryer Building Electrical Room.

B. LT/FMC raceway shall be used:

1. In short lengths not to exceed three (3) feet for connection to motor terminal boxes, dry type transformers and vibrating equipment. Where such equipment is exposed to weather in damp or wet locations, LT/FMC raceway shall be employed.

C. Raceways installed beneath concrete slabs on grade shall be PVC encased in minimum of 3" of concrete on all sides.

D. Concealed raceway run below finish grade shall be PVC and shall be encased in minimum of 3" of concrete on sides, except as noted on drawings or as indicated in Section 16411 - UNDERGROUND RACEWAYS AND DUCTBANKS.

E. RMC raceways turning from below waterproofing membrane of slab on grade to enter building shall be provided with polyvinylchloride coated RMC elbows.

F. Raceway methods in hazardous locations, as defined, by NEC shall be performed in strict compliance with NEC for class, division, and group indicated. Boundaries of hazardous locations shall be as indicated, or defined by NEC.

G. Exposed raceway installed outdoors and in and hazardous locations shall be PVC coated rigid steel.

3.03 INSTALLATION REQUIREMENTS

A. Where LT/FMC raceways and associated fittings are not UL approved as grounding means, raceway shall contain ground wire bonded to boxes.

B. Provide cable supports in conduit raceway risers, as required, by NEC or as indicated.

C. Raceway sizes shall be in accordance with NEC, except as follows:

1. Minimum 3/4", except that 1/2" may be used for control and signal wiring between outlet boxes and recessed lighting fixtures and as indicated.
2. Where indicated.

D. Raceways shall be installed exposed, unless otherwise indicated.

E. Raceway shall be installed with no interference with other trades. Raceways shall be supported at interval, as required, by NEC but not greater than 10 feet. Raceway supports shall be in accordance with the following:

1. Exposed raceways shall be run parallel on wall or ceiling, and shall follow contours of surface to which they are attached. Support raceways employing PVC coated steel one-hole pipe clamps securely fastened to surface to which raceway is attached.
2. Suspended raceways shall be supported by hangers used only for raceway support. Hanger rods shall not penetrate air ducts or equipment of other trades. Raceways shall not be supported from ducts, pipes or hangers provided under other divisions for support of pipes, ducts, or suspended ceilings.

    a. Individual exposed raceway 1 1/4" and smaller shall be supported from 1/4" PVC coated steel rod employing PVC coated steel raceway hangers.

3. Where two or more suspended raceways are run together, they shall be suspended from structure by means of "trapeze" hangers. Hangers shall consist of PVC coated angle or channel iron employing PVC coated "U" bolts to secure raceway at each support.
4. Parts and hardware used for support of equipment, conduits, and fittings shall be galvanized PVC coated steel for exterior, damp or wet locations. Supports for PVC coated conduits shall be PVC bonded. Provide PVC coated steel fasteners for exterior, damp, or wet locations.

F. No raceway shall pass through beams, unless so indicated by Engineer. Raceway shall be located minimum of 6" from steam and hot water piping.

G. Raceway passing from heated to unheated spaces, conditioned spaces to unconditioned spaces, exterior spaces, refrigerated spaces, cold section plenums of air conditioning units, shall be suitably sealed by means of "Duxseal" or sealing fittings to prevent accumulation of condensation.

H. Raceways passing through boundaries, which are indicated as requiring vermin proofing, shall be sealed internally with Johns-Manville "Duct-Seal", or equivalent. Pack annular spaces between raceways and building construction with mineral wool or fiberglass, caulked at both sides with Pecora "Synthacaulk" or Proseal "Ultrasite", or equivalent, in general areas.

I. Cap raceways immediately after installation to prevent entrance of debris and moisture.

J. Raceways turning from slab to enter partition shall be totally concealed.

K. Raceways in close proximity to one another in concrete slabs (at panelboards, switchboards, and motor control centers shall be located and wrapped with wire mesh to prevent cracking of slab, as directed, and approved by Structural Engineer.

L. Raceway nipples connecting outlets in adjoining rooms shall be packed with Johns-Manville "Duxseal", or equivalent, after wires are in place to prevent transmission of noise between rooms, unless nipples are 12" or more in length.

M. Provide No. 14 AWG zinc-coated steel or 1/8" polypropylene pull cord having not less than 200 pound test strength in empty raceways 2" diameter or less. Provide 3/16" 3-strand polypropylene pull cord having not less than 800 pound test strength in empty raceways greater than 2" diameter. Provide minimum of 2 feet of slack pull cord at each end of raceway.

N. Conduit outlet bodies may be installed in exposed work to facilitate wiring installation and, as indicated. They shall not be used for raceway which are to contain cables which cannot tolerate sharp bends.

O. Fireproofing of penetrations of raceways through floors and fire rated walls is specified under Section 16190 - FIRE SPREAD PREVENTION.

P. Provide expansion fittings or expansion/deflection fittings in each raceway crossing building expansion joint or as required by installation to accommodate expansion, contraction or deflection of raceway.

Q. After installation of PVC coated raceways touch-up exposed bare metal with manufacturer's approved touch-up compound.

R. Those installer PVC coated conduit shall be certified by the manufacturer and be able to present a valid, unexpired certified installer card.

3.04 CONCRETE ENCASEMENT

A. Unless otherwise indicated, concrete work for concrete encasement of raceways shall be provided under this section of the specification. Concrete work shall conform to the requirements of Section 03300 - CAST-IN-PLACE CONCRETE.

END OF SECTION 16130

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SECTION 16131

BOXES AND CABINETS

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SECTION 16131

BOXES AND CABINETS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - apply to work specified under this section.

1.02 SCOPE

A. Work includes labor, materials, equipment and services for installation of complete system of outlet, pull and junction boxes.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturer's product data, in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 GENERAL

A. Provide suitable box at outlets especially designed to receive type of fixtures and devices to be mounted thereon, except where otherwise noted for recessed fluorescent fixtures. Provide fixture outlets with fixture supports of size and type required for fixture to be hung. Fixture studs, generally, shall be 3/8 inch.

B. Boxes shall be of type approved for particular purpose intended.

C. Recessed wall outlet boxes shall be at least 4 inches square, except where otherwise indicated.

D. Provide box covers to fit outlet box installed of required depth so edge of ring is flush with finished plaster, masonry, acoustical material, and other finishes.

2.02 OUTLET BOXES

A. Single-, two-, three- and four-gang outlet boxes for use with RMC raceway shall be cast iron FS or FD boxes conforming to UL 498, UL 514 and Federal Specification W-C-586B. Provide matching cast iron covers with neoprene gasket and stainless steel screws.

B. Outlet boxes for use with PVC coated RMC shall be PVC coated galvanized cast metal type with tapped hubs for conduit entrance. Covers shall be of PVC coated galvanized cast metal with rubber gasket. Box bodies and covers shall have a minimum 40 mil-thick polyvinyl chloride jacket on exterior surfaces.

C. Cast outlet boxes installed in hazardous areas, as defined by NEC, shall be PVC coated and suitable for Class, Division and Group location as indicated. Outlet boxes shall conform to Federal Specification A-A-50563 and UL 886, and shall bear UL label as suitable for intended application.

2.03 PULL AND JUNCTION BOXES

A. Provide junction or pull boxes where indicated, and where required to facilitate wire pulling and connection. Provide labels in accordance with Section 16010 - ELECTRICAL GENERAL PROVISIONS.

B. Pull and junction boxes less than 100 cubic inches shall be as specified for outlet boxes.

C. Pull and junction boxes 100 cubic inches and larger shall be fabricated from 12-gauge minimum galvanized steel and equipped with screw cover unless otherwise noted. Sheet metal boxes shall be adequately supported to maintain shape. Interior boxes in electrical and air compressor rooms shall be NEMA 1 construction, unless otherwise noted. Exterior boxes or boxes exposed to excessive moisture shall be NEMA 4X construction. Outdoor flush junction boxes shall be watertight (NEMA 4) outside flanged recessed cover type "YR" as manufactured by OZ/Gedney, or equivalent.

D. Pull and junction boxes 100 cubic inches and larger for use with PVC coated RMC shall be 12-gauge minimum 304 stainless steel. Pull and junction boxes 100 cubic inches and larger for use with PVC raceway shall be fabricated from PVC, or equivalent nonmetallic product. Exterior boxes and boxes exposed to excessive moisture shall be NEMA 4X construction with watertight gasketed covers and external mounting feet.

E. Pull and junction boxes 100 cubic inches and larger installed in hazardous areas, as defined by NEC, shall be suitable for Class, Division and Group as indicated. Boxes shall have neoprene gasket, stainless steel hinges and natural stainless steel finish. Pull and junction boxes shall conform to UL 886 and shall bear UL label, as suitable for intended application.

F. Sheet metal boxes shall be supported to maintain shape. Larger boxes shall be formed of structural bracing into rigid assembly to maintain alignment in shipment and installation.

G. Drain fittings shall be provided in NEMA 4X boxes. Crouse-Hinds, Killar, or equivalent.

2.04 PUSHBUTTON ENCLOSURES

A. Boxes for pushbutton enclosures shall be as specified for Junction and Pull boxes, except that NEMA 12 and NEMA 4X pushbutton enclosures shall conform to UL 508 and pushbutton enclosures installed in hazardous areas as defined by NEC shall conform to UL 698, and shall bear UL label as suitable for its intended application.

2.05 CABINETS

A. Provide cabinets for telephone terminal boards, instrumentation terminal boards and as indicated.

B. Key all cabinet locks. Match Owner's existing keying system.

C. Cabinets shall be NEMA 12 construction with gasketed door and constructed of code gauge 304 stainless steel, unless otherwise indicated. Fronts shall be fitted with continuous side hinged door and stainless steel flush lock with pin tumbler. Control panel cabinets shall be fitted with rear door where indicated. Doors greater than 48 inches in height shall be equipped with three-point latch and vault lock. Cabinets in office areas and in electrical equipment rooms may be of NEMA 1 steel construction. Cabinets in exterior locations or in areas exposed to excessive moisture shall be code gauge 304 stainless steel NEMA 4X construction with gasketed doors.

PART 3 - EXECUTION

3.01 GENERAL

A. Boxes and cabinets shall be sized in accordance with NEC, or as indicated.

B. Floor mounted cabinets shall be mounted on 4-inch high concrete pad in accordance with manufacturer's recommendations. Install where indicated and level in place.

3.02 INSTALLATION

A. Each box shall be securely supported at two or more points and two or more sides to prevent movement in all directions.

B. Boxes shall support devices and face plates. Face plates and devices shall not be used to support boxes.

END OF SECTION 16131

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SECTION 16140

WIRING DEVICES

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SECTION 16140

WIRING DEVICES

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation of complete system of wiring devices.

B. Provide wiring devices for each outlet at the location indicated on the drawings. All devices shall be the product of the same manufacturer, unless of a specified type especially approved for the purpose which is not manufactured by the manufacturer selected for most of the other devices.

C. Check all door swings and be responsible for installing all room light switches associated with doors on the striking side of all doors. If switches are indicated otherwise, the Contractor shall contact the Owner for clarification before installation.

1.03 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc. in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 GENERAL

A. Devices shall comply with UL, NEMA and IEEE standards.

B. Wiring devices shall be as manufactured by Leviton, Cooper, Pass and Seymour, or Hubbell, unless otherwise noted.

2.02 WALL SWITCHES

A. Lighting control switches shall be heavy-duty, specification grade, toggle, quiet type, back and side wired fully enclosed in a composition case and of highest quality in manufacturer's line. Switches shall be rated 120/277 VAC. Terminal screws shall be suitable for use of up to #10 AWG solid.

B. Switches shall be rated 20 amperes and shall be brown in color, unless otherwise noted on drawings.

2.03 CONVENIENCE RECEPTACLES

A. Convenience receptacles shall be UL specification grade and shall conform to NEMA WD1. They shall be heavy-duty type, back and side wired with a green ground screw terminal, automatic ground clip, fully enclosed in a composition case with a nylon face and have a wraparound bridge for installation strength.

B. Convenience receptacles shall be rated 20 amperes, 125 volts NEMA 5-20R and shall be brown in color, unless otherwise noted.

2.04 DEVICE PLATES

A. Provide device plates for all outlets where devices are installed. Where gang combinations are required, provide the combinations under a single multigang plate.

B. Device plates and blank plates for junction boxes in finished areas shall be .040 inch-thick minimum grade 302 stainless steel with satin finish, and shall be UL listed.

C. Device plates and blank plates in unfinished areas shall be galvanized steel.

D. Provide weatherproof outlet enclosures on exterior outlets. Weatherproof enclosures shall comply with UL 514C. The enclosure shall consist of a gasketed device plate with a hinged gasketed wiring device cover of sufficient depth to allow full closure with attachment plug(s) in use. The cover shall have cord port(s) capable of permitting appropriate sized electrical cord(s) to pass through when cover is closed. The safety enclosure shall be of a polycarbonate resin manufactured in accordance with UL 94 HFl. Screws shall be stainless steel. Weatherproof device plates Safety Outlet Enclosures manufactured by TayMac, or equivalent.

2.05 HAZARDOUS LOCATIONS

A. Lighting control switches installed in hazardous areas as defined by NEC shall be suitable for the Class, Division and Group as indicated on the drawings. Switches shall conform to UL 894, and shall bear the UL label as suitable for its intended application. Switch housings shall be stainless steel finish.

B. Receptacles installed in hazardous areas as defined by NEC shall be suitable for the Class, Division and Group as indicated on the drawings. Receptacles shall conform to UL 1010, and shall bear the UL label as suitable for its intended application. Receptacle housings shall be die-cast copper-free aluminum with fiberglass-reinforced polyester finish and top hinged covers. Provide two (2) matching plugs.

PART 3 - EXECUTION

3.01 GENERAL

A. See Section 16120 - WIRE, SPLICES AND TERMINATIONS - 600V for requirements regarding wiring for switches and receptacles.

END OF SECTION 16140

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SECTION 16190

FIRE SPREAD PREVENTION

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SECTION 16190

FIRE SPREAD PREVENTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation of fire spread prevention products.

B. Where raceways, wire or cables pass through openings in floors or fire rated walls, the openings shall be fire stopped so that the possible spread of fire or products of combustion will not be substantially increased.

1.03 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 FIRE STOP FITTINGS

A. Fire stop fittings and blank plugs shall be OZ/Gedney "Fire Seal" or equivalent having a fire rating equal to or greater than the rating of the floor or wall penetrated.

2.02 FIRE STOP SEALANT

A. Fire resistant foam sealant shall be UL classified silicone. Sealant shall be Chase-Foam, CTC-PR-855 or equivalent by Dow Chemical.

PART 3 - EXECUTION

3.01 GENERAL

A. Where raceway, wire or cables pass through openings in floors or fire rated walls, the opening shall be fire stopped so that the possible spread of fire or products of combustion shall not be substantially increased.

3.02 INSTALLATION

A. Raceways passing through floors or fire-rated partitions, unless cast-in-place during construction, shall pass through cast openings, sleeves or core-drilled holes.

B. Where the annular space between the raceway and opening or sleeve does not exceed 1/2", the opening shall be filled with firmly packed mineral wool.

C. Where the annular openings exceed 1/2", fire-stop fittings, as specified above shall be employed.

D. Where sleeves or round openings are provided for future installations, they shall be sealed by means of blank plugs of type specified above.

E. Openings around wires or cables which penetrate floors or fire rated walls shall be sealed employing "fire-stop" fittings installed in cast openings, sleeves or core-drilled holes, properly sized to accommodate the fittings.

END OF SECTION 16190

SECTION 16231

PACKAGED ENGINE GENERATORS

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SECTION 16231

PACKAGED ENGINE GENERATORS

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 REFERENCES

A. The completed installation shall comply with the requirements of the latest issue of NFPA 37 – INSTALLATION AND USE OF STATIONARY COMBUSTION ENGINES AND GAS TURBINES.

B. Provide a certified engine per the EPA's Nonroad Source Emissions Standard 40 CFR89. The appropriate tier level shall apply based upon the HP of the engine.

C. The electrical generating system shall meet all requirements of NFPA 110-2016 – STANDARD FOR EMERGENCY AND STANDBY POWER SYSTEMS including design specifications, prototype tests, one-step full-load pickup, and installation acceptance.

1.03 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation a standby power diesel engine generator system ready for satisfactory and standby operation.

B. Provide No. 2 diesel fueled engine-generator set with weatherproof housing for exterior mounting, complete with fuel supply system, starting battery and charger, starting and control panels, automatic exercise controller, exhaust silencer and piping, and remote alarm contacts. These are minimal requirements.

1.04 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications, installation instructions and general recommendations for the standby power engine-generator system. Include data substantiating that proposed materials comply with specified requirements.

B. The Contractor shall provide drawings for all schematics and a detailed interconnect diagram for the engine-generator set, controls, battery charging system, automatic

transfer switch and remote alarms in addition to the required catalog cuts. Battery calculations shall also be provided.

C. Upon completion of the project the Contractor shall prepare record ("as built") schematic and interconnect drawings.

1.05 SYSTEM DESCRIPTION

A. Upon loss of any phase of utility power or reduction of the nominal voltage by 10 percent, the engine will automatically start and loads will be transferred from the utility bus to the standby engine bus.

B. When utility power is restored to at least 95 percent of the nominal voltage, the following shall occur:

1. Automatic transfer of load back to utility power after 15 minutes of operation.
2. The engine shall run for a cool down period without load as recommended by the engine manufacturer.
3. If the utility power is lost or reduced by 10 percent of the nominal voltage at any time during this phase of operation, the emergency AC system will automatically pick up the load and reset all timers for proper minimum running time and engine cool down.
4. The automatic standby power system shall be capable of returning all components to the ready mode after utility power has been restored.

C. Standby generator shall be provided with controller to automatically exercise the unit with or without load on a regularly scheduled weekly or biweekly basis.

1.06 QUALITY ASSURANCE

A. The responsibility for performance under this Section in its entirety shall not be split up among individual suppliers of components comprising the standby power system but shall be assumed solely by the supplier of the system. The engine generator set shall be a factory assembled and tested product. Local assembly of components to make an engine generator set will not be acceptable.

B. The engine generator set supplier shall be an authorized sales and service representative of the manufacturer. The supplier shall have a maintenance and service facility within a 100 mile radius of the project site where skilled factory trained service technicians are available on a 24-hour-a-day basis. The service facility shall maintain a full stock of replacement parts and shall offer a full maintenance contract for all equipment furnished.

C. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

D. Comply with ASME B15.1.

E. Comply with NFPA 37.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

I. Comply with UL 2200

J. Noise Emission: Comply with applicable state and local government for noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.07 COORDINATION WITH VFD MANUFACTURER

A. Generator manufacturers shall coordinate their equipment with the VFD manufacturer to assure compatibility and show proof of verification prior to submitting shop drawings. See Contract Drawings.

PART 2 - MATERIALS

2.01 GENERAL

A. Engine-generator set unit shall have a standby rated output of not less than that indicated on drawings at 0.8 power factor at 150 feet altitude with an ambient temperature of 122 degrees F. Unit shall operate at 480Y/277 volts, 3 phase, 4 wire, 60 Hz. Rating shall be with all accessories. Unit shall be arranged for automatic starting and transfer of the emergency starting load upon loss of any phase of the normal power source, and automatic re-transfer and unit shut-down upon restoration of the normal power source.

B. Motor starting KVA shall be based on a sustained RMS voltage drop of no more than 10 percent of no load voltage with the specified load KVA at near zero power factor applied to the engine-generator.

C. The engine-generator shall be provided with safety shields over all belts, rotating parts, exposed gears and similar items.

D. Unit shall be by Cummins/Onan, Caterpillar, or Kohler, of size and configuration shown on the Drawings.

2.02 ENGINE

A. Engine shall be 4 cycle turbo charged, radiator cooled type, having necessary horsepower to deliver the rated output at 1800RPM. Engine shall be equipped with the following:

1. Pressure type fuel injection system
2. Fuel oil pump - high lift with a total suction head of 20 feet
3. Replaceable element type fuel filters
4. Electronic solenoid fuel shut off valve
5. Electronic isochronous governor, steady-state regulation
6. Lube oil pump
7. Lube oil pressure relief
8. Lube oil cooler
9. Lube oil level indicator/dip stick
10. Full flow replaceable lube oil filter
11. Replaceable dry combustion air filter
12. All contacts, sensors and other miscellaneous elements to provide all pre-failure alarms and failure alarms and all shutdown functions required
13. Axial cooling for engine driver
14. Set mounted radiator with a duct mounted flange
15. Heavy-duty 24 volt electric starter motor
16. Engine mounted thermostatically controlled jacket water heater that shall be disconnected whenever the engine starts. Heater shall be 120 volts, single phase, 60 Hz.
17. Thermostats to maintain proper operating temperatures
18. Prestone anti-freeze protection to minus 10 degree F
19. Coolant corrosion resistor with replaceable element
20. Flexible fuel oil lines (supply and return)
21. Self-sealing, pre-lubricated coolant pump
22. Manually operated in-line priming pump
23. Sound attenuating cabinet
24. Outside weatherhood protection
25. Provide one spare filter of each type.

2.03 LUBRICATION

A. All bearings, except those specifically requiring oil or water lubrication shall be pressure grease lubricated. All lubrication points shall be readily accessible away from locations dangerous to workmen. Pressure grease lubrication fittings shall be the "Alemite" type as made by the Stewart Warner Corporation or equal with plastic caps to protect fittings from corrosion and debris. The pattern of the fitting shall be selected for accessibility in lubricating and shall meet the approval of the Engineer. Housings of grease lubricated bearings shall be automatically exhausted to atmosphere to prevent excessive greasing.

B. Furnish lubrication charts and schedules for each piece of equipment or machinery. Lubrication shall be Premium Grade. The charts and schedules shall designate each point of lubrication the type of lubricant to be applied and the frequency of lubrication. Charts and schedules shall be submitted to the Engineer in quadruplicate, bound in folios, with each chart and schedule protected by a transparent plastic envelope.

C. Furnish premium grade lubricants for all of the equipment provided under this contract.

D. Furnish one year's supply of each type of premium lubricant required. A typewritten list shall be furnished with the lubricants, designating the specific lubricant to be used with each piece of equipment. This is in addition to the required operating and maintenance manuals which will also contain lubrication requirements.

E. Provide stainless steel grease header blocks and extension hoses that are supported and properly secured for grease fittings that are located in difficult to reach locations or near rotating and dangerous equipment. The header block shall be adjacent to the equipment and easily accessible as determined by the Engineer.

2.04 GENERATOR

A. Generator shall be single prelubricated bearing, self-aligning, four-pole, synchronous type, revolving field, with amortisseur windings, direct drive centrifugal blower for proper cooling and minimum noise, temperature compensated solid-state voltage regulator, with brushless rotating rectifier exciter system. Generator shall be directly connected to engine flywheel housing and driven through a flexible coupling to insure a permanent alignment; gear driven generators are not acceptable under this Section. Insulation shall meet NEMA MG1 for Class H. The maximum temperature rise shall not exceed 105 degrees C ambient. Generator design shall prevent potentially damaging shaft currents.

B. Voltage regulation shall be solid-state design and shall function by controlling the exciter magnetic field between stator and rotor to provide no load to full load regulation of rated voltage within +/-.5 percent during steady-state conditions. The engine-generator set and regulator shall be able to sustain at least 90 percent of no load voltage for 10 seconds with 300 percent of rated load at near zero power factor connected to its terminals. The voltage regulator shall be insensitive to severe load induced waveshape distortion from SCR or thyrister circuits such as those used in battery charging and motor speed control equipment. Include a permanent magnet generator.

C. Exciter shall be three-phase, full-wave, rectified, with heavy-duty silicon diodes mounted on the common rotor shaft and sized for maximum motor starting loads. Systems using three-wire, solid-state control elements (such as transistors or SCR's) rotating on the rotor shall not be acceptable.

D. Generator shall meet or exceed the NEMA "Standards for Motors and Generators". Generators shall also meet or exceed ANSI and IEEE Standards. Provide generator with interference suppression for MGI-22.43.

E. The three-phase, broad range, reconnectible generator shall have 6 leads brought out to allow connection by user to obtain any of the available voltages for the unit.

2.05 CONTROL PANEL

A. Provide a digital lighted, unit mounted control module that is factory built, wired, tested, and shock-mounted by the generator manufacturer.

B. Engine-generator set control shall include the following:

1. Current and potential transformers as required.
2. Remote, two-wire controls with start-stop terminals.
3. Molded case line circuit breaker equipped with instantaneous magnetic trips and long time thermal trips. The instantaneous trips should be set in a range of 500 percent to 700 percent of the full load current of the alternator. The thermal trips shall operate in 15 to 45 minutes when load current is 120 percent of the rated alternator current.
4. Control circuit protection.
5. Manual selector switch: RUN - STOP - REMOTE.
6. Automatic engine shutdown for the following fault conditions:

    a. Overcrank
    b. Overspeed
    c. Low oil pressure
    d. High engine (coolant) temperature
    e. Operation of a remote manual stop station

7. Indicator lamps shall be provided to signal the following functions:

    a. RUN - indicates start system disconnect (green)
    b. OVERCRANK - indicates the starter has been locked out because cranking time was excessive (red)
    c. OVERSPEED - indicates engine has shutdown because of excessive rpm (red)
    d. HIGH COOLANT TEMPERATURE - indicates engine has shutdown because of critically high temperature (red)
    e. LOW OIL PRESSURE - indicates engine has shutdown because of critically low oil pressure (red)
    f. PRE HIGH COOLANT TEMPERATURE - indicates engine temperature is marginally high (yellow)
    g. PRE LOW OIL PRESSURE - indicates oil pressure is marginally low (yellow)

h. LOW COOLANT TEMPERATURE - indicates inoperative coolant heater
i. SWITCH OFF - indicates control switch is in the "STOP" position (flashing red)
j. LOW FUEL - indicates fuel supply is marginally low (yellow)
k. GROUND FAULT - indicates ground fault (red)
l. Provide two SPARE fault condition lamps to be designated later (red)

8. A fault reset switch shall be provided to clear fault indications and allow restarting of the engine after shutdown faults. The control design shall be such that the fault indication shall remain until reset. The fault indicator memory shall not be dependent on the pressure of either ac or dc voltage and shall retain the fault status memory even through complete removal and replacement of the starting batteries. The fault reset function shall operate only when the RUN-STOP-REMOTE switch is in the STOP position. Provide a test switch for indicating lights.
9. Voltmeter, AC - 2 percent accuracy with three phase selector switch with positions for reading phase-to-phase voltages, phase-to-neutral voltages and off (7 positions total).
10. Ammeter, AC - 2 percent accuracy with three phase selector switch with positions for reading phase currents and off (4 positions total).
11. Frequency meter, 45-65 Hz (direct reading dial type).
12. Running time meter (hours - +/-0.6 Hz accuracy).
13. Oil engine pressure gauge.
14. Coolant temperature gauge.
15. Remote stop switch contacts with remote stop switch mounted as shown on plans.
16. Voltage regulator.
17. Cranking cycler to provide three - 15 second cycles with provisions for recrank in the event of a false start.
18. Provisions for low voltage shutdown.
19. Lube oil temperature gauge.
20. Kilowatt meter.
21. Provide dry contracts for the following signals:

a. Generator running.
b. Generator warning.
c. Generator shutdown.

C. Provide a 120 VAC heater with thermostat within the control panel to eliminate condensation.

2.06 BATTERIES

A. Provide 24V DC engine start batteries sized to provide a minimum of 90 seconds of cranking. Control batteries shall be sized to provide control power for all functions

for 12 hours upon loss of utility power. Batteries shall be lead acid. Batteries are to be equipped with explosion proof vents.

B. Provide a skid mounted welded steel battery rack for control and start batteries with bottom pan and an acid resistant molded plastic liner. Angles shall be arranged to support batteries on all sides. Grind smooth and thoroughly clean all welds. Paint with a rust resistant prime coat and an acid resistant finish coat.

C. Provide heavy-duty battery cables and all necessary accessories required to interconnect the batteries and engine generator set.

2.07 BATTERY CHARGER

A. Provide a wall mounted fully automatic current limiting, self-protecting battery charger to automatically recharge the batteries. The charger shall be sized to charge both the start and control batteries. The charger shall maintain 24V DC output voltage with 120 Vac line voltage fluctuations of +/- 10 percent. Provide:

1. Two ranges - float and equalize for lead acid batteries.
2. Automatic AC line compensation.
3. DC cranking disconnect relay to disconnect battery during engine cranking.
4. Automatic surge suppressors.
5. Ammeter and voltmeter, DC.
6. Fused AC input and dc output.
7. Selector switch to transfer from float charge to high rate equalize charge.
8. Low battery voltage sensor and red light.
9. High battery voltage sensor and red light.
10. Charging current failure (loss of AC power) sensor and red light and alarm.
11. Power on green light.

B. Provide contacts for remote annunciation of the following:

1. Low battery voltage.
2. High battery voltage.
3. Charging current failure (loss of AC power).
4. Start battery rectifier failure.

C. The charger shall meet requirements of UL 1236.

2.08 FUEL TANK

A. Provide a dual wall sub-base fuel storage tank with a minimum capacity for continuous 24 hours full load operation. The tank shall be constructed of corrosion resistant steel and shall be UL 142 listed with a Line-X type spray coating. The equipment, as installed, shall meet all local and regional requirements for above ground tanks. It shall include low fuel , and liquid in rupture basin leak alarms and

have all required vents. Fill shall be 2" NPT connection and both the inner and outer pressure relief vents shall be 4" NPT and furnished by the manufacturer of the tank.

B. A Direct Mechanical Level Gauge shall be provided as follows:

1. The direct mechanical level gauge shall be the floating arm level mechanism type with thermometer style liquidator. The float-operated mechanism shall be non-corrosive and have brass rivets secure float arm to gauge indicator arm with no gears, cams, magnets, or tapes to wear, adjust or replace.
2. The thermometer type indicator shall stand out boldly against the calibration chart. The gauge shall feature a zinc based, two-piece die-cast assembly, calibration chart between heavy plastic domes, non-corrosive rivets, and a coated float impervious to fuel oils. The complete unit shall be capable to withstand air pressure in excess of 70 psi.
3. the float arm assembly shall be adjusted according to the tank dimensions. The direct mechanical level gauge shall be Therma-Gauge, manufactured Kreger Sentry Gauge Co., "or equal".

2.09 EXHAUST SYSTEM

A. Provide a critical type exhaust silencer, with flanged inlet and outlet connections mounted so that its weight is not supported by the engine. Provide a flanged flexible stainless steel exhaust pipe, gas proof, 18 inches long minimum connection between the engine exhaust manifold and the silencer.

B. Exhaust piping and muffler shall be sized so that the total back pressure shall not exceed the maximum allowable engine back pressure. Piping shall be Schedule 40 316 stainless steel.

C. Provide an exhaust condensation trap with manual drain valve to prevent condensation from entering the engine.

D. Provide a suitable wall thimble, rain cap at the exhaust outlet, expansion and contraction fittings and similar items as required for the exhaust pipe installation and termination and to protect the [building construction] [weatherproof housing].

E. Exhaust silencer and exhaust pipe shall be installed within generator enclosure.

2.10 FUEL OIL PIPING

A. All fuel oil and vent piping shall be black steel pipe conforming to American Society for Testing Materials (ASTM) Standard ASTM A-106, Grade B, Schedule 40. Fittings for piping within chamber shall be 150-pound malleable iron fittings. Coat piping and fittings with High-Mil Sher-Tar Epoxy Coating (Sherwin Williams). All piping joints shall be fully formed prior to applying coating.

B. Pipe joint sealant shall be teflon tape.

2.11 WEATHERPROOF HOUSING

A. The engine generator set, complete with battery charger, generator control panel and other accessories shall be enclosed in a modular constructed weatherproof housing. The enclosure shall be vermin-proof. The enclosure shall be constructed with removable side panels and end panels. The top and end panels shall be aluminum. The units shall have side and rear access doors.

B. Provide fixed louvered air intake ports on the enclosure sides. Ports shall be provided with bird screen. Gravity shutters which open upon engine start-up shall be provided at the fan discharge end.

C. Provide a 120 VAC alternator heater within the generator to eliminate condensation.

D. Unit shall be provided with a weatherproof shield sound attenuated enclosure, which shall reduce average noise level to 75db at 25 feet.

PART 3 - EXECUTION

3.01 GENERAL

A. Engine generator set shall be installed complete with all accessories. Provide all interconnecting wiring, power wiring, battery wiring, piping, fuel storage tank, etc.

3.02 INSTALLATION

A. Adjust start battery rectifier so that meters accurately indicate voltage.

B. Provide main fuel tank, gauges, valves, tank fill fittings, tank vent fittings, and necessary items as specified to provide a complete system.

C. Contractor shall fill the fuel storage tank serving the engine generator set with the proper fuel at time of Acceptance.

D. Engine, generator and radiator shall be mounted on a common structural steel base provided with shock or anti-vibration mounts, and mounts bolted to concrete pad.

3.03 FACTORY TESTS, CERTIFICATION AND WARRANTY

A. The engine generator set, set-mounted controls, and automatic transfer switch shall be factory assembled and tested prior to delivery to the site. A copy of the factory test report shall be provided, certifying the set maximum power level, voltage and frequency regulation, engine speed regulation, alternator temperature rise, proper operation of automatic controls, etc.

B. The engine generator set shall be of a series which has been tested in accordance with procedures certified by an independent testing laboratory. Tests shall include the following:

1. Maximum power level
2. Maximum motor starting capability (KVA)
3. Structural soundness
4. Fuel consumption
5. Engine alternator cooling air flow
6. Transient response and steady-state governing
7. Alternator temperature rise
8. Single step load pickup
9. Harmonic analysis and voltage wave form deviation
10. Three-phase short circuit test for mechanical and electrical strength
11. Perform factory testing at full load and rated power factor (0.8) for two hours prior to shipment from the factory.

C. The complete system shall be warranted by the manufacturer for a period of two years parts and labor (no deductible) after successful onsite test and acceptance by the Owner. Individual element warranties are not acceptable. Warranty document shall be provided.

3.04 ONSITE TESTS

A. In addition to the factory tests called for above, the Contractor shall perform the following onsite tests of the complete system:

1. After installation of the set is complete, but before final load side connections have been made, perform a load test under manual control with the set carrying its full rate load for a continuous period of not less than 4 hours, and include starting and stopping the set at least 5 times. Operate the set both automatically and manually. Provide a load bank and all required temporary cabling. Observe all engine-generator functions, readings, operational check points, alarms, etc.
2. After final electrical connections have been made and all equipment has been installed, perform a second load test with the set carrying the standby load through the automatic transfer switch, under automatic control, for not less than 1 hour, starting and stopping the set not less than 3 times. Observe all engine-generator functions, readings, operational check points, alarms, etc. Perform field testing using a resistive load bank (1.0 p.f.).
3. Test and demonstrate to Owner's personnel the proper operation of all automatic shutdowns, automatic start/stop controls, transfer switch operation, meters and instruments, etc.
4. Test data shall be collected and recorded on the following:

a. time of day
b. coolant temperature
c. operating oil pressure
d. battery charging rate
e. cranking time
f. crank-to-rated frequency time
g. voltage and frequency overshoot
h. load assumption-to-steady state voltage and frequency stabilization time
i. operating voltage, frequency, current, kilowatts and power factor

5. Monitor and record required test information as specified in NFPA 110.
6. Provide a certification test report and 2-hour load bank test from the factory.

B. Provide a qualified manufacturer's representative during all tests and for instructional period.

C. Repair any defects found during any part of the tests, as soon as possible, and reconduct that part of the test.

D. At least two weeks notice shall be given prior to engine-generator test.

3.05 MAINTENANCE MANUALS

A. The Contractor shall provide Operation and Maintenance (O&M) material in accordance with Division 1 and as specified herein. The manual shall include the following:

1. Catalog data and detailed specification sheets for all elements of the system.
2. Schematics and wiring diagrams for all elements of the system.
3. Detailed interconnection diagrams for the engine-generator set, controls, battery charging system, and remote alarms.
4. Complete operating instructions, maintenance data, and parts list for all elements of the system.
5. Engine-generator factory test and onsite test reports.

END OF SECTION 16231

SECTION 16269

VARIABLE FREQUENCY DRIVES (VFD'S)

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SECTION 16269

VARIABLE FREQUENCY DRIVES (VFD'S) - SIX PULSE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Section 11211 "Horizontal Split Case Centrifugal Pumps"

B. Section 11305 "Return Sludge and Waste Sludge Pumps"

C. Section 11371 "Positive Displacement Blowers"

D. Section 16010 "Electrical General Provisions"

E. Section 16055 "Short Circuit/Coordination Study/Arc Flash Analysis"

F. Section 16120 "Wire, Splices and Terminations (600V or Less)"

G. Section 16420 "Individual Motor Starters"

H. Section 16443 "Motor Control Centers"

I. Division 17 for I&C related sections

1.02 SUMMARY

A. This specification covers the performance, design and manufacture of separately enclosed, preassembled, Variable Frequency Drives (VFD) controllers for 3-phase, squirrel cage induction motors, and VFD's integral to Motor Control Centers.

B. This specification also includes; line reactors, bypass contactors, across-the-line bypass starters, enclosures, and associated controls as shown on the contract drawings.

1.03 SCOPE

A. Provide all labor, materials, equipment and incidentals required, and install, place in operation and field test variable drives.

B. The adjustable frequency controller shall be a sine-coded pulse-width modulated (PWM) design. All drives shall be supplied by one manufacturer. The VFD shall be manufactured within the States of America to alleviate concerns of future serviceability and parts availability.

C. The VFD assembly must fit in the space indicated on the drawings.

1.04 QUALITY ASSURANCE

A. The VFD shall be factory assembled and system tested by the VFD manufacturer to assure a properly coordinated system.

B. Codes: Provide equipment in full accordance with the latest applicable rules, regulations, and standards of:

1. Local Laws and Ordinances
2. State and Federal Laws
3. National Electric Code (NEC)
4. Underwriters Laboratories (UL)
5. American National Standards Institute (ANSI)

C. The variable frequency drive and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of UL and NEMA.

D. The VFD shall be IEEE 519 compliant.

1.05 SUBMITTALS FOR REVIEW AND APPROVAL

A. Submittals shall be prepared by the VFD manufacturer and be specific to the project.

B. Product data sheets showing dimensions and finishes, rated capacities, operating characteristics, furnished specialties and accessories.

C. Shop drawings showing mounting and attachment details, equipment assemblies, dimensions, weights, loads, required clearances, method of field assembly, components location and size of each field connection, power, signal and control wiring, equipment and component layout, elevations, conduit entries, stub-up locations, shipping splits, and shipping weights.

D. Coordination drawings drawn to scale showing the dimensional layout of the VFD and surrounding equipment, equipment working clearances around and above the VFDs, supports locations, indicate ventilation requirements, type of supports, weight on each support, seismic (if required), along with field verified measurements.

E. Bill of material including catalog cuts on major components, including overcurrent protective devices.

F. Catalog cuts for control relays, control stations, indicating lights, intrinsically safe relays, and motor protection relays for motors.

G. Short-circuit ratings of equipment.

H. Time-current-characteristic curves for overcurrent protective devices.

I. Power and control diagrams with field terminals for power, control and I/O wiring.

J. Schematic diagrams including bypass and control circuitry.

K. Wiring diagrams including (if applicable) bypass and control circuitry.

L. Interconnection diagrams showing field terminals for power, control and I/O.

M. Maximum rated input current.

N. Sizing procedures, calculations and/or matrix.

O. Nameplate data.

P. Heat rejection data.

Q. Installation instructions, including grounding and bonding.

R. Operations and maintenance manuals including manufacturer's written instructions for testing, adjusting and programming.

S. Descriptive bulletins.

T. Certifications and warranty.

U. Efficiencies while operating at 25%, 50%, 75% and 100% full load.

V. Factory test reports including harmonics while operating over the entire speed range.

W. Qualification data on the testing agency and individual tester.

X. Field acceptance test reports as described in Part 3.

Y. Harmonic verification, testing and distortion analysis. Catalog data on test instruments used for harmonic distortion testing.

Z. Manufacturer's statement of compliance with latest version of IEEE 519.

AA. Source-quality control reports.

BB. Field-quality control reports and qualifications.

CC. Training syllabus.

DD. Manufacturer's recommended spare and renewal parts.

1.06 SUBMITTALS FOR CLOSE-OUT

A. Final as-built drawings, diagrams and test reports.

B. Operational and maintenance manuals and instruction books.

C. A warranty certificate that includes all parts and labor by the contractor, and the equipment manufacturer for a minimum period of one (1) year unless the manufacturer offers a longer standard warranty, or an extended warranty is agreed upon between the Owner and the Contractor. The warranty period shall begin after the successful completion of the acceptance text.

1.07 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with the manufacturer's instruction. One (1) copy of these instructions shall be included with the equipment at the time of shipment.

B. Upon delivery and before unloading, the equipment shall be visually inspected for any physical damage, scratches or loose components. Notify the owner immediately before unloading and accepting the equipment.

1.08 MAINTENANCE AND SUPPORT

A. During the warranty period, the Contractor shall provide on-site, on-call maintenance services by the Contractor's personnel on the following basis:

1. Service calls shall be on a per-call basis with a 36-hour response.
2. Contractor shall support the maintenance of all hardware and software.
3. Various personnel of different expertise shall be sent on-site depending on the nature of the service required.
4. Cost shall include travel, local transportation, living expenses and labor rates of the service personnel responding to the service call.
5. Should the result of the service request be the uncovering of a system defect covered by the warranty, all costs for the call, including labor necessary to identify the defect, shall be the responsibility of the Contractor.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Basis of Design is predicated on:

Schneider Electric
Manar Khaskia
443.798.4353.

B. The supplier of the assembly shall be the manufacturer of the electromechanical power components used within the assembly such as bypass contactors when specified.

C. The manufacturer shall be ISO 9001 certified.

D. The supplier of the equipment shall have produced similar equipment for a minimum period of ten (10) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with the requirement.

2.02 MATERIAL AND EQUIPMENT

A. Any modifications to the VFD required to meet this specification shall be performed by the manufacturer only. Changes made by the distributor or system integrator to the VFD are specifically not permitted.

B. Where generators are used, the contractor shall provide the voltage, kW, kVA and sub transient reactance for fault calculations.

C. Provide control stations, logic, and control features as specified herein, in other applicable sections of the specifications, and as indicated on the Electrical Drawings, and Instrument Drawings as part of the Contract Drawings or this specification section. Relays and control devices shall be provided within the VFD enclosure as indicated on the Contract Drawings, and as specified herein.

D. Provide all VFDs with an input breaker rated for the available fault current at that point as determined by a short-circuit study.

2.03 VARIABLE FREQUENCY DRIVE

A. Basic Components

1. The VFD shall provide microprocessor control for any three-phase NEMA design B induction motors regardless of manufacturer, with a horsepower and current rating within the capacity of the VFD.
2. The controller's full load current rating shall be based on 50-degrees Celsius ambient at 75-hp and below, and 40-degree ambient above 75-hp. The switching frequency shall be no less than 3.6 kHz to reduce motor noise and avoid increased motor losses. Drives shall conform to UL508C.
3. The drive shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to a variable voltage and frequency output via a two-step operation. The VFD shall run at or above listed switching frequency.
4. Insulated Gate Bipolar Transistors (IGBT's) shall be used in the inverter section. The 6-pulse rectifier shall be shipped integral to the VFD.

Adjustable or variable current sources, Bipolar Junction Transistors (GTO's) or Silicone Controlled Rectifiers (SCR's) are not acceptable.

5. The VFD shall have an efficiency at full load and speed that exceeds 95%. The efficiency shall exceed 90% at 50% speed and load. The VFD shall maintain the line side power factor at no less than 0.96, regardless of speed and load.
6. Losses to be utilized in drive system efficiency calculation shall include input transformer, harmonic filter and power factor correction if applicable, VFD converter and output filter if applicable. Auxiliary controls, such as internal VFD control boards, cooling fans, shall be included in all loss calculations.
7. VFD shall be 6-pulse and include a thermal-magnetic breaker, metal oxide varistors, and line side inductors rated at 1%, 1.5%, 3%, 5% of rated line current.
8. The VFD shall have a one (1) minute overload current rating of 120% for variable torque loads and 150% for constant torque loads.
9. Voltage Dip Ride-Through: VFD shall sustain continued operation with a 40% dip in nominal line voltage. Output speed may decline only if current limit rating of VFD is exceeded.
10. Power Loss Ride-Through: VFD shall be capable of a minimum 3-cycle power loss ride-through without fault activation.
11. AC Line Frequency Variation: +/-3 Hertz.
12. Power Unit Rating Basis: 100% rated current continuous, 110% rated current for one minute, at rated temperature.
13. Acceleration and deceleration time shall be independently adjustable from one second to 60 seconds.
14. Adjustable full-time current limiting shall limit the current to a preset value that shall not exceed 120% of the controller rated current. The current limiting action shall maintain the V/Hz ratio constant so that the variable torque can be maintained. Short time starting override shall allow starting current to reach 175% of the controller rated current to maximum starting torque.
15. The controller shall produce an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection shall be included such that a failure in the controller electronic circuitry shall not cause a frequency to exceed 110% of the maximum controller output frequency selected.
16. Minimum and maximum output frequency shall be adjusted over the following ranges: Minimum frequency 3 Hz to 50% of maximum selected frequency; Maximum frequency 40 Hz to 60 Hz.

B. Ratings

1. Refer to the VFD shown on drawings.

C. Enclosure

1. All VFD enclosures shall be NEMA 1.
2. The enclosure shall be bolted to a concrete equipment pad using stainless steel hardware.
3. The enclosure shall be bolted to the concrete masonry wall using stainless steel hardware and 1-1/2-inch supplemental steel spacers.
4. Each door of the enclosure shall be provided with a document pocket on the interior of the door and a three-point lockable door handle, lockable door handle. Door locks for each door shall be provided and shall be matching for the same enclosure. Provide a total of four (4) keys for the locks.
5. Provide each enclosure with a nameplate entitled "VFD-X", where X corresponds to the unit number. Provide a nameplate for each enclosure to read as follows:

   "CAUTION: 480, 208 VOLT AC, 3-PHASE POWER INPUT"

   "CAUTION: MULTIPLE 120 VOLT AC POWER SOURCES"

6. Provide appropriate nameplates for control stations and indicating lights. Separate compartments for VFD and bypass starter shall be clearly nameplated.
7. Controls and control stations shall be mounted on the face of the enclosure as specified herein.

D. Control Functions

1. Frequently accessed VFD programmable parameters shall be adjustable from a digital operator keypad located on the front of the VFD. The VFD shall have a 3-line alphanumeric programmable display with status indicators. Keypads must use plain English words for parameters, status, and diagnostic messages. Keypads that are difficult to read or understand are not acceptable, and particularly those that use alphanumeric code and tables. Keypads shall be adjustable for contrast with large characters easily visible in normal ambient light.
2. Standard advanced programming and trouble-shooting functions shall be available by using a personal computer's Ethernet port and Windows™ based software. In addition, the software shall permit control and monitoring via the VFD's RS-232 port. The computer software shall be used for modifying the drive setup and reviewing diagnostic and trend information. Provide one copy of the advanced programming software.
3. The operator shall be able to scroll through the keypad menu to choose between the following:

   a. Monitor
   b. Operate
   c. Parameter setup
   d. Actual parameter values

e. Active faults
f. Fault history
g. LCD contrast adjustment
h. Information to indicate the standard software and optional features software loaded.

4. The following setups and adjustments, at a minimum, are to be available:

a. Start command from keypad, remote or communications port
b. Speed command from keypad, remote or communications port
c. Motor direction selection
d. Maximum and minimum speed limits
e. Acceleration and deceleration times, two settable ranges
f. Critical (skip) frequency avoidance
g. Torque limit
h. Multiple attempt restart function
i. Multiple preset speeds adjustment
j. Catch a spinning motor start or normal start selection
k. Programmable analog output
l. DC brake current magnitude and time
m. Proportional/Integral/Differential (PID) process controller

E. Interface Requirements

1. Coordinate interface signals as shown on Instrumentation Drawings.
2. Inputs - A minimum of six (6) programmable digital inputs, two (2) analog inputs and an Ethernet communications interface shall be provided with the following available as a minimum:

a. Remote manual/auto
b. Remote start/stop
c. Remote forward/reverse
d. Remote preset speeds
e. Remote freewheel stop
f. Remote fault reset
g. Process control speed reference interface, 4-20m ADC
h. Ethernet programming and operation interface port

3. Outputs – A minimum of two (2) discrete programmable digital outputs, one (1) programmable open collector output, and one (1) programmable analog output shall be provided, with the following available at minimum.
4. A minimum of two (2) programmable relay outputs with one (1) set of form contacts for each, selectable with the following available parameters at minimum:

a. Fault

b. Run
c. Ready
d. Reversing
e. Jogging
f. At speed
g. In torque limit
h. Motor rotation direction opposite of commanded
i. Over-temperature

5. Programmable open collector output with available 24VDC power supply and selectable with the following available parameters at minimum:

a. Fault
b. Run
c. Ready
d. Reversing
e. Jogging
f. At speed
g. In torque limit
h. Motor rotation direction opposite of commanded
i. Over-temperature

6. Programmable analog output signal, selectable with the following available parameters at minimum:

a. Output current
b. Output frequency
c. Motor speed
d. Motor torque
e. Motor power
f. Motor voltage
g. DC link voltage

F. Monitoring and Displays

1. The VFD display shall be a LCD type capable of displaying three (3) lines of text and the following thirteen (13) status indicators:

a. Run
b. Forward
c. Reverse
d. Stop
e. Ready
f. Alarm
g. Fault
h. Local

i. Panel
j. Remote
k. Hand
l. Auto
m. Off

2. The VFD keypad shall display the following monitoring functions at a minimum:

a. Output frequency
b. Output speed
c. Motor current
d. Motor torque
e. Motor power
f. Motor voltage
g. DC-link voltage
h. Heatsink temperature
i. Total operating days counter
j. Operating hours (with reset function)
k. Total megawatt hours
l. Megawatt hours (with reset function)
m. Voltage level of analog input
n. Current level of analog input
o. Digital inputs status
p. Digital and relay outputs status
q. Motor temperature rise, percentage of allowable

G. Protective Functions

1. The VFD shall include the following protective features at minimum:

a. Over-current
b. Over-voltage
c. Inverter fault
d. Under-voltage
e. Phase loss
f. Output phase loss
g. Under-temperature
h. Over-temperature
i. Motor stalled
j. Motor over-temperature
k. Motor under-load
l. Logic voltage failure
m. Microprocessor failure
n. DC injection braking

H. Diagnostic Features

1. Fault History

a. Record and log faults
b. Indicate the most recent first, and store up to 9 faults.

I. Optional features to be included in the VFD:

1. The bypass shall include a drive input disconnect, a VFD input isolation contactor, bypass across the line and a VFD output contactor that is electrically interlocked with the bypass across the line. This circuit shall include control logic, status lights and motor over-current relays. The complete bypass system Hand-Off-Auto with Inverter-Bypass selector switch(s), and Inverter/Bypass pilot lights shall be packaged with the VFD.
2. AC output contactor to provide a means for positive disconnection of the drive output from the motor terminals.
3. Fused space heaters with thermostat for oversize enclosures to minimize condensation potential upon drive shutdown.
4. Laminated plastic nameplate engraved with user's identifying name or number for oversize enclosures.
5. Pneumatic process follower allowing motor speed control proportional to a 3-15PSIG pneumatic signal.
6. 120 VAC control to allow VFD to interface with remote dry contacts.
7. Motor dv/dt filter for use on motor cable runs exceeding 100 feet for motors with a peak voltage insulation rating less than 1600 Vac.
8. The dv/dt filter shall be located at the VFD and shall reduce the dv/dt clamp any voltage overshoots of the VFD output. It will return the energy in the voltage overshoots to the VFD Dc bus. A power dissipating resistance device is not acceptable. Filter shall be a Cutler-Hammer Motor Rx
9. Dynamic braking control circuitry shall be provided to decelerate the motor faster than the internal losses can absorb. Dynamic braking shall cause an optional resistor bank, when specified; to be switched onto the DC link as required to absorb the regenerative energy. This shall allow the fastest controlled deceleration and/or stop without an over-voltage condition. The resistor bank, when specified, shall be located external to the drive enclosure to prevent overheating of the drive.
10. Resistor bank for dynamic braking load rated for 100 percent braking torque for a 20 percent duty cycle based on a sixty second cycle time.
11. Communication card for interface with Modbus TCP/IP.
12. Provide an input EMI filter to minimize conducted electrical noise to meet the requirements of IEC 61800-3.
13. Active or passive harmonic filters

PART 3 - EXECUTION

3.01 GENERAL

A. Where freestanding, VFD's shall be mounted on a 4-inch high concrete pad and in accordance with the manufacturer's recommendations.

B. Where wall-mounted, VFD's shall be mounted on structural steel with a 1-1/2-inch minimum space from wall unless otherwise recommended from the manufacturer.

C. Provide each VFD with a laminated plastic nameplate engraved to indicate the equipment it controls.

3.02 INSTALLATION

A. Connections to external equipment and connections of the incoming power shall be as shown or, as required, by equipment manufacturer.

B. Enclosures and ground busses shall be grounded as required by the NEC.

3.03 FACTORY TESTING

A. The VFD manufacturer shall provide as a minimum, the following quality assurance steps within his factory:

1. Incoming inspection of components and raw materials based on strategic supplier base and experience.
2. All products subject to 100% testing and final inspection; no sampling plans permitted.
3. All printed circuit boards shall be functionally tested via automatic test equipment prior to unit installation.
4. All inverter power sub-assemblies shall undergo a burn-in test.
5. After all pre-tests have been performed, each complete VFD shall undergo a burn-in test. The drive shall be burned in with a motor load without an unscheduled shutdown.

3.04 SPARE PARTS

A. The following spare parts shall be furnished:

1. The main logic and power supply boards.
2. Three of each type of fuse rated 460V or less.
3. Two of each type of converter power semiconductor.
4. Two of each type of inverter power semiconductor.
5. Five of each type of panel lamp.
6. One of each type of control printed circuit board and gate firing boards.
7. One keypad assembly.

3.05 FIELD QUALITY CONTROL

A. Provide the services of a qualified manufacturer's employed Field Service Engineer to assist the Contractor in installation and start-up of the equipment specified under this section. Field Service personnel shall be factory trained with periodic updates and have experience with the same model of VFD on the job site. Sales representatives will not be acceptable to perform this work. The manufacturer's service representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, installation as specified in manufacturer's installation instructions, wiring, application dependent adjustments, and verification of proper VFD operation.

B. The Contractor under the technical direction of the manufacturer's service representative shall perform the following minimum work.

1. Inspection and final adjustments.
2. Operational and functional checks of VFD and spare parts.
3. The contractor shall certify that he has read the drive manufacturer's installation instructions and has installed the VFD in accordance with those instructions.

C. Coordinate motor and relay settings with the Protection Engineer and Short-Circuit, Coordination and Arc-Flash Studies.

D. Coordinate with controls system integrator for the control and status monitoring for the control and status monitoring signals between VFD and the pump control panel.

3.06 MANUFACTURER'S SERVICE

A. The VFD manufacturer shall maintain, as part of a national network, an engineering service facility within 100 miles of the project site. The facility shall provide start-up services, emergency service calls, repair work, service contracts, maintenance and training of customer personnel.

B. Obtain services of manufacturer's authorized representative for installation, startup, adjustment, and setting of VFD. All features of the VFD, bypass starter and control circuit shall be tested, including remote control and indication features.

C. Manufacturer's authorized representative shall conduct a training session for the Owner's personnel at the site for operation and maintenance of VFD's. Training session shall be conducted in the field at the VFD and shall consist of a minimum of one 8-hour day. The Contractor shall provide a minimum of 10 working days written notice for scheduling of the training session. The site visit by the manufacturer's representative shall be separate and distinct from the site visit performed for testing and startup.

D. Start-up services for VFD's shall be provided by the manufacturer's field service engineer, and shall include inspection of field wiring, complete operational test, final

adjustments to AC variable frequency drive to assure proper performance and instructions to the Owner's operating personnel. Manufacturer shall demonstrate ground fault protection at time of start-up.

E. Adjust all protective device settings to prevent the motor from exceeding its rating or duty cycle.

3.07 FIELD TESTING

A. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment and grounding.
4. Verify the unit is clean.
5. Ensure the vent openings are free from debris and that heat transfer surfaces are clean.
6. Verify the drive overcurrent setpoints are correct for their application.
7. If the drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
8. Apply minimum and maximum speed setpoints and verify those setpoints are within limitations of the load coupled to the motor.
9. Using a calibrated torque wrench verify the tightness of all electrical bolted connections meet the recommendations of the manufacturer.
10. Verify the fuse sizing in accordance with the manufacturer's published data.

B. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2. Test the motor overload relay elements by injecting primary current through the overload circuit and document the trip time of the overload element.
3. Test input circuit breaker by primary injection.
4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential shall be 500-VDC for 300-volt rated cables and 1000-VDC for 600-volt rated cable. Test duration shall be one minute. For units with solid-state components, follow manufacturer's recommendation.
5. Test for the following parameters in accordance with the manufacturer's recommendations:

    a. Input phase loss protection
    b. Input overvoltage protection
    c. Output phase rotation
    d. Overtemperature protection
    e. DC overvoltage protection
    f. Over-frequency protection

g. Drive overload protection
h. Fault alarm outputs

6. Perform continuity tests on bonding conductors.
7. Perform startup of drive in accordance with manufacturer's published data. Calibrate drive to the system's minimum ma d maximum speed control signals.
8. Perform operational tests by initiating control devices by slowly varying the drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
9. Verify operation of drive from remote start/stop and speed control signals.
10. Measure fuse resistance.
11. Conduct a thermographic survey of the equipment and all connections.

C. Test Values

1. Compare bolted connection resistance values to values of similar connections and investigate those values that deviate by more than 50% of the lowest value.
2. Bolt-torque levels shall be in accordance with the manufacturers publish data.
3. Results of a thermographic survey.
4. Overload trip times at 300% of overload element rating shall be in accordance with manufacturers published time-current curve.
5. Results of input circuit breaker tests.
6. Insulation resistance values of control wiring shall not be less than two megohms.
7. Results of relay calibration tests.
8. Results of continuity test on bonding conductors.
9. Control devices shall perform in accordance with system requirements.
10. Operational tests shall conform to system requirements.
11. Investigate fuse resistance that deviate from each other by more than 15%.

D. Initial Energization (VFDs operating Motors at or over 25-HP)

1. Perform Pre-Power meter checks.

a. Confirm all power sources are tagged and locked and are de-energized.
b. With motor leads disconnected from VFD perform insulation resistance testing on motor leads
c. Perform static checks in accordance with manufacturer's model-specific instructions
d. Perform checks of converter IGBTs
e. Perform diode checks of inverter IGBTs
f. Measure resistance to ground of positive and negative bus using a digital multi-meter

g. Measure and record insulation resistance of motor leads.
h. Measure and record impedance and insulation resistance of line reactor (if applicable), compare to nameplate.
i. Measure and record insulation resistance of input isolation transformer (if applicable).

2. Perform initial power on safety checks.

a. Confirm that all power is still tagged and locked out to the VFD.
b. If disconnected, reconnect the line and/or motor leads.
c. Ensure all appropriate control wiring has been reconnected.
d. Conduct a walk around of the VFD and its connected load.
e. Remove tags and locks from the disconnect devices supplying power to the VFD disconnect.
f. When safe, energize the disconnect device that is supplying power to the VFD disconnect.
g. Using a digital multimeter measure the AC line voltage at the supply side of the VFD disconnect device.
h. Record phase to phase voltage and phase to ground voltage
i. Phase to phase are balanced within < 2%
j. Phase to ground are balanced within < 2%
k. Measure and record DC bus voltage

E. Setting the VFD Parameters

1. Program VFD parameters as specified by the customer and the engineer.
2. Typical parameters would include:

a. Motor name plate information
b. Accel/Decel times
c. Min/Max speeds
d. VFD controls
e. Motor protections
f. Check motor direction of rotation
g. Have customer representative confirm that the motor is ready to rotate
h. Bump the motor to check its direction of rotation in the following order:

1) Check rotation from the VFD
2) After checking VFD rotation if a bypass is used, check rotation from the bypass

F. Operation of the Drive and Motor (VFDs operating Motors at or over 25-HP)

1. It is preferred that the testing from this point on be done with the motor coupled to the normal operating load.

2. Testing of an unload application or just a motor is valid but should be noted in the commissioning documentation.
3. Perform operational checks in accordance with manufacturer's model-specific instructions.

    a. Typical operational checks include:

        1) Measure and record motor voltage and compare to VFD display
        2) Measure and record motor current and compare to VFD display
        3) Measure and record line voltage and line current
        4) Measure and record clean power rectifier lead voltages
        5) Perform full power motor run
        6) Confirm control systems function

G. After Testing

1. Final inspection shall verify that the equipment is thoroughly clean. Notify the customer if the equipment is not clean.
2. Note corrective actions taken, deficiencies and recommendations, and any general comments.
3. Apply a test sticker to the equipment.
4. Review and organize all test results and forms.
5. Contact a customer representative to report results and follow-up actions.
6. Write and submit a formal report.
7. Submit startup report to manufacturer for extended warranty.

H. Site Acceptance Testing & Start-up

1. Functional Performance Test

    a. Perform system function tests. The system function tests must prove the correct interaction with external control processes.

I. On-Site Harmonic Verification Testing (VFDs operating Motors at or over 25-HP)

1. Verification testing shall be conducted in accordance with the latest version of IEEE 519. These tests shall validate the facility is not receiving or producing harmonic distortion levels that exceed the IEEE limits.
2. Verification testing shall include:

    a. Base Load Test – Defined as loads not associated with inverters or converters. Under base load conditions the PCC shall be metered for the incoming harmonic content. This test shall be recorded and

analyzed to verify the site is not receiving harmonics exceeding the limits establish by IEEE 519.

b. Base Load plus VFD #1 - Under this load condition the PCC shall be metered for the harmonic content. This test shall be recorded and analyzed to verify the site is not producing harmonics exceeding the limits establish by IEEE 519.

c. Base Load plus VFD #2 - Under this load condition the PCC shall be metered for the harmonic content. This test shall be recorded and analyzed to verify the site is not producing harmonics exceeding the limits establish by IEEE 519.

d. Base Load plus VFD #1 plus VFD #2 - Under this load condition the PCC shall be metered for the harmonic content. This test shall be recorded and analyzed to verify the site is not producing harmonics exceeding the limits establish by IEEE 519.

3. Harmonic Verification Report

a. A complied report shall be developed summarizing all the test procedures, collected data, results and analysis.

b. The report shall be bound and each test separated using tabs. The report shall include an introduction and an executive summary. Graphical or tabular summaries are acceptable in presenting the individual harmonic orders. Harmonic analysis shall include up to the 50^{th} order and include calculations for total demand distortion and total harmonic distortions.

3.08 TRAINING

A. Manufacturer's authorized representative shall conduct a training session for the Owner's personnel at the site for operation and maintenance of VFD's. Training session shall be conducted in the field at the VFD, and shall consist of a minimum of one 8-hour day. The Contractor shall provide a minimum of 10 working days written notice for scheduling of the training session. The site visit by the manufacturer's representative shall be separate and distinct form the site visit performed for testing and startup.

B. The manufacturer's qualified representative shall conduct the training.

C. The training program shall consist of the following:

1. Instructions on the proper operation of the equipment.
2. Instructions on the proper maintenance of the equipment.
3. O&M Manuals and training documentation shall be provided to each trainee.

3.09 MAINTENANCE / WARRANTY SERVICE

A. The warranty period shall begin after the successful completion of the acceptance text.

END OF SECTION 16269

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SECTION 16289

SURGE PROTECTIVE DEVICES

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SECTION 16289

SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

B. Related Requirements:

1. Division 16 Section - "LOW VOLTAGE SWITCHBOARD/ SWITCHGEAR" for factory installed SPDs.
2. Division 16 Section - "MOTOR CONTROL CENTERS" for factory-installed SPDs.

1.03 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.04 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

B. Field Quality: Control reports.

C. Sample Warranty: For manufacturer's special warranty.

D. Maintenance Data: For SPD's to include in maintenance manuals.

1.05 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.06 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replaceable Protection Modules: One set of (3) for each size and type installed.

PART 2 - MATERIALS

2.01 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

2.02 SERVICE ENTRANCE SUPPRESSOR

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

1. Schneider Electric Industries SAS or approved equal.

B. SPDs: Comply with UL 1449, Type 2.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2

1. SPDs with the following features and accessories:

a. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
b. Indicator light display for protection status.
c. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
d. Surge counter.

D. Comply with UL 1283.

E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 240kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V.
3. Line to Line: 2000 V for 480Y/277 V.

G. SCCR: Equal or exceed 200 kA.

H. Inominal Rating: 20 kA.

2.03 ENCLOSURES

A. Panelboard/Switchboard/MCC mounted.

2.04 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads.

B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG.

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Lead length shall not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed 4 feet. Notify Engineer if site condition require a lead length exceeding 4 feet. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.03 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 16289

SECTION 16410

DISCONNECT SWITCHES

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SECTION 16410

DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation disconnect switches.

B. Provide complete items with all components needed for proper operation (such as a fuse for each phase for fused safety switch (FSS) unit).

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Refer to Section 16491 - FUSES (600V AND BELOW)

1.04 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 GENERAL

A. Switches shall be equipped with a cover interlock to prevent operation with cover open. All switches shall be designed to permit padlocking in the off or open position.

B. Switches shall be NEMA 4X and shall have stainless steel enclosures, unless otherwise noted.

C. All fused units shall be provided with Blown Fuse Indicator Modules.

D. Switches shall be UL listed, and shall bear the UL label.

2.02 SAFETY SWITCHES

A. Safety switches shall be meet all the applicable requirements of Federal Specification W-S-865 and shall be horsepower rated in conformance with Table III.

B. Safety switches shall be fused or unfused types, as indicated, and shall be enclosed in NEMA 4X steel enclosures, unless otherwise indicated. Safety switches for 208 volt service shall be heavy-duty type. Safety switches for 480 volt service shall be heavy-duty. Switches shall be front operated type, cover interlocked with switch. All nonconductive parts shall be finished, or otherwise protected against corrosion.

C. All switches shall be visible blade, externally operated with all current carrying parts silver or tin plated. All switches shall have provisions for not less than two external padlocks and capable of accepting copper or aluminum cables.

D. Heavy-duty switches employing current limiting fuses shall be rated to withstand let through currents of 200,000 R.M.S. symmetrical amperes at 480 volts.

E. All FSS units shall accommodate current limiting Class "R" rejection feature fuses.

F. Units shall be manufactured by Square D or approved equal.

PART 3 - EXECUTION

3.01 GENERAL

A. Provide as indicated.

3.02 INSTALLATION

A. Furnish and install one (1) complete set of fuses for each fused unit.

END OF SECTION 16410

SECTION 16411

UNDERGROUND RACEWAYS AND DUCTBANKS

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SECTION 16411

UNDERGROUND RACEWAYS AND DUCTBANKS

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation of a complete underground raceway system.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Refer to Section 03300 - CAST-IN-PLACE CONCRETE.

B. Refer to Section 16110 - RACEWAYS.

1.04 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 RACEWAYS

A. Raceways for "power" and "signal" shall be PVC type 40 with PVC type 40 turnups to points above grade (or at grade), or where penetrating a wall or vertical surface of a structure, which is not part of and not supported as part of the underground raceway.

2.02 CONCRETE

A. Provide concrete material for electrical work as part of the electrical work, and all concrete provided shall be 3000 psi concrete or better as specified under section 03300 - CAST-IN-PLACE CONCRETE.

2.03 REINFORCING

A. Reinforcing bars shall be steel conforming to ASTM A-615, grade 60. Bars shall be free of loose scale, rust, or other coatings that will reduce bond.

B. Reinforcing wire shall be welded wire fabric conforming to ASTM A-185.

2.04 EXPANSION JOINTS

A. Expansion joints shall conform to ASTM D-1752, Type II.

2.05 CONSTRUCTION JOINTS

A. Construction joints shall be formed using "Jahn" Screed Joint materials as manufactured by Superior Concrete Accessories, Inc., or equivalent.

2.06 DUCT SPACERS

A. Spacers for conduits shall be made with an engineering polymer and designed in such a fashion that the fitting performs the function of base and intermediate spacer no matter how the conduits are arranged. Spacers shall be Wunpeece Spacer by Underground Devices, or equivalent.

PART 3 - EXECUTION

3.01 GENERAL

A. Underground raceways shall be encased in concrete (3" minimum) over their entire length and where these raceways are grouped to form a ductbank (2 or more ducts), the ductbank shall be reinforced.

B. Provide 3/16" 3-strand polypropylene pull cord having not less than 800 pound test strength in all empty raceways. Provide a minimum of two (2) feet of slack pull cord at each end of the raceway.

C. Raceways for "power" wiring shall not be closer than 6 inches to raceways for "signal" wiring.

3.02 INSTALLATION

A. Where each raceway penetrates the building floor, building wall, manhole or equipment mounting pad, it shall be PVC type 40 raceway. The exposed end shall terminate in a flush coupling which shall be plugged when the raceway is empty. The portion of the raceway in the wall or pad shall be sealed tightly in place with nonshrink grout. The raceway shall be joined to the rest of the underground raceway via a watertight coupling.

B. Underground raceways shall be installed to be at least 24 inches below finished grade or paving at any point, unless otherwise noted. The 24 inches shall be measured from the top surface of the raceway. They shall be laid to a minimum grade of 6 inches per 100 feet to drain into a manhole whenever possible. Changes in direction shall be accomplished with long sweep bends, and the minimum bend radius shall be equal to

or greater than the values scheduled in the NEC for rigid metal conduit for lead sheathed wire.

C. When placing concrete around raceways, adjust delivery ducts to insure that the fall of concrete is as short as possible and use a splash board to direct the flow away from trench sides and avoid dislodging soil and stones into the trench. When placing concrete, encase from a fixed end to a free end and allow for expansion or contraction of the raceway as the concrete is placed and cured.

D. Raceways shall be thoroughly cleaned before laying and during construction, the ends shall be plugged to keep the interior clean.

E. The bottom of each raceway encasement shall be supported on undisturbed earth, or compacted ground over undisturbed earth, and backfilling shall not be done until the concrete has cured for at least 6 days. Exposed surfaces of concrete shall be kept wet (damp) throughout the 6-day curing period.

3.03 RECORD DRAWINGS

A. Provide Record Set data of the actual elevation of the top of each end of each raceway at the midpoint, at no more than 100' intervals, where changes in elevation are less than 2' between data points or 10' intervals when the elevation between intervals is different by 2' or more between data points.

END OF SECTION 16411

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SECTION 16412

MANHOLES AND HANDHOLES

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SECTION 16412

MANHOLES AND HANDHOLES

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment, and services necessary for the installation of manholes and handholes as indicated.

B. Each manhole shall include1 at least the following: Cast iron cover and rim, collar between the cast iron cover rim and the manhole, grounding rod, pulling irons, aluminum ladder, nonmetallic support members for wire or cable.

C. Each handhole shall include at least the following: Cast iron cover and rim, collar between the cast iron cover rim and the handhole, pulling irons, nonmetallic support members for wire or cable.

D. The Contractor shall be responsible for the structural integrity of each manhole and handhole as installed - including its associated components such as: bearing capacity of the soil or fill supporting it, cast iron cover and rim, masonry collar, manhole and openings through manhole surfaces.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Refer to Section 03411 - PRECAST CONCRETE STRUCTURES

B. Refer to Section 16060 - GROUNDING AND BONDING

C. Refer to Section 16411 - UNDERGROUND RACEWAYS AND DUCTBANKS

1.04 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

B. The Contractor shall determine the required elevation of each manhole and handhole. This information shall be submitted as part of the shop drawing data.

PART 2 - MATERIALS

2.01 MANHOLES

A. Manholes shall be reinforced concrete with minimum inside dimensions as indicated for each manhole and a centered entrance opening of 30-inch diameter (minimum).

B. The manhole, cover, and collar shall be capable of supporting truck loads on the cover and all other loads imposed by dry or wet earth. Provide engineering computations "sealed" by a registered professional engineer as part of the shop drawing submittals for each size of manhole to substantiate that the manhole design accommodates the following, or equivalent criteria:

1. Dead Load:

   a. Concrete at 150 PCF
   b. Earth Cover at 120 PCF

2. Lateral Earth Pressure on Walls:

   a. Equivalent Fluid pressure above the water table at 42 PSF per foot of depth.
   b. Equivalent Fluid pressure below the water table at 83 PSF per foot of depth.
   c. Surcharge on walls equal two feet of dry earth.

3. Live Load:

   a. AASHO H20 truck loading rear wheel load of 16,000 tons + 30% impact (20,800 lbs. total).

4. Ground Water:

   a. The manhole design shall be such that a factor of safety of 1.1 is realized.
   b. Design ground water table elevation shall be as listed on S-1.

C. Manholes shall be custom designed to provide openings for the duct banks of the proper size and location as shown on the drawings. cdRubber or PVC waterstops shall be provided around all four sides of the ductbank openings.

D. Manholes shall be provided a sump pit as indicated. A nonmetallic grille type sump frame and cover shall be installed over the manhole sump.

E. Manholes shall be as manufactured by: Penn Cast, Easi Set, A.C. Miller Products, Inc., or equivalent.

2.02 HANDHOLES

A. Handholes shall be reinforced concrete with minimum inside dimensions as indicated for each handhole and a centered entrance opening of 2 foot by 4 foot (minimum), unless otherwise indicated.

B. The handhole, cover, and collar shall be capable of supporting truck loads on the cover and all other loads imposed by dry or wet earth. Provide engineering computations "sealed" by a registered professional engineer as part of the shop drawing submittals for each size of handhole to substantiate that the handhole design accommodates the following, or equivalent criteria:

1. Dead Load:

    a. Concrete at 150 PCF
    b. Earth Cover at 120 PCF

2. Lateral Earth Pressure on Walls:

    a. Equivalent Fluid pressure above the water table at 42 PSF per foot of depth.
    b. Equivalent Fluid pressure below the water table at 83 PSF per foot of depth.
    c. Surcharge on walls equal two feet of dry earth.

3. Live Load:

    a. AASHO H20 truck loading rear wheel load of 16,000 pounds + 30% impact (20,800 lbs. total).

C. Handholes shall be custom designed to provide openings for the ductbanks of the proper size and location as shown on the drawings. Knockout panels will not be acceptable. Rubber or plastic waterstops shall be provided around all four sides of the ductbank openings.

D. Provide 6" opening through bottom of handhole with nonmetallic grated cover plate for manhole drainage.

E. Handholes shall be as manufactured by: Penn Cast, Easi Set, A.C. Miller Products, Inc., or equivalent.

2.03 MANHOLE COVER AND RIM

A. Frames and covers for manholes shall have inscription, "Power", "Signal", "Telephone" as applicable. Frames and covers for manholes shall be rated for AASHTO H20 wheel loads.

B. Covers shall be solid, except for openings to enable placing and removing the cover, and shall be designed to meet standard US Government designs for underground electric or telephone construction.

C. Covers and rims shall be as manufactured by NEENAH Foundry Company, or equivalent.

2.04 HANDHOLE COVER AND RIM

A. Frames and covers for handholes shall have inscription, "Power", "Signal", "Telephone" as applicable. Frames and Covers shall be as indicated on the drawings and shall be rated for H20 wheel loads in accordance with AASHTO HB-12.

B. Covers shall be solid, except for openings to enable placing and removing the cover.

C. Covers and rims shall be as manufactured by NEENAH Foundry Company, or equivalent.

2.05 GROUNDING ROD

A. Refer to Section 16060 - GROUNDING AND BONDING.

2.06 CABLE RACKS

A. Racks shall be manufactured of a polycarbonate material. Vertical racks shall be capable of supporting Rack Arms 10 inches long at approximately 3" centers. The Racks shall be capable of supporting 120 lbs. per arm without the support bracket and 400 lbs. with the support arm. Racks shall be Standard Duty Underground Device Racks by Underground devices, or equivalent.

2.07 MISCELLANEOUS ACCESSORIES

A. Pulling-in irons shall be as detailed on the drawings and shall be Line Material Industries, Cat. No. DU 2T3, or Chance Cat. No. 8120, or equivalent. Pulling-in irons shall be installed on each wall of the manhole opposite the respective ductbank entrances and on the underside of the top slab, or as indicated.

B. Bell-ends of the same manufacture as the ducts shall be provided on the ends of all ducts entering the manholes.

C. Manhole ladders shall be fabricated from aluminum and shall have 2-1/2" x 3/8" flat bar stringers and shall be as manufactured by Washington Aluminum Company or Reliance Steel Products, Inc., or equal. Safety cages shall be provided for ladders as required by OSHA. Ladder material shall be alloy 6061-T6 except rungs, which may be 6063-T6.

PART 3 - EXECUTION

3.01 GENERAL

A. Provide manholes and handholes as indicated.

B. The minimum depth of cover above the top surface of a manhole shall be 18 inches, and where grass or plants are to be grown in the covering material it shall be a high grade of topsoil.

C. The Contractor shall repair any damage to associated items resulting from settling of a manhole or handhole after its placement at no cost to the Owner.

3.02 INSTALLATION

Provide a grounding rod in each manhole. The rod shall protrude 6 inches above the floor of the manhole and shall extend into unexcavated earth below. At least 8 feet of rod shall be in unexcavated earth.

A. Raceways penetrating manholes and handholes shall be sealed in place and manhole surfaces repaired to prevent the entrance of water into the manhole and handholes.

B. Provide a hard gravel (3.4" size) filled drain field (one cubic yard minimum) under each manhole. Provide a hard gravel (3.4" size) filled drain field (2 cubic feet minimum) under each handhole.

C. Provide a collar between the top surface of manholes and handholes and the cast iron cover rim such that the top of the cast iron cover shall be flush with the surrounding surface in paved areas and extend one inch above grade in seeded areas at final grade elevations. The collar shall be constructed of brick and shall be at least 8 inches thick.

D. Provide vertical cable or wire rack to run from the top to the bottom surface of the manhole. Vertical Racks shall be mounted at 2' intervals around the entire interior of the manhole. Provide rack arms, as required, for cable installation.

END OF SECTION 16412

SECTION 16415

AUTOMATIC TRANSFER SWITCHES

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SECTION 16415

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.
2. Bypass/isolation switches.

1.03 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Wiring Diagrams: Single-line diagram. Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

C. Qualification Data.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

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

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches, bypass/isolation switches, through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for emergency service under UL 1008, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless requirements of these Specifications are stricter.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Transfer Switches:

a. ASCO
b. Russ Electric

2.02 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

C. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels have communication capability matched with remote device.

D. Solid-State Controls: Repetitive accuracy of all settings is plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

E. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

F. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

G. Enclosures: General-purpose NEMA 250, Type 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

H. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.

1. Designated Terminals: Pressure type suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

J. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.

3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

2.03 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

F. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

2.04 AUTOMATIC TRANSFER-SWITCH FEATURES

A. Undervoltage Sensing for Each Phase of Normal Source: Senses low phase-to-ground voltage on each phase. Pickup voltage is adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

B. Time delay for override of normal-source voltage sensing delays transfer and engine start signals. Adjustable from zero to fifty seconds, and factory set for one second.

C. Voltage/Frequency Lockout Relay: Prevents premature transfer to generator. Pickup voltage is adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency is adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

D. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes. Provides automatic defeat of delay on loss of voltage or

sustained undervoltage of emergency source, provided normal supply has been restored.

E. Test Switch: Simulates normal-source failure.

F. Switch-Position Pilot Lights: Indicate source to which load is connected.

G. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
2. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

H. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

I. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

J. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.

K. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

L. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Set exerciser for first Tuesday of every month at 8:00 A.M. Exerciser features include the following:

1. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
2. Push-button programming control with digital display of settings.
3. Integral battery operation of time switch when normal control power is not available.

M. Transfer switch shall be capable of transferring power to auxiliary power in the event of over/under voltage and frequency condition.

N. Provide 3-phase monitors on the utility side and generator side of ATS. Each side shall provide a separate input in conjunction with the ATS position and generator status for monitoring the status of station power.

2.05 BYPASS/ISOLATION SWITCHES

A. Comply with requirements for Level 1 equipment according to NFPA 110.

B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

1. Means to lock the bypass/isolation switch in the position that isolates the transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
2. Drawout Arrangement for Transfer Switch: Provides physical separation from live parts and accessibility for testing and maintenance operations.
3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
4. Contact temperatures of bypass/isolation switches do not exceed those of automatic transfer-switch contacts when they are carrying rated load.
5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
6. Legend: Manufacturer's standard legend for control labels and instruction signs give detailed operating instructions.
7. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

D. The isolating portion of the bypass shall allow the automatic transfer switch to be disconnected from all sources of power and control without operating the enclosure door.

E. The operation of the bypass switch shall be a make before break operation.

2.06 FINISHES

A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.07 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Floor-Mounted Switch: Anchor to floor by bolting.

1. Concrete Bases: 4 incheshigh, reinforced, with chamfered edges. Extend base no more than 2 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated. Cast anchor-bolt inserts into bases. Comply with Division 3 Section "Cast-in-Place Concrete."

B. Identify components according to Section 16010 – ELECTRICAL GENERAL PROVISIONS.

3.02 WIRING TO REMOTE COMPONENTS

A. Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

3.03 CONNECTIONS

A. Ground equipment according to Section 16060 - GROUNDING AND BONDING.

B. Connect wiring according to Section 16120 – WIRE, SPLICES AND TERMINATIONS (600V OR LESS).

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

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.22.3. Certify compliance with test parameters.
3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

    a. Check for electrical continuity of circuits and for short circuits.
    b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    c. Verify that manual transfer warnings are properly placed.
    d. Perform manual transfer operation.

4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    c. Verify time-delay settings.
    d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
    f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

    a. Verify grounding connections and locations and ratings of sensors.
    b. Observe reaction of circuit-interrupting devices when simulated fault current is applied at sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

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

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 1 Section "Closeout Procedures."

1. Coordinate this training with that for generator equipment.

END OF SECTION 16415

SECTION 16420

INDIVIDUAL MOTOR STARTERS

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SECTION 16420

INDIVIDUAL MOTOR STARTERS

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation of a complete system.

B. Motor starters not provided with equipment furnished under other sections of the specifications shall be provided under Division 16. However, the Electrical Contractor shall verify compatibility of each motor starter, the motor served by the motor starter, and the electrical power to be to them, before he connects to any item of equipment.

C. The functional control of all motors shall be as specified under other sections of the specifications, and as shown on the contract drawings. The Contractor shall provide all necessary control devices, parts, components and circuitry to accomplish the functions indicated. The elementary diagrams shown on the electrical drawings are complementary for the purpose of illustrating and describing the various operations.

1.03 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 MANUAL STARTERS

A. Manual starters shall be "toggle" or "pushbutton" actuated. "Toggle" actuators shall be labeled to indicate "on" and "off" positions. "Pushbutton" actuators shall be labeled "start" and "stop". Provide with Hand-Off-Auto selector switch where indicated.

B. Provide each manual starter with a red neon indicator light to "illuminate" when power is present on the load side of the starter.

C. Provide a properly sized starter and overload protection device (in each phase) to be compatible with the motor it controls.

D. Provide manual starter with NEMA 12 enclosure, except where they are affected by outdoor weather (such as those above the roof) or in damp locations provide manual starter with NEMA 4X enclosure. Motor starting switch enclosures for switches not in sight of motor controlled shall have handle guards which permit padlocking in the "Off" position.

E. Starters shall be Square D Class 2510, or approved equal.

2.02 NEMA RATED MAGNETIC STARTERS

A. Magnetic starters shall be furnished with NEMA rated magnetic contactors and external manual reset overload relay with electronic type thermal overload units.

B. Starters for 3-phase motors shall be full voltage, nonreversing, electrically operated, electrically held, three-pole assemblies with three phase overload protection properly sized for the motor protected, unless otherwise indicated.

C. Starters shall be equipped with the following features, unless otherwise indicated on the drawings:

1. 120 volt control transformer with two primary and one secondary fuse and sized to accommodate all connected control circuit devices.
2. Hand-off-auto selector switch.
3. Push-to-test red "on" and green "off" pilot lights.
4. Auxiliary contacts and devices, as required, by control sequences specified in other sections of this specifications and as indicated on Electric Control Diagrams (provide one N.O. and one N.C. minimum), in addition to seal-in and interlocking.
5. Provide auxiliaries as indicated on Control Drawings.

D. Provide combination starter with NEMA 12 enclosures, except where they are affected by outdoor weather (such as those above the roof) or in damp locations, provide combination starters with NEMA 4X enclosures.

E. Noncombination or combination starters shall be Square D, or approved equal. Fusible or nonfusible starters shall be provided where indicated. Circuit breaker combination starters shall incorporate adjustable instantaneous trip-only motor circuit protectors.

PART 3 - EXECUTION

3.01 INSTALLATION

A. In finished areas where conduit is concealed, motor starting switches shall be flush mounted.

B. Provide each motor starter with a laminated plastic nameplate engraved to indicate the equipment it controls. Include nameplate nomenclature to be used with shop drawings.

END OF SECTION 16420

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SECTION 16441

LOW VOLTAGE SWITCHBOARD

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SECTION 16441

LOW VOLTAGE SWITCHBOARD

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - apply to work specified under this section.

1.02 SCOPE

A. Work includes labor, materials, equipment and services for installation of complete low voltage switchboard as indicated.

B. Switchboard shall include protective and metering devices and equipment, as indicated, with interconnections, instrumentation and control wiring.

1.03 SUBMITTALS

A. Submit manufacturer's product data in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

B. Submit Shop Drawings and Project Data for Low Voltage Switchboard, which shall indicate at the following:

1. Subassembly units that will accommodate rigging equipment.
2. Overall outline dimensions, including space available for conduits.
3. Method to secure in place.
4. Each functional part (circuit breaker, meter, switch, sensor, operating control, and accessories).
5. Schematic diagrams and wiring diagrams.
6. Complete rating, including short-circuit rating of bus and interrupting rating of devices.
7. Other information necessary to completely define this equipment.

C. Shop drawings shall be submitted to Power Company along with submission to Engineer.

PART 2 - MATERIALS

2.01 GENERAL

A. Provide dead-front, low voltage switchboard. Switchboard shall be completely factory assembled and shall be product of single manufacturer. Switchboard shall be rated for 480Y/277 volt, three phase, four wire, 60 Hertz service with 100% neutral and 50% ground bus.

B. Switchboard shall be designed, built, and tested in accordance latest editions of NEMA PB2 and UL 891 and NEC. The assembly shall be UL listed, and shall bear UL label.

C. Switchboard shall be suitable for use as service entrance equipment. Equipment shall be provided with UL service entrance label, incoming line isolation barriers and neutral connection to switchboard ground.

2.02 RATING

A. Switchboard current ratings, including devices shall be based upon operation in 40 degree C ambient. Ratings shall be as indicated.

B. Switchboard and devices shall have short circuit rating as indicated.

2.03 CONSTRUCTION

A. Switchboard shall be provided with individually mounted main and group mounted feeder devices, front accessible only.

B. Switchboard shall be completely self-supporting structure of required number of vertical sections bolted together to form one metal-enclosed switchboard 90" high. Sides, top and rear covers shall be code gage steel, bolted to switchboard structure. Frame structure members shall be code gage steel bolted together and reinforced at external corners with rugged gussets internal and external to structure members. Switchboard frame shall be suitable for use as floor sills in indoor installations.

C. Ventilation openings shall be provided in compartment enclosure, as required, by UL component tests.

D. All live components shall be contained in grounded metal enclosure of code gauge modular designed steel frame with removable plates. Individual vertical sections shall be constructed of bolted steel frames.

E. Provide side cable and terminal compartment for cable installation and termination. Cable bending space shall meet requirements of NEC.

F. Vertical sections comprising switchboard shall be rear-aligned.

G. Switchboard shall be provided with adequate lifting means and be capable of being rolled or moved into installation position and bolted directly to floor without use of floor sills.

2.04 SPACE

A. Where "space" is indicated for future devices include bus, device supports and mounting hardware, and connections for future mounting of circuit breaker. Unused device space shall to be covered with blank code gauge steel covering.

B. Vertical main bus bars shall be provided for future branch devices. Device mounting bolts and bus connecting straps shall be supplied with future unit devices. Full height bus bars shall be supplied only where units and space for future units fill vertical section.

2.05 FINISH

A. Steel surfaces shall be chemically cleaned and treated, providing bond between paint and metal surfaces to prevent entrance of moisture and formation of rust under paint. All switchboard surfaces shall be finished with ANSI 61 gray paint.

2.06 BUSSING

A. Buses shall be tin plated copper. Current density of bus shall not exceed 1000 amperes per square inch cross section. Temperature rise at minimum shall be as limited by ANSI standards. Live buses shall be phase-isolated in rear of section.

1. Horizontal bus between vertical sections shall have bus joints bolted with high tensile steel bolts with spring loaded belleville type washers. Bus joints shall be accessible from rear of switchboard.
2. Main bus shall be nontapered.
3. A-B-C type bus arrangement (left-to-right, top-to-bottom, front-to-rear) shall be used throughout to assure convenient and safe testing and maintenance. Where special circuitry precludes this arrangement, bus bars shall be labeled.

B. Neutral bus in feeder sections shall not be further than 20 inches from front of switchboard.

C. Riser bars, run-ins and run-backs shall be rated to carry full frame size continuous current rating (not trip rating) of breakers to which they are connected. Load connection straps shall be one piece and extended beyond main bus.

D. Main bus and riser bus shall be fully isolated from breaker, instrument and auxiliary compartments.

E. Hardware used on conductors shall have high tensile strength and suitable protective finish.

2.07 GROUND BUS

A. Secure copper ground bus to each vertical section structure. Ground bus shall extend entire length of switchboard.

B. Ground bus shall be equipped with terminals at each end for connection to ground system. Terminals shall accommodate indicated ground wire size and quantity.

2.08 CABLE CONNECTORS

A. Cable connectors shall be tin-plated, match bus material, and UL listed for copper cables. Connectors shall be compression type lugs. Connector shall have short circuit ratings equal to RMS symmetrical amperes of switchboard.

2.09 ACCESSORIES

A. Provide power monitor. Power monitor shall be Electro Industries Nexus 1252 with LCD display unit or approved equal.

B. Provide surge protective devices (SPD). SPD's shall be in accordance with Section 16289, SURGE PROTECTIVE DEVICES.

C. Provide current transformers, fuses, potential taps and accessories with ratios suitable for service voltage and current rating of switchboard. Current transformers shall be capable of carrying full load continuous primary current without damage to transformer insulation.

2.10 IDENTIFICATION OF COMPONENTS

A. Provide nameplates in accordance with Section 16010 - ELECTRICAL GENERAL PROVISIONS.

2.11 CIRCUIT BREAKERS

A. Static trip-molded case circuit breakers shall be 600 volt. Molded case circuit breakers shall be UL labeled, listed in accordance with UL 489, meet NEMA AB1 and meet appropriate classifications of Federal Specifications W-C 375B/Gen. Circuit breakers shall have quick-make, quick break over center toggle-type mechanism, and handle mechanism shall be trip-free to prevent holding contacts closed against short circuit or sustained overload. Circuit breaker handles shall assume position between "ON" and "OFF" when tripped automatically. Multipole circuit breakers shall be common-trip, such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Arc extinction is to be accomplished by magnetic arc chutes. Ratings are to be clearly visible. Trip units shall include following:

1. Current setting adjustable from 0.5 to 1.0 times plug rating.
2. Adjustable long-time pickup and delay.
3. Short-time pick-up adjustable from 1.5 to 9 times current setting.

4. Short-time I2t ramp.
5. Instantaneous pick-up, adjustable from 1.5 to 10 times current setting.
6. Ground fault pick-up, adjustable from .2 to .37 times current setting.

B. Feeder circuit breakers shall be molded case, provided with following accessories:

1. Under-voltage trip with time delay.

2.12 CONTROL WIRING

A. Control wiring shall be #14 Type S1S enclosed in top and vertical metal wiring troughs and front-to-rear insulating material wiring though, necessary fuse blocks and terminal blocks within switchboard shall be provided.

B. Groups of control wires for interconnection within or leaving switchboard shall be provided with terminal blocks in metal enclosed steel wiring trough mounted in rear cable compartment, easily accessible, away from runbacks and cable terminals, and with bolted steel cover over terminal blocks. Interconnecting control wiring across shipping splits shall be accomplished by terminal blocks in control wiring trough on top of equipment.

C. Control wires shall be provided with suitable numbering strips where leaving switchboard. Control wire markers shall be marked with origin/destination.

2.13 MASTER NAMEPLATE

A. Provide master nameplate giving switchboard designation, voltage, amperes, phase, wire, short circuit rating, generic order number and manufacturer's name.

2.14 MANUFACTURER

A. Switchboard shall be Square D or approved equal.

PART 3 - EXECUTION

3.01 GENERAL

A. Switchboard shall be mounted on 4-inch high concrete pad in accordance with manufacturer's recommendations. Install, as indicated, and accurately level in place. After installation on concrete pad, internal components shall be inspected and connections checked and tightened.

3.02 INSTALLATION

A. Connections to external equipment and connections of incoming service shall be as indicated, or as required, by equipment manufacturer.

B. Provide labels for instrumentation wiring.

C. Enclosures and ground buses shall be grounded, as required, by NEC and as indicated.

D. After installation switchboard shall be checked, adjusted, and initially energized under direction of manufacturer's representative.

3.03 TESTING AND ADJUSTING

A. Switchboard shall be completely assembled, wired, adjusted and tested at factory. After assembly complete switchboard shall be tested for operation under simulated service conditions. Certified test report of standard production tests shall be available to Engineer upon request.

B. Test low voltage switchboard and components in accordance with Section 16960 – ELECTRICAL FIELD ACCEPTANCE TEST.

C. Test switchboard to verify proper operation of meters, indicators, and accessories.

END OF SECTION 16441

SECTION 16442

PANELBOARDS

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SECTION 16442

PANELBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - apply to work specified under this section.

1.02 SCOPE

A. Work includes labor, materials, equipment and services for the installation of complete panelboard assembly as indicated.

1.03 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

B. Shop drawings shall indicate dimensions, gutter space, bus bar arrangement, metal gauge, and other details.

PART 2 - MATERIALS

2.01 GENERAL

A. Provide panelboards of types indicated and with features, types and sizes of cutouts as indicated. Provide ground bus in panels. Panel buses shall be hard drawn copper of 95% conductivity. The term "Panelboard" shall apply to all types of "Panelboards."

B. Each circuit breaker (main or branch) in panelboard shall be rated to interrupt minimum AIC indicated for panelboard, unless otherwise noted.

C. Outer trims of panel covers shall have piano hinge or panel covers shall have door-in-door construction. Provide doors with concealed hinges and flush tumbler lock and catch on panelboards. Match existing Owner's keying system.

D. Finish surface mounted panel boxes and trim with ANSI 61 gray enamel over rust inhibiting primer treatment or use galvanized surface mounted boxes, which have had treatment applied to galvanizing to prepare surface for painting with paint to match adjoining walls.

E. Where "space" is called for on schedule, provide bus, device supports and connections for future circuit breaker or cutout.

F. Branch circuit breakers within panelboard shall have same mounting.

G. Provide 100% neutral bus in panelboards. Neutral bus in each panelboard shall be isolated from cabinet to prevent neutral grounds at cabinet.

H. Provide 50% ground bus in each panelboard cabinet. Each ground bus shall be bonded to cabinet. Bolt and screw heads of ground bus lugs shall be painted green. In addition, provide nameplates in each panelboard, designating neutral and ground bus.

I. Panelboards shall be constructed in accordance with NEMA PB1, Federal Specifications W-P-115A and WC-375B and appropriate UL requirements, and shall bear UL label.

J. Panelboards shall be suitable for surface mounting, as indicated.

K. Where feeders to branch circuit panelboards feed through and tap to panel gutters shall have minimum width, as per NEC.

L. Main breaker shall be separately mounted above or below branch breakers.

M. Series routing of panelboards not permitted.

2.02 LIGHTING AND APPLIANCE PANELBOARDS

A. Lighting and appliance branch circuit panelboards shall be equipped with "bolt-on" thermal-magnetic circuit breakers. Two or three-pole breakers shall be common trip type and not composed of single pole units with handle-tie. Tandem breakers shall not be permitted.

B. Panelboards shall be Square D, or approved equal.

PART 3 - EXECUTION

3.01 GENERAL

A. Provide panelboards for lighting and power feeders and branch circuits as indicated.

B. Provide labels in accordance with Section 16010 - ELECTRICAL GENERAL PROVISIONS.

3.02 INSTALLATION

A. Circuit numbers indicated on branch wiring on plans are to indicate grouping of loads on circuits, and do not necessarily indicate actual circuit numbers in panelboard.

Circuits shall be so arranged that loads are balanced as closely as practical over phases, and that branch circuit neutral conductor does not serve as common for two or more single phase circuits connected to same phase in panelboard.

END OF SECTION 16442

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SECTION 16443

MOTOR CONTROL CENTERS

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SECTION 16443

MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation of a motor control center.

1.03 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 GENERAL

A. Motor Control Centers shall be suitable for operation on the type service indicated on the drawings with an available fault as indicated on the Motor Control Center Schedule.

B. The entire motor control center shall be suitable for operation at the specified available fault current. The motor control center shall be UL labeled by the manufacturer to indicate the maximum available fault current rating, including the structure, bussing, main feeder, and all units and devices included in the motor control center. This motor control center circuit rating shall be at least as great as the available fault current at the point where the motor control center is to be connected to the system. The bus bracing rating or rating of the main disconnect shall not be an acceptable substitute for this requirement.

C. All unused space in the motor control center shall be capable of accepting future plug-in units. Unused space shall be covered by hinged blank doors.

2.02 CONSTRUCTION

A. Motor Control Centers structures shall be totally enclosed, dead front, freestanding assemblies, conforming to the requirements of UL-845, NEMA ICS 2-322 and the NEC. Structures shall be NEMA 1 - gasketed, unless otherwise indicated.

B. Structures which house modular plug-in units shall be 20" wide with a 4" wide vertical wireway. The vertical wireway shall have a separate hinged door. Access to the wireways shall not require opening control unit doors. Motor Control Center structures shall be 91.5" high including continuous removable base channels. Each section shall include a two-piece top plate and bottom plate. The top plate and bottom plate shall be removable to ease the cutting of conduit entry openings.

C. Motor Control Center structures shall contain a minimum 6" high horizontal wireway at the top of each section and a minimum 6" high horizontal wireway at the bottom of each section. These wireways shall run the full length of the motor control center to allow room for power and control cable to connect between units in different sections.

D. Structures that house a single, full section control unit are not required to have vertical wireways. Those control units must open directly into the motor control center horizontal wireways.

E. All bussing and connections shall be tin plated copper. The main (horizontal) bus shall be rated as indicated on motor control center schedule and shall extend the full length of the motor control center. Bus ratings shall be based on a 50 degree C maximum temperature rise in a 40 degree C ambient. Provisions shall be provided for splicing additional sections onto either end of the motor control center. Each section that accepts plug-in units shall be provided with a vertical bus for distributing power from the main bus to the individual plug-in starter units. The bus shall be of the same material and plating as the main bus, and shall be rated as indicated on the motor control center schedule. The vertical bus shall be connected directly to the horizontal bus stack without the use of risers or other intervening connectors.

F. A tin plated copper ground bus shall be provided that runs the entire length of the motor control center. The ground bus shall be 0.25" x 2.0" and be rated for 600 amps. A compression lug shall be provided in the motor control center for a #4/0 to 250 MCM ground cable. The ground bus shall be provided with (6)-0.38" holes for each vertical section to accept customer supplied ground lugs for any loads requiring a ground conductor.

G. Motor Control Centers shall be separated into shipping blocks of no more than three vertical sections each. Shipping blocks shall not be shipped on their sides. Each shipping block shall include a removable "lifting angle" which will supply an easy means of attaching an overhead crane or other suitable lifting equipment. Shipping blocks shall be joined at the jobsite with the use of integral splice bars. These splice bars shall be pre-assembled into the power bus, not shipped loose in a "splice bar

kit". Splice bars should be installed into the end of the motor control center power bus to allow the installation of additional sections.

H. All power bussing and splice connections shall be isolated from the unit compartments and the wireways. The horizontal bus shall be housed in a molded glass filled polyester support assembly that provides bus insulation and braces the bus against the forces generated during a short circuit. The horizontal bus shall be isolated from the top horizontal wireway by a grounded steel barrier. This barrier shall be removable to allow access to the bus and connections for maintenance. The vertical bus shall be housed in modular glass filled polyester supports that provide bus insulation and braces the bus against the forces generated during a short circuit. These supports shall have openings every 3" for unit stab-on connections.

I. Units with circuit breaker disconnects through 250 amp frame shall connect to the vertical bus through a spring reinforced stab-on connector. Units with larger disconnects shall be connected directly to the main horizontal bus with appropriately sized cable or riser bus. Stabs on all plug-in units shall be solidly bussed to the unit disconnect. Cabled stab assemblies are not permitted. All conducting parts on the line side of the unit shall be shrouded by a suitable insulating material to prevent accidental contact with those parts.

J. All plug-on units shall utilize a two stage advance/retract type operating mechanism which will allow the unit to disengage from the power bus without withdrawing the unit from the motor control center. In the advanced position, the unit stabs engage the vertical phase bus. A nondefeatable mechanical interlock shall prevent the disconnect from being placed in the "on" position while the mechanism is in the retract position. When in this retract position, it shall be possible to close the unit door in order to maintain the enclosure's integrity.

K. A nondefeatable mechanical interlock shall prevent installing or removing a plug-in unit from the structure unless the mechanism is first placed in the retract position. A nondefeatable mechanical interlock shall prevent placing the mechanism in the retract position unless the disconnect is first placed in the "off" position. All nonplug-on units shall utilize a fixed position type operating mechanism in the retract position, unless the disconnect is first placed in the "off" position. All nonplug-on units shall utilize a fixed position type operating mechanism which allows complete "on-off" control of the unit disconnect with clear indication of the disconnect's status. All mechanisms shall include a mechanical interlock to prevent the opening of the unit door when the disconnect is in the "on" position. Another mechanical interlock shall prevent an operator from placing the disconnect in the "on" position while the unit door is open. Provisions shall be provided for locking all disconnects in the "off" position with up to three padlocks. All circuit breaker operators shall include a separate "tripped" position.

L. Motor Control Center wiring shall be Class II, Type C. All starters shall be provided with unit control terminal blocks. Provide one additional block of five spare terminal

blocks per starter. Terminal blocks shall be the pull-apart type rated at 20 amps. All current carrying parts shall be tin plated. Terminals shall be accessible from inside the unit when the unit door is opened.

2.03 FINISH

A. All steel parts shall be provided with a UL listed acrylic baked enamel paint finish, except plated parts used for ground connections. All painted parts shall undergo a multistage treatment process to insure a uniform paint coat with high adhesion. The standard paint finish shall be able to pass at least 300 hours of salt spray per ASTM B117 with less than 1/8" loss of paints from a scribe line. Paint color shall be #49 medium light grey per ANSI standard 255.1-1967.

2.04 CIRCUIT BREAKERS

A. Branch circuit breakers shall be sized as indicated on drawings. Branch circuit breakers shall be thermal-magnetic trip molded case circuit breakers. Circuit breakers shall have a quick-make, quick-break over center toggle type mechanism and the handle mechanism shall be trip-free to prevent holding contacts closed against a short circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. Multipole circuit breakers shall be common-trip such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Arc extinction is to be accomplished by magnetic arc chutes. All ratings are to be clearly visible. All circuit breakers shall be listed by and shall conform to applicable requirements of NEMA ABI-1975 (1981) and meet appropriate classifications of Federal Specifications W-C 375B/Gen. Circuit breakers with frame sizes larger than 100 amperes shall be provided with adjustable magnetic trip elements.

2.05 COMBINATION STARTERS

A. All starters shall be combination magnetic type, unless otherwise indicated and shall be provided with a molded case circuit breaker unit disconnect. All starters shall be furnished with NEMA rated magnetic contactors and external manual reset overload relay with electronic type thermal overload units.

B. Starters shall be full voltage single or two speed, reversing or nonreversing, electrically operated, electrically held, three-pole assemblies with three phase overload protection.

C. Starters shall be equipped with the following features as a minimum, unless otherwise indicated on the drawings:

1. 120 volt control transformer with two primary and one secondary fuse sized to accommodate all connected control circuit devices.
2. Push-to-test red "on" and green "off" pilot lights.

3. Auxiliary contacts (two N.O. two N.C.) in addition to seal-in and interlocking contacts.
4. Start-stop maintained contact pushbuttons.
5. Elapsed time meter.
6. Push-to-test pilot lights color and number as indicated.
7. Provide other auxiliaries as shown on Control Drawings.

2.06 VARIABLE FREQUENCY DRIVES (VFD'S)

A. The Variable Frequency Drive (VFD) controller shall convert 460 volt, +/- 10%, 3 phase, 60 Hz power to adjustable voltage/frequency, 3 phase, A-C power for stepless motor control from 0% to 110% of base motor speed. Speed controller shall be coordinated with high-efficiency, NEMA design B motor, for assurance of compatibility and proper operation. The convertor shall be of the voltage source design with a sine-weighted pulse width modulated (PWM) inverter section. The control scheme shall closely approximate actual sine wave current.

B. The output voltage is to vary proportionally with the output frequency to maintain a constant Volts/Hertz value up to 60 Hz. The output voltage will remain constant above 60 Hz. The controller shall include power conversion components, power control logic devices and regulator circuitry. The regulator shall provide full digital control of frequency and voltage. The controller shall utilize PWM technique to create adjustable frequency.

C. Complete curves of efficiency verses load and speed for the controller/motor shall be submitted for approval. The VFD maximum output current rating shall be a minimum of 100% of the motor nameplate full load. The VFD shall have a 100% rating for one minute for continuous operation. VFD controller and options shall be UL listed and shall comply with the latest standards of ANSI, IEEE, and NEMA. Design and construction of VFD and optional components shall comply with all provisions of the latest edition of the National Electrical Code.

D. The VFD controller shall include the following protective circuits/features:

1. Center-off Instantaneous Electronic Trip (I.E.T.) which clamps firing circuit of converter and invertor sections if:

    a. 100% of VFD rated maximum current is exceeded
    b. DC bus voltage exceeds 760 volts
    c. Phase-to-Phase output short circuit occurs

2. DC disable which clamps firing of converter section in the event of:

    a. Low input line voltage
    b. Loss of input phase

c. Desaturation circuit to drive inverter section base current to zero in event of switch overcurrent.

3. DC bus discharge circuit for protection of operator/service.
4. Three cycle (50 milliseconds) regulator control power dip ride-through.
5. Insensitive to incoming power phase sequence.
6. Light Emitting Diode (LED) monitor lamps for each inverter power stage.
7. LED status indicators on regulator, printed circuit board face plates.
8. Fast acting limiting input fuses.
9. All live power equipment shall be covered by protective shields to ensure safety of operating personnel.

E. The VFD shall have the following digital adjustments available via DIP switches located on the face plate of a single, regulator printed circuit board:

1. Maximum frequency - 0 to 200 Hz.
2. Minimum frequency - 0 to 200 Hz.
3. Acceleration - linear 1 to 600 seconds.
4. Deceleration - 1 to 600 seconds.
5. Volts/hertz - 1 to 14.3V/Hz (programmable).
6. Voltage Offset (Boost) - 0 to 48 volts (programmable).

F. The VFD shall be designed and constructed to operate within the following conditions:

1. 3300 feet elevation without the following conditions:
2. Ambient temperature – 0 degree to 40 degree C.
3. Atmosphere - non-condensing relative humidity 0% to 95%.
4. AC line voltage variation - +/-10%.
5. AC line frequency variation - +/-3%.

G. The VFD shall include the following options, factory installed:

1. Door mounted start-stop and manual-automatic selector switches.
2. Annunciator contact for remote indication of controller fault condition.
3. Through-the-door interlocked disconnect handle with provisions for padlocking.
4. Thermal overload relays for motor overload protection.
5. Isolated process control interface to enable controller to follow a 4 to 20 mA signal.
6. Door mounted diagnostic indicator to annunciate power on, controller run, and inverter enable.
7. Output load ammeter, voltmeter, and frequency indicating meter.
8. Provide contacts to allow alarm input to energy management system.
9. Provide other auxiliaries as shown on Control Drawings.

H. Start-up service shall be provided by the manufacturer's field service engineer, and shall include inspection of field wiring, complete operational test, final adjustments to AC variable frequency drive to assure proper performance and instructions to the Owner's operating personnel.

I. The VFD shall be provided with the following spare parts:

1. One set of all power and control fuses.
2. One of each printed circuit board provided.
3. One of each invertor power semiconductor for each rating supplied.

J. Each VFD application shall meet the requirements for Harmonic Noise Guidelines specified in IEEE Standard 519 for "special application: class at the converter as well as at the "point of common coupling" to any adjacent loads.

1. The VFD manufacturer shall submit calculations for Harmonic Line Noise, including percent distortion factor (%DF), line notch depth, and line notch area at the converter and point of common coupling to adjacent loads for each VFD application.

K. Each VFD application shall meet the requirements of FCC standards for Radio Frequency Interference (RFI). Provide line filters if required for protection of the input power system from RFI generated by the VFD.

2.07 LABELS

A. Engraved, laminated plastic nameplates shall be provided on the motor control center and the door of each compartment. Nameplates shall have 1/4-inch high, white, capital letterings on black background.

B. Control components such as relays, timers, etc., shall be identified by means of durable tags or printed symbols which shall bear the same code letters or numbers which appear on the shop drawings, wiring diagrams, etc.

2.08 ACCESSORIES

A. Provide power monitor as indicated. Power monitor shall be Electro Industries. Nexus 1250 with LCD display or approved equal.

B. Provide Surge Protective Devices (SPD) as indicated. SPD shall be as indicated in Section 16289, SURGE PROTECTIVE DEVICES.

C. Provide all required current transformers, fuses, potential taps and similar items with ratios suitable for the service voltage and current rating of the Motor Control Center. Current transformers shall be capable of carrying full load continuous primary current without damage to the transformers insulation.

2.09 MANUFACTURER

A. Motor Control Centers shall be as manufactured by Square D or approved equal.

PART 3 - EXECUTION

3.01 GENERAL

A. Motor Control Centers shall be mounted on a 4-inch high concrete pad and in accordance with the manufacturer's recommendations. After installation on the concrete pad, all internal components shall be inspected and all connections checked and tightened.

3.02 INSTALLATION

A. Connections to external equipment and connections of the incoming service shall be as shown or as required by equipment manufacturer.

B. Wires from each compartment shall be individually bound and tagged.

C. Enclosures and ground busses shall be grounded as required by the NEC and as indicated on the drawings.

3.03 TESTING AND ADJUSTING

A. Adjust all motor circuit protector settings to coordinate with the motor size to prevent if from exceeding its rating or duty cycle.

B. Test Motor Control Center and Components in accordance with Section 16940 - TESTING AND INSPECTION.

C. After installation, the motor control center shall be checked, adjusted, and initially energized under the direction of the manufacturer's representative.

END OF SECTION 16443

SECTION 16461

LOW VOLTAGE TRANSFORMERS

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SECTION 16461

LOW VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation of complete dry type transformers.

1.03 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

PART 2 - MATERIALS

2.01 GENERAL

A. Provide the dry enclosed and ventilating type transformers as indicated and specified herein. Transformers shall be Square D or approved equal. Transformers shall be UL listed and labeled.

2.02 DRY TYPE TRANSFORMERS

A. Dry type transformers shall be provided with separate primary and secondary windings for each phase. Each primary winding of each transformer having a rating less than 30 KVA shall have a minimum of 2-5% fully rated taps below rated primary voltage. Each primary winding of each transformer having a rating 30 KVA and greater, shall be provided with either four or six taps, two 2-1/2% fully rated above rated primary voltage, the remainder being fully rated 2-1/2% taps below rated primary voltage. Primary windings of 3-phase transformers shall be "delta" connected. Windings shall be copper.

B. Transformers shall have Class "H" insulation in accordance with the manufacturer's standard. Transformers shall have 220 degree C insulation system, in accordance with manufacturer's standard and shall be rated for continuous operation at rated kVA. The winding temperature rise shall not exceed 115 degree C above a 40 degree C ambient. The 115 degree rise transformers shall be capable of carrying a 15%

continuous overload without exceeding a 150 degree C temperature rise. Transformer surface temperature rise shall not exceed 65 degree C. Transformer housings shall be dripproof.

C. Sound ratings of transformers shall meet or exceed ANSI Standard for the particular size. Sound levels shall be as measured in accordance with ANSI C89.2. Transformer shall be in accordance with NEMA ST-20, UL 1561, and UL 506 and bear the UL label.

D. Transformers shall be provided with suitable vibration and noise isolators installed between the core/coil assembly and the enclosure frame.

E. Each dry type transformer shall be provided with a suitable terminal compartment to accommodate the required primary and secondary wiring connections and side or bottom conduit entrance. Transformer shall have terminal boards equipped with factory installed clamp type connectors. The terminal compartment temperature shall not exceed 75^{o} C when the transformer is operating continuously at rated load with an ambient temperature of 40^{o} C. All terminals for wiring connections shall be suitable for copper or aluminum wiring.

PART 3 - EXECUTION

3.01 GENERAL

A. Provide dry type transformers of sizes and voltages characteristics as indicated on plans.

3.02 INSTALLATION

A. Dry type transformers shall be so installed that there is proper clearance around them to permit adequate natural draft ventilation. Clearances from walls and other obstructions for proper cooling shall be, as required, by the manufacturer of the transformers who shall state minimum clearance on his shop drawings.

B. Set transformer taps as directed.

C. Where transformers are hung from the overhead structure, mount transformers with suitable racks hung with spring hangers. Provide supporting structure which does not extend below 7 feet above the finish floor. The Contractor shall submit details of supporting means for review.

3.03 FACTORY TESTS

A. The following test shall be made on all transformers. All tests shall be made in accordance with the latest revision of ANSI and NEMA:

1. Applied and induced potential tests.

2. No-load losses at rated voltage on the rated voltage connection.
3. Ratio tests on the rated voltage connection and on all tap connections.
4. Polarity and phase-relation tests on the rated voltage connections.
5. Continuity tests.

B. Results of the above tests, including no-load loss data shall be submitted in the form of certified test reports.

END OF SECTION 16461

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SECTION 16491

FUSES (600V and BELOW)

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SECTION 16491

FUSES (600V and BELOW)

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation of fuses at all points in equipment provided under this Division that requires them.

B. All fuses shall be of the same manufacturer and shall be of the sizes indicated on the plans. Where fuse size is not indicated, the fuses shall be of the proper size for the equipment protected. All fuses shall be intact, ready for proper operation.

1.03 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

B. Provide a list as part of the shop drawing submittal showing the quantity of each type of fuse (one type for each ampere rating and one type for each variation in voltage, physical shape or performance characteristic). Provide at least 3 spare fuses for each type or 10% of the total number being provided for each type whichever quantity is larger.

PART 2 - MATERIALS

2.01 GENERAL

A. Fuse classes, types and rating have been chosen on the basis of Bussman fuses as listed below. Other acceptable manufacturers are Gould-Shawmut, Cefco, Littlefuse and Reliance Fuse/Brush Fuses, Inc.

B. Peak let-through current (Ip) and energy let-through values (I^2T) of Class L and RK-1 fuses shall not exceed the respective U.L. Standards for these fuses.

C. Provide switches with fuse clip reducers, where required, to convert fuse holders to accept smaller type fuses when fuses of small type than switch are indicated on the drawings.

D. Provide Class "R" fuse rejection kits on all safety switches not already fitted for Class "R" fuses.

2.02 FUSES RATED 600 AMPERES OR LESS

A. Fuses rated 600 amperes or less for all general power circuits shall be dual-element, U.L. Class RK-1 current limiting time-delay type. Fuses shall be of true dual-element construction, incorporating a thermal overload element using a 250^{o}F melting point alloy for thermal protection, and a separate short circuit element. The design shall provide time-delay of not less than 10 seconds at 500% of ampere rating. Interrupting rating shall be 200,000 RMS symmetrical amperes. Dimensions shall be as described in NEMA Standard FU-1 for Class H fuses.

PART 3 - EXECUTION

3.01 GENERAL

A. A fuse identification label, showing type and size, shall be placed inside each enclosure accommodating fuses.

B. Provide one or more wall mounted steel cabinet 30" or 36"H x 24"W x 12"D with key lock door in accordance with Section 16130 - BOXES AND CABINETS for storage of spare fuses. Install cabinet where as directed by Owner. Provide a separate box or compartment within the cabinet for each type of spare fuse. Provide a plastic protected list indicating each type and the required number of spares to be stored. Cabinet shall be Buss type SFC, or equivalent.

3.02 INSTALLATION

A. Fuses shall be installed on the job site. They shall not be installed in equipment at the factory and shipped in place in the equipment.

END OF SECTION 16491

SECTION 16511

LIGHTING FIXTURES

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SECTION 16511

LIGHTING FIXTURES

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the installation of all exterior and interior lighting fixtures as indicated on the drawings.

B. Furnish and install a complete lighting fixture for each lighting fixture symbol shown on the drawings, of the type and quality described herein or on the drawings. Fixtures shall be installed complete with lamps of the wattage indicated, sockets, housing, ballast, shades, diffusers, supports, batteries, and other components and shall be wired ready for operation.

C. Refer to architectural finish schedules and details of ceiling construction. Catalog numbers given for recessed fixtures may not necessarily reflect the exact type in the specified manufacturer's series for the ceiling system provided. Provide the proper unit of the series specified with all mounting accessories to suit ceiling systems in which they are installed.

1.03 QUANTITY

A. Fixture types are indicated by a letter designation and the various types are described on the drawings.

1.04 MOUNTING HEIGHTS

A. Fixture mounting heights are indicated on the drawings.

B. Mounting height for fixtures shall be considered to be the distance between the floor and/or finished grade and the lowest element of the fixtures.

C. Wall mounted fixtures of the same type, in the same space or on the same wall, shall be level with each other, except where otherwise indicated.

1.05 LOCATIONS

A. Fixtures shall be located approximately where indicated on drawings, symmetrical within the space and symmetrical with each other, except where otherwise indicated.

If construction conditions, architectural, structural, mechanical or electrical, disclose that fixtures cannot be installed as shown on the drawings, this shall immediately be brought to the Engineer's attention.

1. Exit lights shall be installed so as to be easily visible and not obscured or hidden by building construction features.
2. Pairs of wall mounted fixtures, flanking architectural features, such as doors, shall be installed symmetrical and level with each other.

1.06 MANUFACTURERS

A. The lighting design was based on the fixture type and manufacturers specified and only the fixture indicated by catalog number or series has been approved. If the Contractor elects to substitute a fixture for that specified, he shall submit all required shop drawing data for the proposed fixture and specified fixture for evaluation. The substituted fixture shall be equal, or better in quality to that specified and will be evaluated on the following comparisons:

1. Appearance.
2. Performance including Distribution (ITL/ETL photometrics, VCP data and similar items), Efficiency and Utilization, and Spacing Ratios.
3. Construction including Gauge of Materials, Quality of Materials, Finishes of Materials, Workmanship, Rigidity and Installation Ease.
4. Maintenance requirements including Hinging and Latching, Cleaning, Ballasts replacement and Relamping.

B. Details of nonstandard fixtures indicated on the drawings may be modified by the manufacturer, providing it can be demonstrated to the satisfaction of the Engineer that performance is equal or improved.

1.07 SUBMITTALS

A. Submit shop drawings, manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements.

B. The Contractor shall include in his preliminary "List of Materials" hereinbefore specified, a complete listing of all lighting fixtures showing manufacturer, type, model and/or series for acceptance for use on this project.

C. After satisfactory review of the lighting fixture list, the Contractor shall submit additional complete descriptive data for each lighting fixture. Data shall consist of construction details, operating characteristics, VCP data, ITL/ETL photometrics, ballast data, battery data, efficiency data, lens and diffuser specifications, as necessary, for complete evaluation of compliance with contract documents. For

substituted product, provide photometric data in electronic IES format on CD or USB storage device; PDF format is unacceptable.

PART 2 - MATERIALS

2.01 GENERAL

A. All exterior hardware such as screws, nuts, washers, anchor bolts and similar items shall be stainless steel.

B. Wall mounted exterior fixtures shall be supplied with compatible cast outlet wall boxes and proper neoprene gasketing to exclude moisture.

C. All stem suspended fixtures shall be provided with semirigid ball joint, self-aligning type support fittings so that all fixtures hang level with vertically aligned stems. "All thread" shall not be used for support of fixtures.

D. Finish of fixtures shall manufacturer's standard, unless otherwise specified.

E. All exposed unpainted aluminum parts of lighting fixtures shall have natural anodized or color anodized finish.

F. Where a letter designating fixture type is adjacent to a row or in a room of fixtures, it shall be understood that all fixtures in the row shall be of the type. Although the catalog numbers or series of the fluorescent fixtures hereinafter described refer to 4' units, 8' units may be used where applicable.

G. All material shall be of the best grade of approved manufacturing standards and all workmanship shall be first class, such as shall produce fixtures of a high character and fine finish of the type specified.

H. All fixtures shall be prewired at the factory and shall be wired for polarized system with one wire in each fixture to be distinctly marked for its entire length. All wire shall bear the UL label.

2.02 DRIVERS FOR LED MODULES

A. Comply with ANSI C136.22 and C62.41.2 and UL 1012. Include the following features unless otherwise indicated:

1. Drivers: Class 1 LED type, 120-277V, 60Hz.
2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C).
3. Maximum Ambient Operating Temperature: 104 deg F (40 deg C).
4. Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by manufacturer.

B. Driver: Electronic type, 0.90 power factor (minimum), total harmonic distortion (THD) 20% (maximum) with 9kV surge suppression.

2.03 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours of rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

a. Battery: Sealed, maintenance-free, lead-acid type.
b. Charger: Fully automatic, solid-state type with sealed transfer relay.
c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
f. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.04 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.05 FIXTURE TYPES

A. The various kinds of lighting fixtures which shall be provided by the Contractor are designated by type letter and specified on the contract drawings.

PART 3 - EXECUTION

3.01 GENERAL

A. All fixtures shall be fully protected until final acceptance.

B. Before final acceptance of the lighting installation, the Contractor shall clean lenses, trims, and reflecting surfaces of all lighting fixtures. Replace burnt-out lamps, excessively noisy drivers and any defective portions of fixtures.

3.02 INSTALLATION

A. Light fixtures shall be mounted as close to the locations shown on the drawings as possible, allowing for architectural, mechanical, and structural features. The Contractor shall coordinate exact location of each fixture before installation.

B. Lighting layout in mechanical and electrical equipment spaces is diagrammatic, indicating type, quantity and general circuiting of the fixtures. Exact location and mounting heights of fixtures shall be adjusted, as approved by the Engineer to prevent shadows being cast by pipes, ducts and similar items to provide the best overall illumination.

3.03 TESTS

A. Furnish all equipment and instruments necessary for testing the complete fixture installation, as may be directed by the Engineer. The tests shall demonstrate to the satisfaction of the Engineer the following:

1. That all fixtures are free from short circuits and unspecified grounds.
2. That all fixtures operate satisfactorily and quietly.

B. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

C. Emergency Lighting Adjustments:

1. Aim adjustable lamp heads to provide initial illumination that is no less than an average of 1.0 footcandle and a minimum at any point of 0.1 footcandle measured along the path of egress at floor level.

END OF SECTION 16511

SECTION 16670

LIGHTNING PROTECTION SYSTEM

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SECTION 16670

LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.01 NOTE

A. The requirements of Section 16010 - ELECTRICAL GENERAL PROVISIONS - shall apply to all work specified under this section.

1.02 SCOPE

A. The work includes all labor, materials, equipment and services necessary for the furnishing and installation of a complete lightning protection system for the buildings.

B. The Contractor shall coordinate the installation of lightning protection system with other trades to insure proper fit and adequate clearances.

C. The installation shall be made by a Contractor regularly engaged and experienced in the installation of lightning protection systems. Installation shall be made by fully licensed technicians.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Refer to Section 13125 - METAL BUILDING SYSTEMS

B. Refer to Section 16060 - GROUNDING AND BONDING

C. Refer to Section 16120 - WIRE, SPLICES AND TERMINATIONS (600V OR LESS)

D. Refer to Section 16130 - RACEWAYS

E. The Contractor shall coordinate the work as specified herein this section with work to be performed and equipment to be furnished under other Divisions of the Specifications to insure a complete and satisfactory lightning protection system installation.

1.04 REFERENCES

A. NFPA 780 - Lightning Protection Code - Latest Edition.

B. UL 96 - Standard for Installation Requirements for Lightning Protection Systems - Latest Edition.

C. UL 452 - Antenna Discharge Units.

D. UL 497 - Protectors for Paired Conductor Communication Circuits.

E. UL 497C - Protectors for Coaxial Communications Circuits.

F. UL 449ED.3 - Surge Protective Devices.

1.05 SUBMITTALS

A. Submit manufacturer's product data, etc., in accordance with provisions of Section 16010 - ELECTRICAL GENERAL PROVISIONS. Manufacturer's data shall include specifications and installation instructions. Include data substantiating that proposed materials comply with specified requirements. Submittals for the lightning protection system shall which shall include, but not be limited to, at least the following:

1. Cables or Conductors
2. Air terminals and mounting bases
3. Grounding Terminal Plates and Terminal Lugs
4. Thru-roof or wall connectors and cable support/fasteners
5. Pipe clamps, bonding plates and cable tap clamps

B. The Contractor shall furnish calculations and a complete scaled plan shop drawing showing complete installation, in addition to the required catalog cuts. Drawings shall indicate location of surge suppressors to meet UL standards.

C. After completion of the installation, provide the Owner with a UL Master Label covering the installation.

D. Upon completion of the project, Contractor shall prepare AS BUILT drawing indicating locations of all air terminals and connection details.

PART 2 - MATERIALS

2.01 GENERAL

A. All components in the Lightning Protection System shall be Listed by UL and shall bear the UL Label.

2.02 AIR TERMINALS

A. Air terminals shall be 5/8" x 18" solid aluminum, and shall extend at least 18" above the object to be protected. All air terminal bases shall be cast aluminum with stainless steel bolt-pressure cable connectors.

B. The air terminals in the center roof area shall be 5/8" x 48" solid aluminum with a proper brace.

C. Air terminal bases for flat roof areas shall be of the adhesive type.

D. The air terminals shall be spaced so as not to exceed 20' apart around the outside perimeter of the roof or the ridge and not over 50 square feet apart through the center of flat roof areas.

2.03 LIGHTNING CONDUCTORS

A. The conductors shall consist of Listed 37 strands of 13-gauge aluminum wire weighing 200 pounds per 1,000 feet for roof conductors, and 28 strands of 14-gauge copper wire weighing 375 pounds per 1,000 feet for downlead conductors. A perimeter cable shall be installed around the entire main roof of each building, and all penthouses and cooling towers. Each perimeter cable shall be connected to at least two (2) down leads, providing a two-way path to ground from each air terminal. All center roof air terminals shall be interconnected with conductors to the outside perimeter cable. Conductors on flat roof areas may be run exposed. Ground connections shall be made around the perimeter of each roof and to the main down conductor at a maximum of 100' on center. Irregularly shaped structures may require extra down conductors to provide a two-way path to ground from each air terminal.

2.04 MISCELLANEOUS COMPONENTS

A. Conductor fasteners shall be an approved type of noncorrosive metal, have ample strength to support conductors and shall be spaced not to exceed 3' on center.

B. All cable connectors shall be cast aluminum with screw-pressure type stainless steel bolts and nuts.

C. All threaded fasteners, unless otherwise specified, shall be alloy A1S1 Type 316 stainless steel.

D. All concrete embedded cable interconnections, cable to rebar bonding connections, cable to ground grid connections, and all similar connections drawings shall be accomplished by exothermic welding as specified in Section 16450 - GROUNDING SYSTEMS.

2.05 MANUFACTURERS

A. All components of the Lightning Protection System, with the exception of exothermic welds, ground grid components, grounding terminal plates and lighting poles shall be the products of one of the following manufacturers:

1. Thompson Lightning Protection, Inc.
2. East Coast Lightning Equipment, Inc.
3. Harger
4. Erico International Corporation
5. Heary Brothers Lightning Protection Co., Inc.

B. Manufacturers of equipment ancillary to the Lightning Protection System shall be as indicated.

PART 3 - EXECUTION

3.01 GENERAL

A. All downlead conductors shall be run concealed, unless otherwise indicated. Concealed conductors shall be installed in 1" diameter PVC type 40 raceway. Provide pitch pans wherever conduit penetrates the roof.

B. Connect lightning protection system to ground grid as specified in Section 16450 - GROUNDING SYSTEMS and as indicated on the drawings.

C. Existing structures adjacent to new structures that are 20' or more in height and extending from structure 30' or more, shall be equipped with a lightning protection system. Downlead conductors on existing structures may be run exposed.

D. Wherever a main grounding conductor, embedded in concrete, must transit an expansion joint or construction joint, an expansion joint crossover assembly shall be installed.

E. All exposed down lead conductors shall be installed in a one (1) piece, roll formed, galvanized sheet steel or iron guard. The guard shall be installed using masonry expansion anchors and brass machine screws and mounted with the bottom edge one (1) foot below finished grade.

3.02 BONDING

A. All metal bodies within 6' of the conductor shall be bonded to the system with approved fittings and conductor. Connections between dissimilar metals shall be made with approved bimetallic connections.

1. Bonding of all metallic objects and systems at roof levels and elsewhere on the structure shall be complete. Primary bonds for metal bodies of conductance shall be bonded with appropriate fittings and full-size conductor and shall consist of, but not be limited to, the following:

a. Roof exhaust fans
b. HVAC units and related piping and ductwork
c. Exhaust vents and any other roof piping systems
d. Roofladders
e. Skylights

2. Metal bodies of inductance located within six feet of a conductor or object with secondary bonds shall be bonded with secondary cable and fittings and shall consist of, but not be limited to, the following:

a. Roof flashings
b. Parapet coping caps
c. Gravel guards
d. Isolated metal building panels or siding
e. Roof drains
f. Downspouts
g. Roof insulation vents
h. Any sizeable miscellaneous metals

B. Exterior architectural metal fascia, curtain walls, and mullions which extend the full height of the structure shall also be bonded, if not inherently bonded, thru the building frame.

3.03 INSTALLATION

A. Wherever aluminum-to-aluminum, aluminum-to-bronze or aluminum-to-iron or steel connections are made, an antioxydant/deoxydant (e.g. DE-0X or PENETROX joint compounds) shall be applied to all contact surfaces immediately prior to assembly of connection.

B. Each Lightning Protection System installed pursuant to this specification section shall be awarded the UL Master Label (Label C).

C. Provide UL rated surge suppressors at the following locations:

1. Power entrance to the building.
2. Signal cables entering the building.

D. Provide additional devices as necessary to obtain Master UL Label. Contractor shall be totally responsible for obtaining Master UL Label.

E. Provide UL Master Label after successful installation of Lightning Protection System.

END OF SECTION 16670

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SECTION 16960

ELECTRICAL FIELD ACCEPTANCE TESTS

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SECTION 16960

ELECTRICAL FIELD ACCEPTANCE TESTS

PART 1 - GENERAL

1.01 SCOPE

A. After the electrical installation is complete, it shall be thoroughly tested by the Contractor to demonstrate that the entire system is in proper working order and in accordance with the Drawings and Specifications:

1. Tests are in addition to individual tests at the Manufacturer's plant, and may not substitute for same.
2. Tests are also intended to provide, ensure, or determine the following:

a. Provide initial acceptance tests and recorded data that can be used as a bench mark for future routine maintenance and trouble shooting by plant operating forces.
b. Ensure a successful start-up with a minimum of last minute interruptions and problems.
c. Determine the suitability of the equipment and systems for energization and placing into operating service.
d. Provide assurance that each system component is not only installed satisfactorily but performs, and will continue to perform, its function in the system with reasonable reliability throughout the life of the plant.

B. The costs of all tests shall be the responsibility of the Contractor, including the expenses of retests because of defects and failure of equipment to meet Specifications:

1. Wiring and equipment which is defective, or which fails to meet Specifications, shall be replaced by the Contractor, unless specific approval for repair is given by the Engineer. The Contractor shall bear the costs for either action.
2. Also, the Contractor shall provide sufficient personnel to assist operating forces in any additional checks they may require for acceptance, start-up, run-in and placing the equipment and systems into continuous service.

C. Make necessary openings in circuits for testing instruments and place and connect all instruments, equipment, and devices, necessary for the tests. Upon completion of tests, remove instruments and instrument connections and restore all circuits to permanent condition.

D. Contractor shall notify the Engineer, in writing, at least seven calendar days before the test is to take place. The tests shall be conducted in the presence of the Owner/Engineer and shall not be started without his permission.

E. Contractor shall supply electric current necessary for the tests.

F. Contractor shall place and connect all instruments and equipment needed for the test, remove same and restore circuits when tests are complete.

G. All testing and checkout work shall be performed with fully qualified personnel skilled in the particular tests being conducted. This is essential for obtaining and properly evaluating data while the tests are in progress and for insuring that important facts and questionable data are reported.

H. The Contractor shall ensure that all testing and checkout work is conducted in a safe manner. Special safety precautions such as the following to be utilized where appropriate:

1. Locking and tagging procedures
2. Barricades.
3. De-energization and/or isolation of equipment prior to testing.
4. Review of procedures with the Owner's safety personnel.
5. Erection of warning signs.
6. Stationing of guards and watchmen.
7. Maintenance of voice communications.
8. Personnel orientation.

I. The sequence of all tests and checks shall be such that the equipment can be energized immediately after the completion of the applicable tests.

J. Tests are in addition to all other tests specified under other sections and shall be coordinated by the Contractor.

1.02 QUALITY ASSURANCE:

A. Codes and Standards

1. All inspections and tests shall be in accordance with the following applicable codes and standards latest revisions except as provided otherwise herein.

a. All Standard, Special and Supplemental Conditions of the Contract
b. NEMA: National Electrical Manufacturer's Association
c. ASTM: American Society for Testing and Materials
d. IEEE: Institute of Electrical and Electronic Engineers
e. NETA: International Electrical Testing Association
f. ANSI: American National Standards Institute

1) ANSI C2: National Electrical Safety Code
2) ANSI Z244-1: American National Standards for Personnel Protection

g. State and Local Codes and Ordinances
h. ICEA: Insulated Cable Engineers Association
i. AEIC: Association of Edison Illuminating Companies
j. Occupational Safety and Health Administration

1) OSHA Part 1910; Subpart S, 1910.308
2) OSHA Part 1926; Subpart V, 1926.950 through 1926.960

k. National Fire Protection Association, Batterymarch Park, Quincy, MA 02169:

1) ANSI/NFPA 70B: Electrical Equipment Maintenance
2) NFPA 70E: Electrical Safety Requirements for Employer Work places
3) ANSI/NFPA 70: National Electric Code
4) ANSI/NFPA 78: Lightning Protection Code
5) ANSI/NFPA 101: Life Safety Code

2. All inspections and tests shall utilize the following references:

a. Project Design Specifications
b. Project Design Drawings
c. Project Short Circuit and Coordination Study
d. Manufacturer's instruction manuals applicable to each particular apparatus

B. Coordination:

1. Coordinate activities, and cooperate with others on project, to ensure that systems are energized when required, loads applied, and other requirements of Sections are carried out on timely, coordinated basis.
2. Other Sections of specifications require services of one or more manufacturer's representatives, to ensure that equipment supplied has been installed properly and adjusted to proper working order. Advise representative of all applicable tests in this Section, so that work will be coordinated, and tests combined where feasible.
3. It is important that equipment warranties or guarantees not be voided by the Contractor's testing and checkout work. The checks and tests will normally be supplemental to and compatible with the manufacturer's installation instruction leaflets and literature. Where deviations are apparent, the manufacturer's review shall be obtained prior to testing. Reasonable cooperation to be extended to permit witnessing by the manufacturer's

representative if so requested. Where any questionable repairs, modifications, significant adjustments, tests or checks are to be made, the Contractor shall contact the Owner's Representative to determine if the work should be performed by or with the manufacturer's representative.

C. Conditions:

1. No testing of any kind shall be done without written approval or the presence of the Owner. The Contractor shall obtain from the manufacturer all data required to verify calibrations, to set and test equipment provided.

2. The Contractor shall notify, in writing, the Owner at least 72 hours prior to tests. The notice shall identify the test and the time that the test will be performed.

3. Tests shall be performed by an independent testing agency approved by the Owner. Each two-technician field test crew shall include at least one test technician who provides current certification as such by either NETA or NICET.

1.03 SUBMITTALS

A. General:

1. Contractor shall submit to the Engineer four copies of instrument calibration curves, plotted test results, and all measurements and data.
2. All inspections, tests, and calibrations to be reported in writing. The recorded data form shall have the signatures of the persons conducting the tests and authorized witnesses. The data shall be designed to serve as the test and inspection checklist for inspection requirements. The test and checkout data shall also include any data taken prior to the adjustments, repairs, drying out, or similar work prior to final testing and acceptance. "As-found" and "as-left" test data shall be recorded and reported in writing.
3. Copies of Test Data Reports shall be incorporated in each of the related Service Manuals. The Data Reports shall include those items of equipment contained in the Service Manual. Reports shall be separated by a divider labeled "Electrical Field Acceptance Tests". Reports shall contain data for all power conductors and controls including instrumentation conductors and devices for static and dynamic equipment in the Service Manual. In addition, Operating Tests of the equipment shall be included in this section of the Service Manual.

PART 2 - MATERIALS

2.01 TEST EQUIPMENT

A. Contractor shall provide all necessary test equipment, calibrated for these specific tests by a recognized, independent test laboratory. The calibration must have been performed no more that a year from acceptance test.

1. Test equipment shall include, but not be limited to, the following:

a. Three-phase wattmeter suitable for motors up to 200 hp.
b. Ammeters (0-600 A).
c. Voltmeters (0-600 V).
d. Megger (500 V) to be used for equipment 600 volts or less.
e. Clamp-on ammeters (0-300 A).
f. Current transformers (as required).
g. Potential transformers (as required).
h. AC-DC volt-ohm millimeter.
i. All test equipment needed for high-voltage cable tests.
j. Turns ratio test set.

PART 3 - EXECUTION

3.01 INSULATION RESISTANCE TESTS

A. Cables

1. Insulation resistance tests shall be performed in accordance with NETA (International Electrical Testing Association, Inc.) Standard, Cable Insulation Resistance Test, between conductors and conductors to ground.
2. Each circuit tested shall have an insulation resistance between conductors and between each conductor and ground of not less than the following:

a. Cable 600 V and below shall have a minimum insulation resistance of 50 megohms.
b. In no case shall a phase conductor have an insulation resistance 40 percent less than the phase conductor with the highest insulation resistance.

B. Switchboard Assemblies

1. An insulation resistance test shall be performed in accordance with the appropriate NETA Insulation Resistance Test method, all switchboards, panelboards, fuseholders, switches, receptacles, and overcurrent devices shall be in place and power sources and load equipment disconnected.
2. Solid state devices and electronic components shall be disconnected prior to applying 500 volts or higher to the circuit.

C. Motors

1. An insulation resistance test shall be performed in accordance with NETA Standard, Motor Insulation Resistance Test.

3.02 GROUND RESISTANCE

A. The grounding system shall be tested for continuity of connection and for resistance to flow of current through ground connections:

B. The ground resistance of conduits, equipment cases, and supporting frames shall be near that for the system as a whole.

C. Measurement shall be made with a vibroground or ground megger, using the three point method (fall of potential).

3.03 CONDUCTOR CONNECTIONS

A. Make up no connections at service entrance, transformers, substations, motors, motor control centers, and switchgear permanently until correct phase rotation of all equipment is determined. Install and insulate these connections temporarily, if necessary, while determining proper rotation. Make permanent connections after proper rotation has been established and subsequent to completion of insulation resistance and dielectric tests.

3.04 SWITCHBOARD

A. Test for corona shall be performed only after an insulation resistance test has been completed.

B. The sharp, discrete pulses characteristics of corona may be detected by a cathode ray oscilloscope, radio, noise meter, voltmeter or headphone.

C. The recorded test results shall include temperature; humidity; description of the specimen, including terminations an components of the system connected to the specimen; plus the overpotential test results.

D. Verify torque on all bolts for bus bar connections

1. Bus bar and terminal connections shall be inspected to ensure that all joints have proper torque tightness.
2. Torque values for all types of joints involved shall be in accordance with manufacturer's recommendations.
3. Check support and bracing

a. Bus bar support insulators and barriers shall be inspected to ensure that they are free from contamination.

b. Insulators shall be checked for cracks and signs of arc tracking. Mounting hardware shall be inspected and all joints checked for proper torque value.

3.05 INSTRUMENT TRANSFORMERS

A. Electrically tested for polarity and ratio

1. On each transformer winding, the manufacturer's polarity markings shall be verified.
2. The test data shall include the following:

   a. Manufacturer's stated ratio for each tap position.
   b. Test turns ratio results.
   c. Percent error per tap position.
   d. Manufacturer's indicated polarity.
   e. Test result polarity.

3. One each set of transformer windings, the turns ratio shall be determined for all no-loads taps, using the two voltmeter method for control transformers and the two ammeter method for current transformers.

B. Confirm test switch wiring and operation

1. A functional test shall be performed on the test switch of the current transformer to ensure that the secondary leads are shorted and that no open circuit conditions exist. A functional test shall also be performed on the control transformers to ensure that no short circuit exists across the secondary leads.
2. All control wiring shall be checked to ensure proper operation of the device being powered.

3.06 OPERATING TESTS

A. Test all mechanical and electrical interlocks:

1. Mechanical interlocks shall be examined to ensure the interlock is free to operate and that bearing surfaces are free to perform their intended function.
2. Check for correct adjustment of primary disconnect mechanisms in plug-in units. Shall be mechanically interlocked with the door to ensure that the door is held closed with primary disconnect in the ON position.
3. Check for provisions for padlock mechanisms on disconnect operating mechanisms.
4. Check motor starters equipped with a defeater mechanism to ensure that they can be operated to release the door interlock with the disconnect device in the ON position.

5. Check all electrical interlocks for loose wiring, proper mechanical alignment and operation. Also inspect all contact surfaces to ensure they are clean and not pitted.

B. Circuit Breaker Operation:

1. Installation and inspection of 480V power circuit breakers shall be in accordance with NEMA Pub. No. SG-3:

a. Perform tests in accordance with NETA Section 8.6.1.2.

2. Molded case 600 volt circuit breakers of the time-delay instantaneous type are to be checked for possible damage during shipment or storage by:

a. Inspecting the breaker visually for physical damage.
b. Performing several mechanical ON-OFF operations.
c. Circuit continuity check on each pole with the circuit breaker in the closed position.
d. Three hundred (300) percent of breaker rated continuous current applied to each pole to determine that the circuit breaker will trip on an overload.
e. At least one test shall be made in the range of element of the trip device.

C. Test all remote control stations for operation:

1. A functional test shall be performed for all remote pushbutton stations and manual motor starters to ensure their proper operation.
2. Control stations tested under actual operating conditions shall perform their intended function.

D. Check insulation resistance of control power transformer (CPT):

1. An insulation resistance test shall be performed per NETA Transformer Insulation Resistance Test.
2. The reported test data shall be given in ohms.

E. Check motor operation:

1. The motor shall be run for at least four hours as close to full load as possible.
2. Motor alignment, wiring capacity, speed and operation shall be checked to verify compliance with Specifications.

F. Verify potential transformer (PT) circuits and test switches:

1. A functional test shall be performed on the test switch of the potential transformer to ensure that the proper voltage is on the secondary windings.

2. All control wiring shall be checked to ensure proper operation of the device being powered.

G. Contractor to demonstrate complete operation and functions of all equipment and devices not specifically included herein:

1. A functional test shall be performed on all equipment including all power wiring, motor starters, controls and control wiring to ensure that all equipment is operating properly and that the system is operating as designed.

3.07 FINALLY

A. All defects found in new equipment shall be repaired at once and the tests reconducted at the Contractor's expense.

B. Results of the above tests shall show the equipment and wiring meets the requirements of this specification before final acceptance. Should any of the above tests indicate defects in materials or workmanship, the faulty installation shall be repaired or replaced at once, and the tests reconducted at the Contractor's expense.

C. All circuit breakers, etc., found defective shall be replaced.

END OF SECTION 16960

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SECTION 17000

SYSTEM INTEGRATOR

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SECTION 17000

SYSTEM INTEGRATOR

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes the requirements and responsibilities of the System Integrator (SI).

B. The Contractor must retain the services of a qualified System Integrator to furnish and configure the additions to the Process Control System (PCS) including hardware, software, and communication system requirements. The SI must provide the integration services, system start-up, testing, and documentation required for the PCS additions with the existing PCS as shown on the drawings, and as required in Division 17 of the Specification.

C. It must be the responsibility of the SI to be the single point of contact for the coordination of the control system and the equipment provided by the SI, vendors and all sub-contractors.

D. Prior to commencing work at any facility, the SI must perform a Field Pre-Test to verify existing facility conditions as well as the functions and functionality of existing equipment. The Contractor must document and submit any discrepancies or non-operational equipment found where the work is to be performed to avoid potential liability problems and conflicts. Unless otherwise noted on pre-testing reports, it must be assumed that all existing equipment is functional and operating as required.

1. Inspection must include operating process equipment, verifying readouts and signals on existing instrumentation, actuation of valves, switches and breakers, PCS and network equipment, conduit routing, and control and network cable connections.

2. Provide written inspection results detailing discrepancies or no discrepancies as applicable. All discrepancies must be noted to and reviewed by the Owner.

1.02 SYSTEM DESCRIPTION

A. The existing PCS must be modified to include new process control and networking equipment. After modification, the PCS must operate as a single integrated system.

B. The PCS System must be comprised of new and existing PLC-based control panels at plant process areas with PC Workstation for monitoring and control. Plant process areas must communicate to the PCS on an Ethernet data network using fiber optic and CAT 6 Ethernet cabling.

C. The PCS must provide supervisory control and monitoring of the new and modified plant process areas. The control panels and associated workstations must provide monitoring and control based upon system inputs and outputs, and as described in Division 17.

D. New control panels as shown on Contract Drawings will be added to the PCS network. Each of these new control panels must be provided with independently operating PLCs.

E. Operator functions, which include all PCS monitoring, control and reporting functions, must be virtually identical to all existing operator workstation locations.

1.03 RELATED WORK

A. Related work specified elsewhere includes, but is not limited to:

1. Section 01300 – Submittals
2. Section 01106 – Construction Coordination.
3. Section 17100 – Fiber Optic Communication System
4. Section 17143 – Factory Acceptance Testing
5. Section 17166 – Site Acceptance Testing
6. Section 17250 – Programmable Logic Controllers
7. Section 17400 – Instrumentation
8. Section 17441 – Control Panel Hardware

1.04 QUALITY ASSURANCE

A. The PCS hardware, software, communication devices and instrumentation must be provided by a single source System Integrator.

B. All Equipment should be of the latest version available at the time of bid.

C. All like equipment should be provided by the same manufacturer to the fullest extent possible to achieve a standardization of equipment, maintenance and spare parts.

D. All packaged PCS equipment provided by manufacturers must be coordinated to properly function with the existing PCS network infrastructure.

1.05 SUBMITTALS

A. System Integrators that are not pre-approved must provide a qualifications package for review. The qualifications package must include the following information, and must

be organized into separate subsections in the qualifications package submittal in the order indicated:

1. Company Background - Provide a brief company overview detailing SI's experience, capabilities, and available resources. Description of available resources must include labor categories, staffing, equipment, material availability, testing equipment, and training staff and aids.

2. Experience in Municipal Water and Wastewater Applications - Provide a list and detailed description of a minimum of three (3) recent (last 7 years) projects involving Water and/or Wastewater Pumping, Storage or Treatment Facilities that the SI has had responsibility for as the Systems Integrator. Each project must be provided with the project duration and date of completion. At the Engineer's discretion and request, the SI must provide as-built project documentation and drawings for the instrumentation and control systems integration work performed by the SI for one of the projects contained on the list of projects provided. Each of the listed projects must be provided with the SI Project Manager's name.

3. Project Plan - Provide a brief project task list detailing the personnel to be utilized for engineering and design, fabrication, installation, calibration, testing, demonstration, and training for this project. Include resumes for all personnel performing services for this project. Provide name and resume for the proposed SI Project Manager for this project.

4. Quality Assurance Plan - Provide a brief summary of the SI's in-place quality assurance plans for performing work from shop drawing and submittal preparation and engineering through testing and training.

5. Facilities and Equipment - Provide a detailed list of office and fabrication space, location where fabrication of panels will take place, and available meeting facilities at the SI's location (This is not intended to imply that meetings must be held at the SIs location for this project).

B. Provide submittals as defined in the related sections of Division 17 and in accordance with the submittal requirements of Section 01300, Submittals.

C. Pre-Construction Site Inspection Report

1. Provide written report of completion of site inspection and testing of equipment. Report should detail discrepancies found during testing. Include details about broken or inoperative equipment; missing devices; cracked or broken pavement; and other issues found at station that the Contractor should advise the Owner of prior to commencement of construction activities.

2. Reports for stations without found discrepancies must indicate no discrepancies found.

3. Report should indicate if equipment was not able to be tested and for what reason it was not.

1.06 SEQUENCE AND SCHEDULING

A. Schedule and perform the work to minimize adverse effects on the operations of the Owner's facilities in accordance with specification Section 01106, Construction Coordination.

B. Schedule the work to allow ample time for development and configuration of operational control logic by the Owners programming engineer for all PLC, OIT and HMI software, and review of such development by the Owner, or designated representative. Configuration programs must be provided to the Owner and/or Owners programming engineer on or before factory acceptance testing.

C. Prerequisite Activities and Lead Times: Do not start following key Project activities until prerequisite activities and lead times as listed below have been completed and satisfied:

1. Shop Drawing Reviews by Engineer:

   a. Prerequisite: Engineer acceptance of Schedule of Values and Progress Schedule.

   b. Schedule: In accordance with completed schedule of Shop Drawing and Sample submittals specified in Section 01300, Submittals.

2. Factory Acceptance Testing Prerequisites:

   a. Associated test procedures and submittals completed.

   b. PCS coordination meeting is conducted.

   c. PLC and OIT configuration programming completed.

3. Control Panel (PLC and OIT) Shipment to Site:

   a. General Prerequisites:

      1) Approval of PCS Shop Drawings and preliminary operation and maintenance data.

      2) PCS Configuration Logic Testing completed

      3) Factory Acceptance Testing completed and approved test report submittal.

4. Control Panel (PLC and OIT) Installation Prerequisite: Equipment received at Site.

5. Loop Testing Prerequisite: Associated test procedures submitted and approved.

6. Communication Link Testing Prerequisite:

   a. Associated test procedures submitted and approved.

   b. Loop Testing compete.

7. Functional Test Prerequisite:

   a. Associated test procedures submitted and approved.

   b. Loop Testing compete.

   c. Communication Link Testing complete.

8. Performance Test Prerequisite: Functional Test completed, and facility started up.

9. Training Prerequisite: Associated training plan Submittal completed.

10. PLC and HMI Configuration Training Prerequisite: PLC and OIT hardware and software Shop Drawings approved and all required testing is complete.

1.07 CONTRACT DRAWINGS

A. Approximate Locations

1. The locations of equipment shown on the Contract Drawings are approximate only. The Contractor must coordinate final locations of equipment and conduit with actual dimension of equipment provided and other trades to avoid conflicts. No additional compensation will be made for relocations, reconnections or additional work required as a result of failure to coordinate with other trades.

B. Diagrammatic Drawings

1. The circuit diagrams shown on the Contract Drawings are diagrammatic and functional only and are not intended to show exact circuit or wiring layouts, number of fittings or other installation details. The Contractor must furnish all labor and materials necessary to install and place in satisfactory operation; a fully complete functional system.

2. The motor starter circuit diagrams shown on the Contract Drawings are not intended to show all the requirements and features of the motor starter.

3. The number of conductors shown on the Contract Drawings is the minimum required. Contractor must install as many conductors as required for the complete and satisfactory operation of all systems.

4. Contractor is responsible for field verifying existing control circuits and providing wiring interface to meet the intended operation of the device. Contractor must mark-up schematic drawings to reflect actual field connections and termination points.

1.08 PROTECTED WORK

A. Dry Locations

1. Dry locations are areas not normally subject to dampness or wetness. An area designated as dry may temporarily be subjected to dampness or wetness, as in the case of a building under construction.

2. All equipment and enclosures installed in Dry Locations must be NEMA Type 12, unless otherwise noted.

B. Wet Locations

1. Where installed outdoors or areas designated as Wet Locations, all work must meet the requirements of the National Electric Code (NEC) for Wet Locations.

2. All equipment and enclosures installed in Wet Locations must be NEMA Type 4X Stainless Steel, unless otherwise noted.

C. Hazardous Locations

1. Where installed areas designated as Hazardous Locations, all work must meet the requirements of the NEC for Hazardous Locations.

1.09 WARRANTY

A. Correct defects in hardware, software, and workmanship that develop within one (1) year after final acceptance of the Work.

B. Upon written notice, furnish labor and materials to immediately replace and make good, without expense to the Owner, faulty materials or equipment.

C. Include warranty against defects of design, workmanship and material.

D. Provide original equipment manufacturer warranties from the time equipment is received until one (1) year after final acceptance. Include technical support and services of field service personnel.

PART 2 - PRODUCTS

2.01 SYSTEM INTEGRATOR

A. The following System Integrators are pre-approved to perform the work required for this contract

1. Trijay Systems
   10 Maple Ave.
   Line Lexington, PA 18932
   (215) 997-5833

2. Southern Flow, Inc.
   6445 Industrial Way, Suite A
   Alpharetta, GA 30004
   (770) 667-5169

B. System Integrators that have not been pre-approved must meet the following general requirements and submit a qualifications package as specified herein

1. The SI must be regularly engaged in the business of instrumentation and controls and must be responsible for the furnishing, coordination, installation and testing of the instrumentation, controls and control panels specified herein and referenced in other Sections.

2. The SI must demonstrate the requisite resources of in-house staff, facilities and finances to complete the project in the schedule specified. These resources must include personnel who are direct payroll employees of the SI to design, fabricate, stage, implement and test the entire integrated system at the SI's facilities. In-house personnel must include all disciplines associated with system manufacture, fabrication, and integration to include but not be limited to engineering, drafting, analog and digital control systems and wiring design, construction, wiring, labeling, software configuration, project management, documentation, and quality control. The SI must have staff that is experienced in conducting and performing training of Owner's operations and maintenance staff in the use and troubleshooting of the specific instrumentation, controls, hardware and software provided on the project.

3. The SI must assign a specific person to be the SI Project Manager for this project. The Project Manager must be a direct employee of the SI, must be assigned to this specific project, and must be skilled and experienced in project management, and in the type of work described herein. The Project Manager must be assigned for the period of the Contract. Should it become necessary to replace the SI Project Manager, the Contractor must submit to the Engineer the credentials of the person assigned as a replacement.

4. The SI must maintain a UL listed fabrication shop located at the SI facility for the assembly of the various control panels, cabinets, consoles, instrument racks, enclosures, and wiring required for this project. This shop must be available for inspection by the Engineer to observe quality control and workmanship. The SI facilities must include hardware and software owned by the SI for development and support of any system software, and any testing and demonstration equipment to be utilized on the project.

2.02 GENERAL

A. Provide the hardware as specified complete specifications and contract drawings, installation assistance, testing, startup, manufacturing, and demonstration of equipment.

B. Provide signal isolation devices as required.

C. Provide communication equipment as required to interface the PCS components to the communication network.

D. Provide operations and maintenance manuals in accordance with Specification 01300, Submittals, and specified training.

E. Provide all required PCS HMI system software licenses required in the specification and as shown on the drawings.

F. Provide configuration programming of the PLC programming software, Human Machine Interface software (HMI) and operating system software. See Section 3.0 Programming Requirements for additional programming information.

G. Before the implementation of any software on to the existing PCS, provide the Owner with a complete back-up of the existing PLC software and HMI software.

H. Purchase, assemble, test, install and startup the PLC-based control panels, network equipment, and other required PCS panels. Installation must comply with the Specifications under Division 16 and 17.

I. Provide integration and startup of PLC-based control panels and PLC communications to operator workstations (OWSs) loaded with HMI software, and PLC interfacing via fiber optic and CAT 6 Ethernet cabling.

J. Complete testing, installation, and startup of software for communications between the existing Pump and Blower Building, Pump and Blower Building 2 and Filter Irrigation Pump Station.

K. Provide all incidental hardware and software accessories, including connectors, cables, switches, routers, modems, converters, adapters, drivers, and programming software necessary to modify, assemble and program a complete and functional PCS.

L. Furnish and install new PLC-based control and remote I/O panels at designated plant sites as shown on the Contract Drawings and described in the project Specifications.

M. Provide insurance and protection of all equipment, materials, and documentation until delivered to Owner.

N. Provide coordination assistance necessary for the proper calibration of the overall PCS.

O. Test all Process Control System equipment for proper operation. Should a discrepancy occur, assist the Contractor to resolve the discrepancy to provide proper operation.

P. Furnish submittals, instruction manuals, operating instructions, maintenance manuals, installation drawings, termination (wire-marking) diagrams and all other specified documentation, representing the final configuration (or version) of the hardware and software as installed in the field and accepted by the Owner. Provide software configuration files in the following format to the Owner for use by the Owners designated programming engineer:

1. The original source files in standard programming software file format as needed for immediate support of the system.

Q. Furnish spare parts as defined in the Specifications.

R. Provide warranty and support as stated in the Specifications.

PART 3 - EXECUTION

3.01 COORDINATION

A. The SI is responsible for coordinating the compatibility, constructability and operations of all components and equipment of the PCS.

B. The SI is responsible for coordinating and assigning of IP network addresses and network configurations between all PCS components, including third party manufacturer provided devices in accordance with the Owner's requirements.

C. The SI must coordinate the exchange of data between the PCS and third-party manufacturer provide control panels. Data must be exchanged between these using the same communication methods and protocols used throughout the PCS. Manufacturers provided PLC's must be programmed to map all required data to/from read and write registers with their PLC for operational functions such as setpoints, start commands, control routines, etc. The SI will be responsible to read and write data to the data tables from the PCS.

D. PCS Coordination Meeting:

1. The system integrator must conduct a PCS coordination meeting with the Owner and Owners designated Programming Engineer to coordinate and discuss the details of the PLC programming, OIT graphics, HMI graphics, and communication requirements for all new PCS equipment and existing PCS modifications. The Engineer will actively participate in the coordination effort and the request of the Owner.

2. The meeting must consist of:

a. Review of the Sequence of Operations and Control Narratives.

b. Determine the requirements, arrangement and functions of the OIT graphics.

c. Determine the requirements, arrangement and functions of the SCADA HMI graphical interface

d. Determine the requirements and arrangements of the PCS communications cabling and equipment. Communications include all new and existing connections of CAT 6 and fiber optic communication cables and the configuration of all Ethernet network devices and switches.

3. Timing: A minimum of 60 days prior to Factory Acceptance Testing of any System Integrator or Manufacturer supplied PCS panels as described in Specification 17143, Factory Acceptance Testing.

E. Programming Coordination

1. The Owners programming engineer must have access to the PLC and OIT for downloading application programs and testing.

2. Contractor must notify the Owners programming engineer a minimum of 2 weeks prior to site acceptance testing.

3. Contractor's construction schedule must allow for an additional 2 weeks following the completion of site acceptance testing for the Owners programming engineer to complete logic modifications and testing onsite as a result of Site Acceptance Testing.

3.02 SYSTEM CONFIGURATION

A. The System Integrator is responsible for providing a functional and configured PCS. The system must be capable of scanning I/O, communicating to other PCS and Manufacturer's control panels and displaying and archiving data on the graphical systems.

B. System configurations must include new and existing components including networking communications devices, network media, PLC hardware, graphical interface terminals and Human-Machine Interface software and communications.

C. The SI must maintain a copy of all configuration files and base controller programs in a read-only format. Files will be available for testing and verification of the operating system in the event that a dispute arises.

D. The SI must provide and configure communications to third party provided control panel PLCs as shown in the Contract Drawings.

3.03 PROGRAMMIN REQUIREMENTS

A. The programming required from the SI must be limited to the initial configurations and communications routines. The SI must be responsible to demonstrate the successful configuration and capability to transmit and receive data by the system to include PLC's; OITs; PCS Workstations; wired network devices and connections.

B. The Owner's designated Programming Engineer must be responsible for completing operational logical and graphical interface programming for specific PCS functions.

C. SI must provide to the Owner's designated Programming Engineer a copy of the system configuration files and base programs at the completion, submission and acceptance of the factory acceptance test.

D. Logic for controlling process operations will be added to the base files by the Programming Engineer as provide by the SI.

E. Programming completed by the Programming Engineer will be limited to functions required for process control, data acquisition, alarms and historian purposes only. All configurations programming to allow for these functions and data transfers will be completed by the SI.

3.04 MODIFICATIONS TO EXISTING APPLICATIONS

A. Existing operational PLC logic and HMI applications must be backed up and dated prior to making any changes and/or additions to the existing applications.

3.05 INSTALLATION

A. Provide a qualified field service engineer to guide and assist in the handling, placement, installation and checkout of the PCS and to be on-site whenever any PCS equipment is being installed.

B. Make all communications equipment, communications link and network cable terminations and connections.

C. Coordinate with both the Mechanical and Electrical Contractors to provide a complete exchange of information as necessary to install all equipment and instrumentation provided.

3.06 FIELD QUALITY CONTROL

1) Provide the following on-site services in conjunction with, and support of the Contractor's field quality control requirements:

   a) Certify in writing that the PCS equipment has been installed per the manufacturers' drawings and recommended installation procedures, the

PCS equipment power and grounding requirements have been satisfied, and that field wiring and terminations to the PCS equipment are properly installed and correctly identified. Report any discrepancies.

b) Certify in writing that the PCS is ready for field-testing.

c) Assist in resolving interface discrepancies between the input/output subsystem and panels, equipment, instrumentation, or final control devices.

d) Submit certifications in accordance Specification 01300, Submittals and include final certifications, after discrepancies are resolved, as part of O&M manual.

e) Attend progress meetings.

f) Make pre-shipment site visits.

g) Conduct all system testing including both factory and site acceptance testing.

h) Perform and/or provide training for equipment and software provided under Division 17 of the Specifications.

i) Include time to repair or correct shipping defects and make additional trips as a result of shipping problems.

END OF SECTION

SECTION 17100

FIBER OPTIC COMMUNICATION SYSTEM

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SECTION 17100

FIBER OPTIC COMMUNICATION SYSTEM

PART 1 - GENERAL

1.01 REFERENCES

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

1. Institute of Electrical & Electronic Engineers, Inc. (IEEE): 802.3, Telecommunication and Information Exchange Between Systems.

2. International Organization for Standardization (ISO).

3. National Electrical -Code (NEC).

4. Telecommunications Industry Association (TIA); Electronics Industry Association (EIA):

5. 492, Specifications for Optical Waveguide Fibers.

6. 568, Commercial Building Telecommunications Cabling Standard.

7. 607, Commercial Building Grounding and Bonding Requirements for Telecommunications.

1.02 ABBREVIATIONS

A. ATM: Asynchronous transfer mode.

B. AUI: Attachment unit interface.

C. dB: Decibel.

D. DNI: Desktop network interface.

E. FDDI: Fiber distributed data interface.

F. FIM: Facilities Information Management.

G. F.O. or FO: Fiber Optic

H. FOCS: Fiber Optic Communication Subsystem.

I. FOIRL: Fiber Optic Inter Repeater Link.

J. GBps: Gigabits per second

K. LAN: Local area network.

L. LIMS: Laboratory Information Management System.

M. MHz: Megahertz.

N. Micro: x 10-6.

O. MIS: Management Information System.

P. MBps: Megabits per second.

Q. N: Newton.

R. n, nano: x 10-9.

S. nm: Nanometer.

T. OTDR: Optical time-domain reflectometer.

U. PICS: Process Instrumentation and Control System.

V. µm: Micrometer.

W. UPS: Uninterruptible power supply.

X. V ac: Volts alternating current.

Y. WAN: Wide area network.

1.03 SYSTEM DESCRIPTION

A. This section covers requirements for Fiber Optic Communication Subsystem (FOCS).

B. Function of FOCS is to transmit digital data between network nodes. Requirements listed identify minimum acceptable system performance.

C. Provide a FOCS based on referenced standards for use in the following local and wide area networks:

1. Ethernet.

2. Fast Ethernet.

3. Gigabit Ethernet.

D. Network communications will be used by the Plant Control System (SCADA) to distribute data and coordinate Owner's operations.

1.04 SUBMITTALS

A. General: Administrative, Shop Drawings, Samples, Quality Control, and Contract Closeout Submittals must conform to the requirements of Specification 01300, Submittals.

B. Shop Drawings and Product Data:

1. Contractor must prepare and submit a detailed site layout diagram. The FOCS subcontractor must coordinate information for site drawings, duct bank layouts and conduits with installing subcontractor. At a minimum, the site layout diagram must include the following information:

a. Duct banks, access holes, pull-boxes and fiber distribution panels. Indicate specific identification nomenclature for all devices.

b. Site drawings showing below grade duct bank and conduit routings between access holes and buildings, with conduit counts and identification.

c. Site drawings showing below grade innerduct routings through conduits, with innerduct counts and identification.

d. Cable routings through innerducts and to patch panels, fiber centers, or network nodes, with cable and node identification. Provide detailed patch panel drawings showing patch panel designation, fiber cable designation, and fiber connections with color coded fibers indicated, terminal numbers and connection types.

e. Calculated optical power losses for each fiber path.

f. Provide routing tables on site drawings to show innerduct, lobe color/number, included fiber designations, etc.

2. Contractor must prepare and submit schedule of cable marking tags. Schedule must be prepared showing cable identifier, fiber colors and their assigned use and the terminating points (panel location) of the fiber cable. Coordinate fiber cable designations with layout diagrams.

3. Re-Submit all drawings and cable schedules after installation showing As-Built conditions and certified measured optical power loss for each cable path.

4. Cable schedule showing:

a. Cable identification.

b. Points connected by cables

c. Fiber counts for each cable and identification of used fiber pairs.

d. Cable length and attenuation, with two connector pairs and no splices, based on TIA/EIA 568, Annex H.

5. Component Data:

a. Manufacturer and model number.

b. General data and description.

c. Engineering specifications and data sheet.

d. Scaled drawings and mounting arrangements.

6. Fiber Optic System O&M Manual

a. Prepared in accordance with Specification 01300 - Submittals.

b. Prepare Operations and Maintenance manual for fiber optic system. Manual must include a network plan showing routing of distribution cables inside and outside plant premises.

c. Fiber Optic system plan drawing on (11”x17”) must show:

1) Distribution cable routes through conduits, raceways and duct banks.

2) Locations of patch panels and terminating points.

3) Distribution cable designation as shown on cable marking tag.

d. Provide schedule of terminating points of fiber cables, equipment connected and network types. Table must show cable designations of all distribution cables and patch cables.

C. Administrative Data and Quality Control Submittals:

1. Provide evidence that the installer is certified in accordance with an industry standard certifying organization to perform installation work. Certifying authority must be actively engaged in developing standards and certifications for the installation of structured cable systems and specifically fiber optic cable installation. Certifying authority must be BICSI or equivalent organization.

2. Subcontractor Qualifications:

   a. FOCS Subcontractor: Minimum of 5 years' experience providing, integrating, installing, and commissioning of similar Structured Cable Fiber Optic systems.

   b. FOCS Subcontractor's Site Technician: Minimum of 2 years' experience installing similar systems and BICSI Level 2 Optical Fiber certified. Provide copy of certification certificate.

   c. All installation and testing of the fiber optic cable systems must be performed under the direct and continuous on-site field supervision of the certified FOCS Site Representative submitted.

   d. Owner acceptance of FOCS Subcontractor does not exempt FOCS Subcontractor or Contractor from meeting Contract Document requirements nor does it give prior acceptance of subsystems, equipment, materials, or services.

3. Submit a Manufacturer's Certificate for the controls and cabinets specified herein in accordance with Section 01 78 00, entitled CLOSEOUT SUBMITTALS.

4. Manufacturers suggested installation practice.

5. Testing related submittals for:

   a. Factory Reel OTDR Test Results. Must be reviewed and approved by the Owner prior to installation of Fiber Optic Cables.

   b. Installation OTDR Test Results. Must be reviewed and approved by the Owner prior to termination of Fiber Optic Cables.

   c. Terminated Fiber OTDR Test Results. Must be reviewed and approved by the Owner prior to connection of control network to Fiber Optic Cables.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Cable:

1. Rated for installation in exposed indoor/outdoor conduits, direct buried conduits and duct banks as shown on Contract Drawings.

B. Equipment:

1. Outside, Aboveground: Minus 40 to 80 degrees C.

2. Control Rooms, Equipment Rooms: 30 to 55 percent relative humidity, 18 to

24 degrees C.

3. Other Interior Areas: 0 to 100 percent relative humidity, 5 to 35 degrees C.

1.06 EXTRA MATERIALS TO BE PROVIDED

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

Item	Quantity
Patch Cables	One spare cable of each length and termination style provided
Patch Panel Module	One spare module of each configuration provided

PART 2 - PRODUCTS

2.01 FIBER OPTIC DISTRIBUTION CABLING

A. Fiber Characteristics: Multimode

1. Comply with TIA/EIA 568.
2. 62.5/125 μm graded-index glass.
3. Tight-Buffered, 900 μm buffer:
    a. Inner buffer: Acrylate, UV-cured, soft.
    b. Outer buffer: PVC, elastomeric, hard.
4. Maximum Attenuation:
    a. 850 nm: 3.0 dB/km.
    b. 1300 nm: 1.0 dB/km.
5. Minimum Bandwidth:
    a. 850 nm: 200 MHz-km.
    b. 1300 nm: 500 MHz-km.
6. Color-coded buffer.
7. Minimum Bend Radius, Buffered Fiber: 1 inch.
8. Proof Testing: 100 kpsi.

B. Cable:

1. Fiber Type and Count: As shown on Contract Drawings.
2. All Dielectric Construction: No electrically conductive components in fiber optic cable are allowed.
3. Helically Wound: Buffered fibers helically wound; approximately 5 turns per meter.
4. Gel-Free: Fibers tight-buffered, not in gel-filled loose-tube.
5. Core-Locked with no separator tape.
6. Style: Distribution.
7. Strength Member:
    a. Nonconductive; integral part of cable; supports stress of installation and load during use.
    b. Fiberglass epoxy rod, aramid fiber, kevlar.
    c. Minimum Tensile Strength: 600 pounds.
8. Protective Covering:
    a. Polyvinylchloride (PVC); riser rated.
    b. Continuous and free from holes, splices, blisters, and other imperfections.
9. Minimum Bend Radius:
    a. Short-term Under Tension: 20 times cable diameter.
    b. Long-term Without Tension: 15 times cable diameter.
10. Identification:
    a. Identify cables with permanent tags shown at beginning, end and the entrance and exits at man-holes, and pull boxes.
    b. Use waterproof tags and identifications.
11. Special Features: Riser rated.
12. UL listed in accordance with NEC 770.179(b).

2.02 FIBER OPTIC PATCH CABLES

A. Provide patch cables in lengths as required to make connections shown through plastic wire ducts. Provide spare length as required to avoid straining cable.

B. Patch Cable Configuration:

1. Patch cables must be bonded pairs with color coded shrouds on the pre-terminated end to indicate TX and RX.

2. Individual tight-buffer thermoplastic, fibers single or multimode, to match fibers being jumpered on.

3. Protected with kevlar strength members and enclosed in PVC jacket.

C. Patch cable type and connectors must be coordinated with fiber type and equipment connected. ST connectors must be provided if compatible.

D. Fiber ends must have beveled edges for easy insertion and strands must be made from glass. Polymer fiber strands are not acceptable.

E. Cables must be pre-terminated by the manufacture and must be certified to have less than 0.2 dB insertion loss per connector.

2.03 FIBER OPTIC CABLE MEDIA TAGS

A. Distribution cables must be marked with 316L stainless steel laser engraved cable tags with raised fastening loops on each end. Tags must be marked with FO path identifier including unique cable designation and termination points of cable. Coordinate with FO Plan drawing.

1. Secure tags using 316L stainless steel metal self-locking ties through raised fastening loops at both ends of cable marker.

2. Metal cable tags and ties must have smooth rounded edges that will not cut cable jackets.

3. Metal tags and ties must be clear-coated with protective acrylic coating prior to installation. Coating must be AWWA approved for use in drinking water facilities.

B. Patch cables must be individually marked with self-laminating laser printed polyester wrap-around labels.

1. Labels must be white with black laser-printed lettering and clear self-laminating section wrapped around entire cable diameter.

2. Mark each strand of the patch cable with unique designation relating to the distribution cable and strand that it is attached to.

C. Provide fiber optic cable markings at all patch panels and terminating points of fiber optic cable and at all entry points of conduit, raceways, duct banks and/or hand holes that the cable passes through.

2.04 INNERDUCT

A. Innerducts must be textile woven sleeves manufactured from white polyester and nylon resin polymer monofilaments. Innerducts must be rated for outdoor use and sized per manufacturers recommendations for fiber and the conduit/duct installed in.

B. Provide sizes and quantities as required for one fiber to be installed in each lobe in conduit. Provide minimum 3 lobes or with minimum of one additional spare lobe provided, whichever is greater.

C. Each sleeve must be provided with color-coded internal pull tape and the sleeve and pull tape must be distance marked at 5 feet and 1 foot intervals respectively.

D. Provide conduit plugs or inflation type termination bags at conduit openings.

E. Manufacturer and Product:

1. MaxCell.

2. Or approved equal.

2.05 DIN RAIL FIBER PATCH PANEL

A. Function: Provides industry-standard DIN-rail mounted cable management system and termination point for interface between fiber optic cable and control panel equipment cables.

B. Features:

1. Used in either cross-connect or interconnect configuration.

2. DIN rail mounted modular, expandable system.

a. Accommodate up to 6 or 12 fiber terminations and 2 cable entries per module. Provide number of terminations and modules as required according to Contract Drawings.

b. Integrated cable management and cord grip for each module.

c. Fiber Optic Connectors: SC and ST. Coordinate connector type with equipment

terminations.

C. Manufacturers:

1. Belden.

2. Or Equal

2.06 WALL MOUNTED FIBER PATCH PANEL

A. Function: Provides industry-standard wall mounted cable management system and termination point for interface between fiber optic backbone cable and equipment cables.

B. Features:

1. Used in either cross-connect or interconnect configuration.

2. Enclosure: Metal housing with black powder coat finish

3. Wall mounted, expandable system.

a. Accommodate up to 12 fiber terminations. Provide number of terminations and modules as required according to Contract Drawings.

b. Fiber Optic Connectors: ST or SC. Coordinate connector type with equipment terminations.

c. Provide connector housing to accommodate up to 12 fiber connections.

d. Integrated cable management and cord grip for each module.

C. Manufacturers:

1. Corning, Model SPH-01P
2. Or Equal

2.07 CONNECTORS

A. Features:

1. In accordance with requirements of TIA/EIA 568, Section 12.4.3 or Annex F.

2. SC and ST connectors with 12.7 millimeter spacing between ferrules. ST connectors are preferred if compatible with existing equipment terminating types.

3. Pull Strength: 0.2 N minimum.

4. Durability: Sustain minimum 500 mating cycles without violating other requirements.

    a. Ferrules: Free-floating low loss ceramic.

    b. Polarizing key on duplex connector systems.

B. Attenuation:

1. In accordance with requirements of TIA/EIA 568, Section 12.4.4.

2. Maximum of 0.2 dB per connector.

PART 3 - EXECUTION

3.01 PREPARATION

A. Conduits must be provided and installed in accordance with requirements under Division 26, Electrical.

1. Ensure that installed conduit system conforms to fiber optic system requirements, including:

    a. Conduits and Innerducts: Size and number.

    b. Access Holes, Handholes, and Pull Boxes: Location and size, to ensure cables and innerducts can be installed without exceeding manufacturer's limitations.

    c. Outlet Boxes: Size to coordinate with outlet cover plates for adequate volume and bend radius.

2. Spare Conduits:

    a. No cables must be pulled into spare conduits.

    b. 100 percent spare conduit capacity required for all buried conduits only, i.e., for every conduit with one or more cables in it, there must be one spare equal-size conduit with no cables.

3. Expansion Plugs: Seal conduits to stop ingress of water and grit with fabricated expansion plugs.

B. Innerduct:

1. Installation:

    a. In accordance with manufacturer's recommendations.

b. In spare and installed fiber optic conduits.

c. Color Code: Install no more than one innerduct of each color in single conduit.

d. Terminations: Terminate innerducts in conduit with fabricated termination kits.

2. Sealing:

a. Cabled Innerducts: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion seals that have separate seals for each cable.

b. Empty Innerducts: Seal empty innerducts immediately after installation to stop ingress of water and grit with fabricated expansion plugs. Remove plugs as required to install cables.

c. Innerduct to Conduit: Seal gaps between innerducts and conduit with sealing compound such as 3M Ductseal.

3. Identification: Identify innerducts at both ends by methods such as color-coding or waterproof tags wired through innerduct wall. Coordinate with fiber optic cable plan.

C. Fiber Optic Cable:

1. Installation by approved BICSI Level 2 Optical Fiber certified installer.

2. Install cables in accordance with manufacturer's requirements

3. Install cable directly from shipping reels. Ensure that cable is not:

a. Dented, nicked, or kinked.

b. Subjected to pull stress greater, or bend radius less, than manufacturer's specification.

c. Subjected to treatment that may damage fiber strands during installation.

4. Cables per Conduit or Innerduct: One cable maximum.

5. If calculation indicates that cable will attenuate signals more than 8 dB, reroute may be allowed, if approved by Owner.

6. Splices: Splices will not be permitted. Install fiber optic cables in unspliced lengths between fiber optic patch panels.

7. Identification: Identify cable on both ends and in access holes and pull points it goes through in accordance with cable marking instructions in this section.

8. Sealing: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion plugs.

9. Access Holes:

    a. Provide supports for cables in access and handholes.

    b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.

    c. Provide minimum of 10’ coiled service loop in each access hole.

D. Fiber Patch Panels:

1. Install securely in field panels as shown on Contract Drawings.

2. Minimum, one per facility having one or more network nodes.

3. Terminate all fiber strands from trunk cables in Fiber Patch Panel.

E. Cable Terminations:

1. Terminate cables in accordance with TIA/EIA 568.

2. Fan out fiber cable to allow direct connectorization of connectors. Sleeve over individual fibers with transparent furcation tubes. At point of convergence of furcation tubes, provide strain relief with metal or high density plastic fan-out collar.

3. Break-Out Kits:

    a. Terminate cables using manufacturer-supplied break-out kits.

    b. Terminate in accordance with manufacturer’s recommendations.

4. Slack:

    a. Fiber Centers, Hubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment included with fiber patch panel.

    b. Communications Management Outlets: Minimum, 1-meter slack fiber, coiled neatly in outlet box.

5. Connectors:

    a. Terminate 100 percent fiber strands in each cable to specified connectors.

b. Connect into fiber management system.

3.02 CABLE MARKING

A. Cables must be marked with unique designations originating from the distribution cable with continuity throughout the patch panel and patch cables.

1. Distribution cable must be marked with designations in the form of FO-DX-YYZZ for distribution cable and FO-P-XYYZZ(C) for patch cable in the following scheme:

<table>
<tr><td>Type</td><td>Prefix</td><td colspan="2">unique ID</td><td>Strand</td></tr>
<tr><td></td><td>P:</td><td colspan="2">XYYZZ</td><td>C: Color Code</td></tr>
<tr><td rowspan="3">FO (Fiber Optic)</td><td rowspan="3">D = distribution cable
P = Patch cable</td><td rowspan="2">X = Mode</td><td>1 = Single</td><td rowspan="3">B = Blue
O = Orange
G = Green
N = Brown
S = Slate
W = White</td></tr>
<tr><td>2 = Multi</td></tr>
<tr><td colspan="2">YY = Number of Strands in distribution cable
ZZ = 2-digit sequential number</td></tr>
</table>

2. Marking Example:

a. 6-Strand Multi-Mode Distribution cable: FO-D2-0601

b. 12-Strand Multi-Mode Distribution cable FO-D2-1202

c. Patch cable individual strands that are connected to Blue and Orange strands of the above referenced 6-strand distribution cable = FO-P2-0601(B) and FO-P1-0601(O)

B. Distribution cable markings must also indicate the terminating points and patch panel locations for the cable. Locations must indicate plant, process area and PCS panel names where patch panel is installed.

3.03 FIELD QUALITY CONTROL

A. Test components of installation in accordance with standards and specifications.

B. Provide equipment, instrumentation, supplies and skilled staff necessary to perform

testing.

C. Advise Owner at least 48 hours in advance of each test. Owner must have option to witness and participate actively in tests.

D. Document test results of each cable to confirm that at least specified number of fibers meet standards, in accordance with Supplement titled As-Built Fiber Optic Cable Installation.

E. For each conduit and innerduct, complete As-Built Conduit/ Innerduct Installation form included as Supplement to this section.

3.04 TEST AND INSPECTION

A. Conduit:

1. Testing and Sealing of Spare Conduits.

2. Conduit and Innerduct Testing:

a. Blow full-diameter mouse through each spare conduit and innerduct to verify they are unrestricted over full length.

b. If any conduit is not unrestricted over full length, advise Owner.

3. Documentation: Confirm that conduit test As-Built Conduit/Innerduct Installation form documentation includes details of innerducts.

B. Cable Testing:

1. TIA/EIA 568: Demonstrate that 100 percent fibers in each cable meet requirements of TIA/EIA 568, Annex H as modified here:

a. Perform OTDR testing to measure attenuation in both directions, not in one direction only.

b. For multimode fibers only: Measure attenuation at both 850 nm and 1,300 nm.

c. Each fiber strand must be individually tested.

2. Replace and retest cables that do not have specified number of fibers that meet attenuation standards.

3. Cable testing must be performed by the FOCS Contractor at three different phases. Perform OTDR testing on:

a. Pre-installed reel test prior to installation

b. Installed cable test prior to terminations

c. Terminate fiber between patch panels prior to performing the Communications Infrastructure Test.

d. OTDR Test results documentation must be submitted to the Engineer and approved prior to performing the Communications Infrastructure Test.

C. Communications Infrastructure Test (CIT):

1. Configuration of all switches must be done by the PICS Contractor prior to doing the CIT, with the assistance of the Manufacturer's Representative. Configuration must include, but not be limited to, setting assigned IP Addresses and configuring Hyper-Rings.

2. Test the Ethernet LAN portion of the Network by "pinging" all Ethernet nodes from an operator workstation located in the existing Admin Building control room. Testing must be performed by the PICS Contractor with assistance as required by the FOCS Contractor (to help resolve problems).

3. Test Documentation: Test procedures, forms and checklists must be signed by the Contractor.

3.05 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, As-required to perform activities as listed below:

1. As-required for installation assistance and inspection.

2. As-required for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

3. As-required for prestartup classroom or Site training.

4. As-required person-days for facility startup.

5. As-required for post-startup training of Owner's personnel. Training must not commence until an accepted detailed lesson plan for each training activity has been reviewed by Owner.

END OF SECTION

SECTION 17143

FACTORY ACCEPTANCE TESTING

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SECTION 17143

FACTORY ACCEPTANCE TESTING

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes the requirements for in-factory tests to demonstrate that the hardware and software are in conformance with the Specifications. The testing activities are intended to provide a thorough, unbiased evaluation of the system in the Contractor's manufacturing facility. A complete inventory of the system components must be taken at the start of the test.

B. Failure to present any system hardware, manuals or other items for inspection must be cause for cancellation of the test until missing item(s) can be supplied. A piecemeal inspection is not acceptable.

1.02 SUBMITTALS

A. Include the following information in the submittal for all test specified in this section:

1. A detailed step-by-step test procedure of each test at least four weeks in advance of each scheduled test date. Include sign-off sheets and punch list forms. Procedure documents must include the following:

a. Contain, in the Contractor's format, the test ID number, name, and description.

b. Test schedule and checklists including the logical step-by-step procedures with expected response at each step and provide space for recording of actual results.

c. Provide space for approval of each test.

d. Contain minimal reference to other documents.

e. Generally, be structured such that simpler tests are run first.

f. Be written such that they can be used by the Owner's personnel during testing.

g. Describe any steps necessary to simulate inputs required by the test.

2. Confirm, in writing, times and dates two weeks before a test.

3. Within 2 weeks following completion of the factory acceptance tests, submit the completed test sign-off form to the Engineer.

1.03 General

A. The purpose of the test is to verify, insofar as practical, a fully integrated system, including all components, being used under simulated conditions similar to those for which the system was designed. Test hardware and basic software functions to the extent possible. Factory testing of field mounted, process instrumentation is not required.

B. In-factory testing will be conducted by, and is the responsibility of, the System Integrator (SI). The Engineer will actively participate in the test at the requested of the Owner. The Engineer reserves the right to test any specified function whether or not explicitly stated in the test submittal. The Engineer has the final authority on whether or not a test is successful.

1. The hardware tested will be the Owner's hardware. Exceptions to this will be granted only by the written approval of the Engineer. Where exception is granted, use hardware of the same make, model and revision level as the Owner's.

2. If the Owner's hardware or basic software is not used, provide written certification that the hardware or software used will perform exactly as the Owner's and that the hardware and software components are in every way the same.

3. Substitute equipment may be necessary for system components that cannot be tested at the factory because they are either existing, or because it would be physically impractical or otherwise impossible to perform a factory test. Submit all substitute equipment for approval.

C. The test must include the complete setup of all PCS components including but not limited to servers, network and communications hardware, PLC's, OIT's, etc., insofar practical. The test must demonstrate successfully transmit two-way data between all servers, PLC's and OIT's.

D. The SI must develop a test application for each of the HMI's, PLC's and OIT's, to communicate and display data transferred between the HMI's, PLC's and OIT's to the extent possible. The test requirements, as described below in further detail, must show transition of data from all PLC input points to all other OITs and HMI display screens, and activation of PLC output points from the OITs and HMI display screens.

E. Demonstrate the following:

1. The components can function as stand-alone subsystems and perform the specified requirements.

2. The components can be integrated into a complete Process Control System (PCS) and perform the specified requirements.

3. The system has the capability of performing full monitoring of all input/output points and internally generated points.

4. The system has the capability of performing monitoring and control (manual and automatic) of all equipment as specified.

5. Demonstrate all supervisory control and monitoring functions and system interactions using the Control Panels and Remote I/O Panels.

F. Meet the following criteria prior to the start of the test:

1. Complete submittals and resolve disputes.

2. Have an Engineer review and approve test procedures.

3. Set a test date that is agreeable to all.

4. All hardware and basic software must be fully operational.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 SYSTEM HARDWARE AND FUNCTION TEST

A. Perform the functional tests of the system components under normal ambient temperature. System hardware and functional tests must include, but are not limited to, the following:

1. Verification of hardware/software and manuals against inventory lists.

2. Test showing that the proper indications are given at the PLC, OIT and HMI when one or more digital input points change momentarily. Test all digital input points.

3. Start/stop operation on control output points, showing proper indication. Test all control output points.

4. Analog signals must be tested with a signal generator. Testing of analog points must verify that the readings are within the specified accuracy when the inputs are at 25, 50, 75 and 100 percent of full scale. Test all analog input and analog output points.

5. Testing of OIT and HMI functions and performance.

6. Verification of scanning and data acquisition of status and data points across the local and wide area network connections.

7. A series of communication tests showing all message protocols and formats to which the equipment is designed to respond and demonstrating that any error-

detection or error-correction capabilities function properly, and that the equipment does not respond to erroneous commands.

8. Verification of the performance (to the extent possible) and functional operation of the integrated PCS as specified elsewhere. Design the factory tests to properly demonstrate the polling performance of all Control Panels and Remote I/O Panels.

9. Test operation of the Control Panels and Remote I/O Panels under ac and dc power failure conditions operating on UPS power.

10. Test the response of the Control Panels and Remote I/O Panels under total power failure.

11. Demonstration of the systems handling of error conditions and the use of diagnostics.

12. Testing of the behavior of the system in various modes, including point failure, communications failure, peripheral and hardware component failures, and switching of peripheral devices.

13. Demonstrate the programmable logic capabilities of the Control Panels.

14. Demonstration of backup and reload functions.

B. The Engineer and Owner will test control software, database points, displays, logs, and reports developed and implemented by the System Integrator.

3.02 CORRECTION OF DEFICIENCIES

A. The following paragraphs are applicable to all tests:

1. Document discrepancies found during each test and maintain in a record file. Describe the subsequent corrections. Proper operation will be verified by representatives of the Engineer.

2. Faulty and/or incorrect operation of major functions (i.e., major discrepancies) may be cause for suspension or restarting of the entire test, pending the correction of the problem. Minor discrepancies noted may be corrected and retested.

3. The system will not be shipped until successful completion of testing is certified by the Engineer. Delay in shipment of the system due to failure to pass testing will not be considered an unavoidable delay and justification for later delivery.

3.03 TESTING AIDS AND EQUIPMENT

A. Provide use of the following documentation:

1. One copy of each submittal applicable to the equipment to be tested.
2. One copy of the Drawings and Specifications together with addenda and change orders.
3. One master copy of the test procedure.
4. A complete inventory of the equipment to be tested including make, model and serial number.

B. Provide use of the following support facilities:

1. Desk with key lock or lockable room with table for Owner use.
2. Meeting room.
3. Reproduction facilities for copying test information.

C. Provide use of the following test equipment:

1. I/O Test Set. Wire to representative input and output components to allow testing.
2. Off-line diagnostic and test programs.
3. Maintenance and test equipment including, but not limited to: computers running the software applications, analog signal generator, electrician's tool set, and any special test equipment.

END OF SECTION

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SECTION 17166

SITE ACCEPTANCE TESTING

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SECTION 17166

SITE ACCEPTANCE TESTING

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes the requirements for field-testing of the Process Control System (PCS).

B. The System Integrator must be responsible for coordinating field testing with all party's including the Electrical and General Contractors and all third-party manufacturer provided equipment, such that each party is responsible to be present for testing as required. The System Integrator must be responsible for the testing with assistance from third party manufacturers, the Electrical Contractor and the General Contractor to ensure a complete working PCS.

1.02 SUBMITTALS

A. Include the following information in the submittal for all test specified in this section:

1. A detailed step-by-step test procedure of each test at least two weeks in advance of each scheduled test date. Include sign-off sheets and punch list forms. Procedure documents must:

   a. Contain, in the Contractor's format, the test ID number, name, and description.

   b. Testing schedule and checklists including the logical step-by-step procedures, methodology and equipment required to be used for testing with expected response at each step and provide space for recording of actual results.

   c. Provide space for approval of each test.

   d. Contain minimal reference to other documents.

   e. Generally, be structured such that simpler tests are run first.

   f. Be written such that they can be used by the Owner's personnel during site testing.

   g. Describe any steps necessary to simulate inputs required by the test.

2. Confirm, in writing, times and dates two weeks before a test.

3. Within 2 weeks following completion of any field tests, submit the completed test sign-off form to the Engineer.

1.03 GENERAL

A. Field testing of the PCS will be conducted by and is the responsibility of the System Integrator. The Engineer will actively participate in the test at the request of the Owner. The Engineer reserves the right to test any specified function whether or not explicitly stated in the test submittal. The Owner reserves the right to reject the system whether any portion of the system operation is deemed unsatisfactory by the Engineer.

B. Meet the following criteria prior to the start of the site acceptance testing.

1. Complete submittals and resolve disputes.
2. As-built factory drawings for a PCS and motor control panels.
3. In-Factory Testing as specified under Section 17143 has been completed, certified and test reports submitted.
4. Power provided to all PCS and motor control panels.
5. Have Engineer reviewed and approved test procedures and schedules.
6. All control wire pulled and labeled.
7. All network cables are pulled labeled and connected.
8. All instruments are installed, field calibrated and ranges verified.
9. Set a test date that is agreeable to all.
10. All parties agree that the complete system is ready for testing.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 GENERAL

A. Perform field-testing to verify the operation of the PCS. Begin testing immediately after installation of each major subsystem. Perform field-testing sequentially and organize by facility, area and by unit process within each area. Field tests are:

1. Loop tests.
2. Communications link tests.
3. System function tests.

B. Meet the following conditions prior to the start of any testing:

1. Correct deficiencies noted during pre-requisite testing.

2. Have documentation on-site pertinent to the part of the system being tested.

3. Have on site, labeled, and properly stored, spare parts, expendables and test equipment pertinent to the part of the system being tested.

4. Have Engineer reviewed and approved test schedules and test procedures.

5. Recompile, relist and reload, from supplied source code, programs that are source code and compiler dependent.

6. Have all parties certify that the system has been checked and is ready for testing.

C. Schedule all field-testing through the Engineer on a daily basis.

1. The Engineer may redirect testing from one facility, area, or unit process to another. Make no claim for delay or additional costs for testing if the testing effort is redirected to a different facility, area, or unit process provided the following conditions are met:

a. The redirection does not cause more than a one-hour interruption to the testing to move test equipment and test personnel to the new facility, area, or unit process.

b. There is no change in the amount of test equipment or personnel requirements.

c. The redirection is not arbitrary. Process operational constraints, personnel availability, and other's work are valid reasons for redirection.

d. The redirection does not occur more than once in any workday subsequent to the daily scheduling meeting.

2. Perform no testing which may affect facility operations without Engineer concurrence.

D. Perform tests by following the operation and maintenance manuals word-for-word unless approved otherwise by the Engineer. Lack of complete, detailed manuals will be cause for declaring the test to have failed regardless of the actual test results.

E. Begin testing by performing the following steps:

1. Check equipment against shop drawing lists and submittals.

2. Verify that the equipment has been installed in accordance with Contract Documents and manufacturer's directions.

3. Power up the equipment and run diagnostics to verify error-free operation.

4. Load all software.

F. The Owner will participate in all testing activities at the Owner's discretion.

1. This participation will serve as a learning experience for the Owner's operations and maintenance personnel.

2. This participation does not relieve the Contractor from the specified requirements for testing.

3. Recognize and adjust for Owner involvement in developing test procedures and schedules.

4. Owner participation and use will be such that it does not adversely affect specified testing requirements. Make no claim for delay unless the following conditions are met.

    a. The Owner and the Engineer are notified verbally that Owner actions could cause delay if continued.

    b. The Owner persists in the delay action.

    c. Submit written documentation within 24 hours, which describes the Owner action and the impact.

3.02 LOOP TESTS

A. Loop tests will be performed separately at each plant site/PCS panel location and will demonstrate the proper operation of each signal and control loop circuit associated with an I/O point. Tests will include process instrumentation, field interface device or circuit, the interface wiring and the associated I/O hardware.

    1. All field instruments and equipment interfacing with the equipment under test must have been calibrated and/or tested in accordance with the requirements of the individual specification sections.

B. Check each loop from the end element to the respective control display. Include instruments, control devices, panels, termination cabinets, I/O cards and other devices in the loop to ensure proper operation.

C. Test the operation of each PLC I/O point, both discrete and analog I/O.

D. Whenever possible, motion check the final control element through panels and through operator stations. When not possible to perform a motion check, simulate the motion check at the final control element location. Clearly describe how the loop was checked, and if motion check was simulated, describe why the motion check was not possible. The Owner must be available to operate existing equipment and test feedback as required

E. Document loop checks and submit to the Engineer. Include:

    1. Loop number.

    2. Loop description.

    3. Termination information.

4. Loop drawing reference.
5. Type of test(s) performed.
6. Date tested.
7. Problem description, if any.
8. Signature of tester and date.
9. Signature of Engineer and date.

F. Summarize loops found to contain defective or inoperable equipment on separate sheets and submit to the Engineer.

1. Correct and recheck your work.
2. The Engineer will coordinate correction of defective work by others. Perform rechecking as a part of this Contract.
3. Limit rechecking of defective work by others to 10 percent of the total number of loops. Do not perform additional checkout work unless directed by the Engineer.

3.03 COMMUNICATIONS LINK TESTS

A. Perform testing to demonstrate that the data transfer between PCS hardware and software equipment. Perform testing to demonstrate that specified performance levels for communication equipment are met.

B. Test and verify data transfer via communications links to all PCS connected devices.

C. Document testing and submit to the Engineer. Include:

1. Communication link description.
2. Communication link address.
3. Drawing reference.
4. Type of test(s) performed.
5. Date tested.
6. Problem description, if any.
7. Signature of tester and date.
8. Signature of Engineer and date.

3.04 OPERATIONAL FUNCTION TESTS

A. Loop, and Communications Link testing must be successfully completed prior to the start Function Tests. Testing will be performed at each plant site/PCS control location and must demonstrate the proper wiring, configuration, operation of monitoring and control, data and signal handling functions, power circuits, controller functions, communication functions.

B. Organize testing sequentially by process area or function. Tests must be performed in conjunction with the Owner and any third part manufacturers required for controls PLC, OIT and HMI programming functions. Demonstrate test results at the site on a programmer unit linked to the equipment being tested.

   1. All field instruments and equipment interfacing with the equipment under test must have been wired, terminated, calibrated and/or tested in accordance with the requirements of the individual specification sections.

C. Maintenance/Support tests must be performed as follows:

   1. Include a demonstration of the following:

      a. System status displays and use.

      b. Diagnostics.

      c. Power fail/restart.

   2. Document and submit demonstrations to the Engineer. Include:

      a. Description of function.

      b. Signature of tester and date.

      c. Signature of Engineer and date.

      d. Problem description, if any.

D. Testing must include loop tests defined above under Loop Testing.

END OF SECTION

SECTION 17250

PROGRAMMABLE LOGIC CONTROLLER

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SECTION 17254

PROGRAMMABLE LOGIC CONTROLLER

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes the requirements of the Programmable Logic Controllers and Input/Output hardware.

B. Related sections include:

1. Section 01300 – Submittals
2. Section 17010 – System Integrator
3. Section 17441 – Control System Hardware

C. Submittals

1. Include the following information in the submittal for this section:
    a. Data sheets and catalog literature.
    b. Describe how the PLC functions. Include the following:
2. A description of the PLC input/output functions, addressing system and card layout, including any special configuration rules and limitations, instruction sets, and programming procedures.
3. Describe each communication interface. Include protocols, the type of network, the error recovery routines, and the available utility functions.
4. Describe how faults are detected, isolated and corrected. Describe on-line diagnostic tests and off-line tests.
    a. Dimensional data.
    b. Interface and cable data.
    c. List of spare parts being provided as specified.
    d. PLC programming software information required for the hardware.
    e. Annotated PLC configuration files in hard copy format and on USB flash drive.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish and install PLCs, I/O and communication devices for data acquisition, monitoring and control. Provide programmable controllers which are part of a standard line of programmable controller products. Provide ruggedized components designed specifically for industrial environments.

B. Provide standard baseplate assemblies to house the processor, power supply, communications modules and input/output subsystem.

C. Provide equipment of modular design using plug-in assemblies. Wherever possible, provide interchangeable assemblies and sub-assemblies for equipment performing similar functions.

D. Identify major assemblies and sub-assemblies, circuit boards, and devices using permanent labels or markings to indicate the catalog number and manufacturing date code.

E. Use manufacturer supplied chassis or cable connections for data communication between components.

2.02 MANUFACTURER

A. Provide Modicon, M340.

B. No substitutions allowed.

2.03 PLC AND I/O CHASSIS

A. The chassis must consist of the following features:

1. Modular type.

2. Cable to accepts all modules, including the PLC, Communication Modules and I/O Modules.

3. Chassis must be sized to accept all I/O modules required for the specified I/O and be provided with a minimum 20% spare capacity for all I/O types.

2.04 PLC PROCESSOR

A. The PLC must be provided with the following features:

1. Minimum 4MB of memory

2. 1 – USB Port

3. Support up to 1000 I/O points

4. Support up to two (2) communication modules

5. Support the following programming languages:

a. Relay Ladder

b. Structured Text

c. Function Block

d. Sequential Function Chart

2.05 INPUT/OUTPUT COMPONENTS

A. General:

1. Provided with I/O wiring screw terminals
2. Front of module status LED's

B. Digital Input:

1. 24 VDC
2. 16 Individually Isolated Inputs

C. Digital Output:

1. 24 VDC
2. 16 Individually Isolated Relay Outputs

D. Analog Input:

1. 4-20mA Signals
2. 15 bit resolution
3. 8 Channels

E. Analog Output:

1. 4-20mA Signals
2. 15 bit resolution
3. 8 Channels

2.06 COMMUNICATIONS COMPONENTS

A. Communication modules must be provided as shown on the drawing to communicate to the plants local area network.

B. The communication modules must be provided with the following features:

1. 1 – Imbedded RJ-45 Copper

2. Support Modbus TCP/IP communications protocol

3. 10/10 Mbps

4. Provided with the capacity to support connection to all network devices shown on the drawings

2.07 POWER SUPPLY

A. Provide power supplies for internal operation of the processor, chassis, and I/O subsystem.

B. Operate the PLC and I/O from nominal 24 Vdc power.

C. Power supplies must be sized to power all modules in the PLC chassis, including a minimum 20% spare capacity.

2.08 SPARE PARTS

A. Provide the following spare parts:

1. One (1) spare I/O Module of each type provided.

2. One (1) spare Power Supply of each type provided.

2.09 MAINTENANCE

A. Provide special tools necessary for normal operation, maintenance and calibration.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install PLCs and input/output components in panels as shown on the Drawings.

B. PLC, I/O and communication device configuration must be performed using the latest PLC firmware version of the manufactures programming software.

END OF SECTION

SECTION 17400

INSTRUMENTATION

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SECTION 17400

INSTRUMENTATION

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes the requirements for furnishing, installing, and placing into operation field-mounted and panel-mounted instrumentation.

1. Related sections include:

a. Division 16 – Electrical

b. Division 17 – Instrumentation and Controls

1.02 REFERENCES

A. Work covered by this Section must comply with all relevant portions of the following regulations and standards:

1. American Petroleum Institute (API):

2. American Society for Testing and Materials (ASTM):

3. Instrument Society of America (ISA)

4. International Standards Organization (ISO)

5. National Electrical Manufacturers Association (NEMA)

6. Underwriters Laboratories, Inc. (UL)

7. National Electric Code (NEC)

8. Institute of Electrical and Electronic Engineers (IEEE)

1.03 SUBMITTALS

A. Include the following information in the submittal for each instrument specified in the section.

1. Tag number and description.

2. Data sheets and catalog literature. Provide data sheets as shown in ISA-S20-1981. For instruments not included in S20, submit data sheets using a format similar to those shown.

3. Mounting details, including all dimensions, installation methods, elevations and sections.

4. Range, size, weight, outline and dimension drawings, materials of construction, enclosure classification.

5. Description of any integral instrument controls.

6. Methods and materials required for installation. Include power and signal connection details with complete wiring diagrams.

7. List of recommended spare parts.

8. List of optional accessories.

B. Include the following information in the final operations and maintenance manuals for each instrument specified in the section.

1. Operation and maintenance manuals for each instrument.

2. Specific arrangement and dimension drawings for the installation of each instrument. Include locations of each instrument or device.

3. Installation certifications.

4. Calibration certification for each instrument.

5. Calibration/Data sheets.

6. Tag data to be included on instrument tag.

C. Exceptions to the specifications or drawings must be clearly defined by the supplier. Failure to clearly indicate exceptions must be basis for rejection of the submittal.

D. Submittals must be reviewed with respect to their conformance with the Contract documents. Unless provided for reference or clarification of unspecified items, submittals which do not address specific Specification items will not be acceptable. Address items in each specification or note specifically which items are omitted.

1.04 SYSTEM DESCRIPTION

A. All instrumentation supplied must be of the most current and proven design. Specifications and drawings call attention to certain features but do not purport to cover all details entering into the design of the instrumentation equipment.

B. The equipment provided must be compatible with the functions required for the pump station controls.

C. All necessary fuses and cables required for instrumentation equipment must be provided with the equipment.

D. Provide instruments that operate on 24V dc power, except where specifically noted. Provide

instruments which return automatically to accurate measurement upon restoration of power after a power failure.

E. Provide and install transmitter power supplies in local panels or enclosures as required.

F. Provide two wire instrument transmitters which produce isolated 4-20 mAdc analog signals. Follow ISA-S50.1-1982. All analog transmitter and controller outputs must be capable of driving into at least 800 ohms unless otherwise specified.

G. Provide alarm and status points with an isolated contact rated at 5A, 120 VAC. The contact will be closed when the normal, non-alarm condition to be sensed is true.

H. Provide instruments that are constructed so that they are impervious to damage by dust, moisture, fungus and airborne contaminants.

I. Provide instruments complete with mounting hardware, floor stands, wall brackets, or instrument racks.

J. Local indicators must provide direct readings utilizing the same range, scale and units as that reported via the station control system. Instruments selected must have ranges and indications appropriate to the process.

K. Circular chart recorders must be provided in NEMA 12 enclosures. All other instrumentation must be provided in NEMA 4X housings or enclosures.

1.05 QUALITY ASSURANCE

A. Provide only new, standard, first-grade materials throughout, conforming to standards established by Underwriters Laboratories (UL), Inc. and National Electrical Manufacturers Association (NEMA) and so marked or labeled.

B. Provide material and equipment in accordance with applicable codes and standards, except as modified by the specifications.

C. Use single source manufacturer for each instrument type. Use the same manufacturer for different instrument types whenever possible.

D. Coordinate instrumentation to assure proper interface and system integration. Provide signal equipment, to include, but not to be limited to, transducers, signal converters and power supplies. Coordinate the various subcontractors, equipment suppliers, and manufacturers.

1.06 DELIVERY, STORAGE AND HANDLING

A. Have each manufacturer or supplier package instrumentation to protect against shipping damage, dust, moisture, and atmospheric contaminants. Include a shipping label which contains the following information:

1. Tag number and description.

2. Instructions for unloading, transporting, storing and handling at the site.

B. Receive instrumentation at the site. Inspect instrumentation for damage in shipment. Return all damaged instrumentation to the manufacturer for replacement at no cost to the City.

C. Do not store instrumentation out-of-doors. Provide dry, permanent storage facilities and pay storage cost.

PART 2 - PRODUCTS

2.01 LEVEL COMPONENTS

A. Ultrasonic Sensor/Transducer

1. The transducer must serve as a combination transmitter and receiver designed to emit a conical ultrasonic beam onto a surface and receive the return echo.

2. The transducer must be a seamless, hermetically sealed, chemical resistant Kynar-encapsulated unit.

3. The transducer must be non-contact design and include no moving parts or mechanical linkages.

4. Ultrasonic depth transducer must utilize an integral temperature sensor to compensate for changes in the speed of sound caused by air temperature variation.

5. Ultrasonic depth transducer must be capable of operating at ambient temperatures from -40 to 95°C (-40 to 203°F).

6. Transducer drive – 44 KHz, 400 volt peak pulses of 1-millisecond maximum duration at a maximum repetition rate of 300 milliseconds.

7. Blanking Distance must not exceed 12 inches.

8. Potted 1-inch NPT (female thread) nipple for conduit mounting of transducer.

9. Transducer selection:

a. Up to 33 feet for Milltronics/Siemens level transmitter: Milltronics/Siemens, Model XPS-10. For Endress & Hauser level transmitter: FDU-91F. Beam angle must not exceed 12° from centerline to echo perimeter (i.e. 12° diameter of echo perimeter).

b. Up to 50 feet for Milltronics/Siemens level transmitter: Milltronics/Siemens, Model XPS-15. For Endress & Hauser Level transmitter: FDU92. Beam angle must not exceed 6° from centerline to echo perimeter (i.e. 6° diameter of echo perimeter).

B. Ultrasonic Level Transmitters

1. The system electronics for the level transmitter must measure and convert the time lapse

between transmitted and received ultrasonic signals into a linear 4-20 mADC signal proportional to the liquid level being measured.

2. The electronics must also compensate the liquid level signal for the time delay variation caused by temperature changes.

3. The transmitters must be capable of sending its output signal into a load of 750 ohms.

4. Operating temperature range of the electronics must be –20 to 50°C (-5 to 122°F).

5. Memory must employ non-volatile EEPROM such that configuration parameters and alarm setpoints are not lost upon power loss. No battery must be required.

6. Indoor mounted transmitter must be wall-mounted polycarbonate NEMA 4X enclosure.

7. Outdoor mounted transmitter must be panel-mounted polycarbonate NEMA 3 enclosure. These transmitters must be provided with NEMA 4X stainless steel instrument enclosure. Instrument enclosure must be provided with accessories as indicated on Contract Drawings.

8. Configuration and integration must be performed using an intrinsically safe infrared hand-held programming device that is compatible for configuration of all transmitters specified. Transmitters must also be capable of being configured using the HART protocol.

9. Transmitter must be capable of echo profiling and false echo rejection using diagnostic software and be field configurable to drive 4-20 mA output underspan (3.8 mA) or overspan (22.8 mA) upon failure.

10. Integral digital display field configurable to read in engineering units, including inches, feet, and gallons, GMP, MGD, and level differential in inches.

11. Transmitter must have six (6) multipurpose relays consisting of four (4) Form “A” and two (2) Form “C” relays, rated 5 amps at 250 VAC non-inductive. Configure one Form C to energize upon Loss of Echo.

12. Transmitter must have the following certifications: General Purpose CE, FM, CSA and UL Listed

13. Performance Requirements

    a. The systems must have accuracy of 0.25-percent of range or 0.24-inch, whichever is greater.

    b. Blanking distance must not exceed 10 inches.

    c. Resolution – 0.1-percent of range or 0.08 inch, whichever is greater.

d. Power Requirements – 120 VAC, 36 VA/17 watt draw maximum.

C. Float Switches

1. Manufacturers

a. Float switches must be provided for level control and level monitoring where shown on the contract drawings and scheduled herein.

b. Manufacturer and series must be the following, or equal:

1) Mjk automation – model 7030 (mercury free)

2) Anchor scientific – eco-float se/si

3) Siemens (consolidated electric) – model 9ge#f (mercury free)

4) Or equal

2. Equipment design

a. Float (ball) must be direct acting, leak-proof, shock-proof, and constructed of Polypropylene or other corrosion resistant material. Switch must be electromechanical microswitch or snap-action switch. Mercury float type switches are not acceptable

b. Switch

1) Switch assembly must be a hermetically sealed micro-switch that is activated by moving counterweight as the switch assembly changes position in the fluid.

2) Switch contacts must be rated minimum of 10a at 120vac. Switch must be provided with one normally open (no) and one normally closed (nc) contact.

c. Cable

1) Float switch cable must be provided with the sensor as an integral assembly. Cable must be pvc insulated, oil resistant, and suitable for use in sewage and wastewater applications. Cable must be sealed at the float utilizing a flexible boot and compression type lock seal.

2) Cable must be 3-wire cables, provided with a minimum size conductor of No.17 awg.

3) Cables must be provided in sufficient length to mount the float switches in the locations shown on the contract drawings plus an additional 10 feet (minimum) of cable. Cables must be provided in continuous length between the floats and the associated junction box or control panel.

4) Excess cable must be coiled and tie-wrapped to the cable mounting support.

D. Submersible Level Transducer

1. Manufacturers

a. The suspended pressure transducer type level sensing equipment shown in Table 17375-1 must be the following or equal:

1) KPSI, Series 700

2) Endress+Hauser, Waterpilot FMX 167

3) Or Equal

2. Equipment Design

a. Pressure Sensors/Transducer

1) Sensor must be housed in a 316 stainless steel housing and must be suspended less than 1 foot above the bottom of the wet well.

2) Sensor must utilize piezoresistive sensing technology to translate pressure to a 4-20mADC linear signal. Transmit a 4-20mADC signal directly proportional to level in the wet well.

3) Sensing diaphragm components must be 316 stainless steel.

4) Sensor must be compensated for atmospheric pressure by means of a polyurethane vent tube incorporated into the cable assembly. Provide Aneroid Bellows or GoreTex filter to prevent moisture from entering the vent tube.

5) Stainless steel sensor housing must have a removable cover with a set of perforations to protect the sensing port from damage.

6) All fasteners must be 316 stainless steel or non-metallic.

7) Provide with integral sensor cable. Provide sufficient length of cable to coil and wrap 10’ length of spare cable for maintenance.

8) Provide manufacturer's termination panel for external electrical connection.

9) FM approved Class I Division 1 Group D.

b. Performance Requirements

1) Minimum distance measurement of 30 feet.

2) The systems must have a minimum accuracy of +0.5 percent of range.

3) Sensor must not be subject to loss of accuracy due to immersion in wastewater sludge with concentrations up to 6 percent.

4) Response time not to exceed 600 ms.

5) Linearity – 0.2 percent of measurement range.

6) Turndown – 10:1

7) Temperature operating range - -4 to 140 degrees F.

3. Accessories

a. Nameplates – Refer to Section 17000. Wording of nameplate must be as specified in Table 17375-1.

b. Mounting hardware – Provide stainless steel mounting hardware as necessary to mount equipment in locations as described in the Contract Documents. Mounting hardware must include cable support/grip and anti-snag cone to protect cable.

c. Cabling – Provide power and signal cable and conduit to locate transmitters in locations listed in Table 17375-1 and the Contact Documents according to Section 17000.

d. Lightning and Surge Protection – Provide lightning and surge protection for the equipment listed in Table 17375-1 in accordance with Section 17000.

e. Provide a 4-inch diameter perforated Schedule 80 PVC pipe to serve as a stilling well to reduce turbulence and lateral movement. Locate stilling well as detailed on the Contract Drawings. Transducer must be secured by a minimum of six points about its diameter to eliminate all lateral movement. Transducer must be removable by pulling the suspension cable out of the stilling well from ground level while the stilling well remains in place in the wet well. Secure the stilling well to the wet well wall at three-foot intervals.

All straps used for attaching the stilling well to the side of the well must be stainless steel. All fasteners must be stainless steel epoxy-grouted type with stainless steel nuts.

4. Controls

a. All electrical equipment and wiring must be in full conformance with Division 16, Electrical Specifications.

b. Refer to Contract Drawings for wiring requirements

2.02 PRESSURE COMPONENTS

A. Pressure Transmitter

1. General:

a. Function: Measure pressure and transmit signal proportional to pressure.

b. Type:

1) Electronic variable capacitance or silicon strain gauge.

2) Two-wire transmitter; “smart electronics”.

c. Parts: Transmitter and accessories.

2. Performance:

a. Range: As shown on the drawings.

1) Select transmitter’s factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL but does not exceed it.

2) Accuracy: Plus or minus 0.075 percent of span.

3) Ambient Operating Temperature: Minus 40 degrees F to plus 175 degrees F, with integral meter.

4) Process Operating Temperature: Minus 40 degrees F to plus 250 degrees F.

5) Humidity: 0 to 100 percent relative humidity.

6) Hazardous Location Certifications: As shown on the

drawings.

b. Features:

1) Type: Gauge pressure.

2) Adjustable damping.

3) LCD indicator.

a) Display in either percent or engineering units, field configurable.

c. Wetted Metallic Parts: Type 316 stainless steel.

d. Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.

e. Wetted O-Rings: Glass filled TFE, graphite filled PTFE, or Viton.

f. Bolts and Nuts (if required): Type 316 stainless steel.

g. Fill Fluid: Silicone.

h. Ability to remote mount transmitter.

3. Process Connections:

a. Line Size: As shown on the drawings.

b. Connection Type: FNPT.

c. Direct/remote Diaphragm Seal: As shown on the drawings.

4. Signal Interface:

a. 4 to 20 mA dc output with digital signal.

1) Nominal Maximum Loop Resistance with External 24V dc Power Supply: 550 ohms.

5. Enclosure:

a. Type: NEMA 4X.

b. Materials: Coated aluminum.

c. Mounting bracket, unless otherwise shown on the drawings.

1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.

6. Accessories:

7. Two-valve (isolate and vent) Stainless Steel Manifold: As shown on the drawings.

B. Manufacturers and Products:

1. Gauge Pressure Units:

a. Rosemount.

b. Foxboro.

c. SMAR.

2. Absolute Pressure Units:

a. Rosemount.

b. Foxboro.

c. SMAR.

2.03 FLOW COMPONENTS

A. Electromagnetic Flowmeter

1. Manufacturers

a. For equipment listed in Table 17400-1 the flow metering equipment manufacturer and model must be the following or equal:

1) Endress & Hauser Promag 53W flow transmitters

2) Foxboro 9100 series flow tubes

3) Foxboro Model IMT-25 SDADB10M-A-B flow transmitters

4) Krohne Model EnviroMag 2000 flow tubes

5) Krohne Model IFC 010 F flow transmitters

6) Rosemount Model 8705 flow tubes

7) Rosemount Model 8732C flow transmitters

a) Or Equal

2. Equipment Design

a. Flow Elements

1) Flow elements must be magnetic flow tubes, low frequency electromagnetic induction type and must produce a 4-20 mA output linear to liquid flow rate.

2) The flow tubes must have ANSI Class 150 flanged ends.

3) The flow tube housing must be stainless steel or cast aluminum.

4) Flow tubes must be lined as required by Table 17400-1.

5) Electrodes must be conical-shaped (bullet nose) and must be Type 316L stainless steel, Hastelloy C, or Zirconium. Verify compatibility with media monitored.

6) The flow tube housing must be splash-proof and weather-resistant. It must be capable of accidental submergence in up to 30 feet of water for up to 48 hours without damage to the electronics or interruption of the flow measurement.

7) For Effluent Flowmeter FIT-711 and Irrigation Flowmeter FIT-1011, 1012, 1013 – Provide reinforced connecting cable (coil and signal cable) as recommended by the manufacturer for underground cable installation.

b. Flow Transmitters - The electronics portion of the magnetic flow meters must include both a magnet driver to power the magnet coils and a signal converter.

1) Signal converters must be wall mounted, housed in a NEMA 4X enclosure.

2) Terminal strips for electrical connections must be supplied. Housing must not need to be opened to make adjustments.

3) Transmitter (Converter) Electronic Characteristics

a) The electronics must be of the solid state, feedback type and utilize integrated circuitry.

b) The input span of the signal converter must be continuously adjustable

between 0-1 and 0-31 fps and the range adjustment must be direct reading.

c) Complete zero stability must be an inherent characteristic of the meter system to eliminate the need to zero adjust the system with a full pipe at zero flow.

d) The converter must not be affected by quadrature noise nor must it require zero adjustment or special tools for startup.

e) Input and output signals must be fully isolated.

f) The converter output must be 4 to 20 mA dc into 800 ohms.

g) The electronics must be designed for operation on 120 VAC +10 percent, 60 Hz +5 percent.

h) The converter must also include:

(i) Integral zero return to provide a constant zero output signal in response to an external dry contact closure.

(ii) Direct adjustment of scaling factor in engineering units.

(iii) Integral calibration self-test feature to verify proper operation at the electronics.

(iv) Local direct reading indicator calibrated in gallons per minute or million gallons per day as directed by the Engineer. Flow totalizer with manual reset.

(v) Low-Flow Cutoff: Drive the output signal to zero when the measured flowrate is 0-10% (adjustable) of full scale and when fully developed flew no longer exists.

i) The meters must be hydraulically calibrated and the calibration must be traceable to the National Institute of Science and Technology (NIST).

c. Performance Requirements

a) The equipment furnished must measure, indicate, and transmit flow rates to within ±0.5-percent of actual flow from a flow velocity of 0.5 FPS to 31 FPS. Refer to Table 17400-1 for flow ranges for each meter.

2) Accuracy must not be affected by changes in percent solids or changes in fluid density, temperature, or viscosity. Accuracy must not be affected by the presence of air bubbles to a greater extent than the fluid volume represented by such air bubbles.

a) Maximum power consumption for each flow element must be 15 watts.

d. Equipment design specifications must be considered as an integral part of the performance requirements.

3. Accessories

a. Nameplates – Refer to Section 17000. Wording of nameplate must be as specified in Table 17400-1.

b. Mounting Hardware – Provide stainless steel mounting hardware as necessary to mount equipment in locations as described in the Contract Documents.

c. Cabling – Provide power and signal cable and conduit to locate transmitters in locations listed in Table 17400-1 and the Contact Documents according to Section 17000.

d. Lightning and Surge Protection – Provide lightning and surge protection for the equipment listed in Table 17400-1 in accordance with Section 17000.

e. Flow tubes must be provided with stainless steel grounding rings and straps at each end and wired to ground.

f. Spool Pieces – Provide one spool piece for each flow tube provided. Provide the General Contractor with the spool piece according to their timeline for working on the respective segment of pipe.

g. Portable secondary calibrator for checking calibration of the magnetic flow meters must be provided. The unit must have an adjustable setting to simulate signal output for a given flow velocity from 0 to 99.99 ft/sec. This unit is not required for flow meters with calibration checking integral to the transmitters.

2.04 DOOR / HATCH SWITCHES

A. Switches must be rugged sealed units rated for use in industrial environments. Switches must be manufactured of aluminum housing and must be provided with a stainless steel armored cable. Provide required mounting hardware and fasteners of Stainless Steel.

B. Provide switches with DPDT contacts.

C. Installation must be wired to provide an input when all doors are in the closed position and turn off when any one of the doors wired in series opens. Hutches and doors must be wired as different inputs.

D. Switch must be GE Interlogix/Sentrol 2500 series or equal.

2.05 THERMOSTATS AND FREEZSTATS

A. Thermostats must be the heating type with contacts closing on failing temperature, and must use be used for control of heating elements located in the tank base and vault. Thermostats must be provided with a range of 35 degree F to 65 degree F. Thermostats must be mounted in control panels following the Contract Documents, and must be manufactured by one of the following manufacturers:

1. Honeywell,
2. Trane,
3. Robert Shaw,
4. Carrier

B. Freezestats must be similar to thermostats except they must have normally closed contact that opens on failing temperature.

2.06 INSTRUMENT NAMEPLATES

A. Each instrument must be provided with 316 stainless steel tags attached to the instrument with 16 gauge 316 stainless steel wires or stainless steel screws. Letters must be 3/16 inch high, fully impressed so that all characters are completely formed, crisp and deep. The following information must be included on the tag:

1. Tag number and description.
2. Manufacturer.
3. Model and serial number.

B. An instrument nameplate schedule must be submitted to the Engineer for approval prior to performing any engraving.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine the Drawings and the site for placement and connections of instrumentation. Investigate the space in the buildings through which the equipment must pass to reach its final location. Make provisions to move the instrumentation into place. The Contractor must coordinate with the equipment supplier to resolve any clearance or connection problems before

the equipment is received on site.

B. Secure and utilize instrument mounting details from the manufacturer or supplier for installation purposes.

3.02 INSTALLATION

A. Provide labor, materials, tools, equipment, supplies and services and auxiliary devices including, but not limited to, bracket and mounting hardware to install the instrumentation.

B. Unless specifically shown, do not mount direct reading or electrical transmitters on process piping. Mount on instrument racks or stands or in enclosures mounted on walls.

C. Install the instrumentation and auxiliary devices so that they are accessible for maintenance. Provide space between instruments and other equipment and piping for ease of removal and servicing. Generally, install instrumentation to be accessible from floor level or grade.

D. Follow additional installation specification as specified in the individual instrument sections.

E. Provide unions, couplings, shut off valves and adapters for process piping to field instrumentation interface, as shown on instrument mounting detail drawings.

F. Minimize process interruptions during installation, removal, or replacement of instruments and devices. Any operating interruptions must be at the convenience of operations personnel.

3.03 FIELD QUALITY CONTROL

A. Provide instrument manufacturer's services for installation assistance, field calibration, startup and training. Provide manufacturers certificate for each instrument at each site stating that installation is in accordance with manufacturers recommended practice.

B. Provide training as described in Specification Section 01735.

C. Remove the shipping stickers, paint splatters, dirt, grease and other contaminants to restore the instrumentation to a clean and like new condition prior to final acceptance.

3.04 DEMONSTRATION

A. Prepare instrumentation installation certification and calibration certification sheets for each instrument. Use these sheets for documenting installation, testing and calibration.

B. For each installation certification sheet, include the following information:

1. Project name.

2. Tag number and description.

3. Manufacturer.

4. Model and serial number.

5. Date, time and person who performed mechanical installation verification.

6. Date, time and person who performed electrical installation verification including wiring terminations.

7. Space for comments.

8. Space for sign off and date.

C. For each calibration certification sheet, include the following information.

1. Project name.

2. Tag number and description.

3. Manufacturer.

4. Model and serial number.

5. Date, time and person who performed calibration.

6. Calibration data to include:

a. Input, output, and error at 0 percent, and 100 percent of span for analog instruments.

b. Switch setting, contact action, and deadband, if applicable, for discrete elements.

7. Space for comments.

8. Space for sign off and date.

D. Conduct a performance test for each instrument. Furnish special tools, calibration equipment and labor to perform the tests. Demonstrate that the instrument performs as specified. Test analog devices at 0, 25, 50, 75, and 100 percent of scale.

E. For each analog instrument performance test, prepare a performance test sheet and include the following information:

1. Project name.

2. Tag number and description.

3. Manufacturer.

4. Model and serial number.

5. Date, time and person who performed test.

6. Test date to include output and error at each test point.

END OF SECTION

SECTION 17441

CONTROL PANEL HARDWARE

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SECTION 17441

CONTROL PANEL HARDWARE

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the equipment and installation practices for the control system hardware.

1.02 REFERENCES

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

1. Instrumentation, Systems, Automation Society (ISA): S50.1, Compatibility of Analog Signals for Electronic Process Instruments.

2. National Electrical Manufacturers Association (NEMA):

a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.

c. ICS 2, Industrial Control Devices, Controllers and Assemblies.

3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

4. Underwriters Laboratories Inc. (UL): 508A, standards for Safety, Industrial Control Panels.

1.03 SUBMITTALS

A. Instrumentation and Controls shop drawings submittals with comply with Section 01900.

B. Data sheets and catalog literature describing the hardware and software to be provided.

C. Instrumentation and Controls shop drawings include, but are not necessarily limited to complete terminal identification diagrams and schedules, complete point-to-point interconnection diagrams, complete single line and elementary wiring diagrams for all panels. Diagrams must be oriented to display the general arrangement and location of wiring and equipment which is seen when facing the appropriate panels for maintenance an adjustment purposes, i.e., for panels wired and serviced from the front, diagrams must depict a front view, and for panels wired and serviced from the rear, diagrams must depict a rear view. Mirror image diagrams are prohibited. Terminal point and wire identification on all shop drawings must be identical to related terminal point and wire identifications on equipment panels and absolutely no deviation from this requirement will be permitted.

D. Panel shop drawings must contain the following:

1. Top and base plan, showing location of equipment and all conduits to and from equipment,

supports, doors and clearances.

2. Front and rear elevations, showing general arrangement, complete with dimensions.

3. Elevation sections (right and left sides' minimum, others as required).

4. Mounting details of all principal equipment.

5. All panel and accessory drawings must be drawn to a scale not less than 1-inch equals 12-inch.

6. All principal items must be identified with an encircled number which will correspond to an individual item in a "List of Principal Equipment". The List of Principal Equipment must be arranged in columnar form, reading from left to right as follows:

   a. Item Number

   b. Quantity

   c. Description

   d. Make

   e. Size

   f. Material

   g. Form

   h. Type

   i. Bulletin or Catalog Number

   j. Rating in Volt, Amperes and Horsepower or KVA

   k. Remarks. Under "remarks" column must be other pertinent information not covered by the above column headings.

   l. The panel information must be printed on the instrument and control shop drawings: Separate submission of anything other than the instrument and controls shop drawings, or in any other form than herein before described, will not be acceptable.

7. A complete wiring diagram showing all electrical apparatus, both within the equipment and connections to external equipment, must be submitted. All wires must be shown continuous from end to end and identified by numbers. A wire connected to one side of a contract such as pushbuttons, relays or selector switches must change its identifying number when leaving the opposite side of such contacts. Any and all wires passing from panel to panel across the panel joints, which must be disassembled for shipping, must have matched terminal blocks at these joints. The terminal blocks must be identified with the

respective wire numbers.

a. All wires entering and/or leaving the equipment must be brought to the terminal blocks and identified.

b. Wireless or numbered type diagrams will not be accepted, nor will blank blocks with separate drawing reference numbers be considered. It must be the responsibility of the equipment manufacture to obtain internal wiring diagrams of all foreign equipment and coordinate or reproduce these diagrams into single complete wiring diagram. The physical relationship of all controls must be identical to the finally developed general arrangement drawing herein before described.

8. A complete schematic, elementary drawing with all wiring numbers corresponding to the wire numbers on the wiring diagram must also be submitted.

a. They must be printed on this drawing, adjacent to the schematic diagram, a complete "Sequence of Operations, "stating what must be done to put the facility in operation for the first time, starting from the main incoming service. The sequence of operations must start with a general heading under which the normal starting sequence will be described, along with any special functions of the individual parts or combinations of control devices, including all interlocking.

b. The next heading must be "Operation Normal-Automatic", under which must be described the complete normal-automatic sequence of the controls making reference to the schematic control diagram, reading from left to right, indicating wire numbers, coils, relay contacts, etc. Following must be the heading "Operation Normal-Hand Control", under which will be described the complete hand operation of the facility, when bypassing the automatic sequence. Finally, the heading "Power Failure", under which will be described precisely what can and will happen upon the failure of power and on restoration of power after a power failure in both the "Hand" and "Automatic" sequences. This drawing must be of a scale such that all symbols, lines and notes can easily be read by maintenance forces under emergency conditions.

9. All information described herein must be shown on the instrument and controls shop drawings. Separate submission of electrical information on anything other than these electrical drawings or in any other form than herein before described will not be submitted in addition to the information on the electrical drawings where necessary to provide complete understanding of the construction, maintenance, repair and operation of any basic component.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For control panels, all installed devices and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for control panels and all installed components.

2. Detailed instructions of operating the control panels. Submit preliminary and final versions

of the manuals for the control panels. Preliminary manuals must be provided after shop drawings are approved but before the factory test. Final manuals must be provided after the control panel is installed, adjusted and tested in the field.

G. As-Built Information:

1. Provide as-built information of control system hardware that includes all the wiring diagrams, programming information, input/output lists, drawings, catalog cuts and other relevant information with any changes that have taken place in the field during construction.

H. Provide submittal of 24VDC Power Supply and UPS battery backup calculation.

1. Provide written calculations demonstrating the maximum load of devices being powered by the power supplies and UPS.

2. Provide written calculations demonstrating the maximum duration of the UPS battery backup under maximum load conditions.

PART 2 - PRODUCTS

2.01 SIGNAL CHARACTERISTICS

A. Analog Signals:

1. 4 to 20 mA dc, in accordance with compatibility requirements of ISA S50.1.

2. Unless otherwise specified or shown, use Type 2, two-wire circuits.

3. Transmitter: Load resistance capability conforming to Class L.

4. Fully isolate input and output signals of transmitters and receivers.

B. Pulse Frequency Signals: de pulses whose repetition rate is linearly proportional to process variable over 10:1 range. Generate pulses by contact closures or solid-state switches.

1. Power source: Less than 30V de.

C. Discrete Signals:

1. Two-state logic signals.

2. Utilize 120V ac or 24 vdc sources in accordance with the Contract Drawings for control and alarm signals.

3. Alarm signals must be normally open, close to alarm isolated contacts rated for 5 ampere at 120V ac and 2 ampere at 30V dc.

2.02 CONTROL PANELS

A. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), UL 508, state and local codes, and applicable sections of NEMA, ANSI, and ICECA.

B. Conform to NEMA ratings (NEMA 250) as specified in individual equipment sections.

C. Control panels must meet the NEMA ratings and be provided with the equipment as shown on the drawings.

D. Enclosure Types:

1. Type 4 or 12 Panels:

a. 16-gage minimum steel construction

b. 12-gage steel subpanel

c. Doors must be rubber-gasketed with continuous hinge.

d. Where enclosures are mounted outside or in unheated areas, provide them with thermostatically controlled heaters that will maintain the inside temperature above 40 degrees F.

2. Type 4X Panels:

a. 14-gage minimum metal thickness for enclosure.

b. 12-gage steel subpanel.

c. Doors must be rubber-gasketed with continuous hinge.

d. Where enclosures are mounted outside or in unheated areas, provide them with thermostatically controlled heaters that will maintain the inside temperature above 40 degrees F.

3. Type 7 Panels:

a. Provide in Class I, Division 1 hazardous locations as shown on the drawings.

b. Cast aluminum type

c. Corrosion resistant, high strength steel cover bolts

E. Doors:

1. Three-point latching mechanisms in accordance with NEMA 250 Type 1 and 12 panels with doors higher than 18 inches.

2. For other doors, stainless steel quick release clamps.

3. External flange with corrosion resistant fasteners in accordance with NEMA type 7.

F. Cutouts must be cut, punched, or drilled and finished smoothly with rounded edges.

G. Access: Font, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.

H. Temperature Control:

1. Louvers

a. Include washable aluminum air filters with louvers used for ventilation.

b. Provide 1 can of filter spray adhesive for every enclosure.

2. Fans

a. Provide forced ventilation fans, where used, with washable, aluminum air filters and finger guards.

b. Operate fan motors on 115 Vac, 60 Hz Power. Include thermal protection. Use motors rated for 20,000 hours of continuous operation without lubrication or service.

c. Provide exhaust grilles with filters.

d. Provide 1 can of filter spray adhesive for every enclosure.

3. Heaters For Condensation Control

a. Provide thermostatically controlled, fan driven heaters for all outdoor enclosures for condensation control unless otherwise specified.

b. Meet the following requirements:

Power:	115 Vac, 60 Hz.
Rating:	100 Watts for panels smaller than 24 inches by 48 inches. 200 Watts for larger panels.

c. Provide thermostats that sense air temperature in the panel and are adjustable from 40 to 80 degrees F.

d. Mount heaters near the bottom center of the enclosure. Do not mount electronic components closer than 6 inches to the heater.

4. Heaters For Freeze Protection

a. Provide thermostatically controlled heaters for freeze protection as specified elsewhere.

b. Meet the following requirements:

Power:	115 Vac, 60 Hz.
Rating:	100 watts for panels smaller than 10 inches by 16 inches. 150 watts for panels smaller than 12 inches by 24 inches. 250 watts for panels smaller than 18 inches by 30 inches. 500 watts for panels smaller than 24 inches by 48 inches.

5. Corrosion Inhibitors

a. Furnish enclosures with vapor phase protective corrosion inhibitors.

b. Provide adequate corrosion inhibiting devices, tape, or emitters for the individual panel volume.

c. Activate the inhibitor upon delivery to the site. Do not store panels with inhibitors inactive. If necessary, cover panels to reduce ventilation and prolong inhibitor life.

d. Provide one spare corrosion inhibitor for each panel enclosure.

I. Push-to-Test Circuitry: For each push-to-test indication light, provide a fused push-to-test circuit.

J. Lighting: Minimum of one hand switch controlled internal 100 watt incandescent light for panels 12 cubic feet and larger.

K. Minimum of one 120 volt GFCI duplex receptacle for panels 12 cubic feet and larger.

L. Finish:

1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel); Manufacturer's standard gray unless otherwise specified.

2. Internal Surfaces: White enamel.

M. Panel Manufacturers:

1. Hoffman.

2. H.F. Cox.

N. Breather and Drains: Furnish with NEMA 250, Type 4 and 4X panels.

1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECDI N4D, Breather Model ECDI N4B.

2.03 CONTROL PANELS ELECTRICAL

A. UL Listing Mark for Enclosures: Mark stating “Listed Enclosed Industrial Control Panel” per UL 508A.

B. I & C and electrical components, terminals, wires, and enclosures UL recognized or UL Listed.

C. Control Panels without Motor Starters:

1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed form power panel.

2. Locate to provide clear view of and access to breakers when door is open. Group on single subpanel. Provide typed directory.

3. Circuit Breakers:

a. Coordinate for fault in branch circuit trips, branch breaker, and not main breaker.

b. Branch Circuit Breakers: 15 amps at 250V ac.

c. Breaker Manufacturers and Products:

1) Heineman Electric Co.; Series AM.

2) Airpax/North American Philips Controls Corp.; Series 205.

2.04 CONTROL PANELS WITH THREE-PHASE POWER SUPPLIES AND MOTOR STARTERS

A. Interlock main circuit breaker with panel door.

1. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.

2. Mount operator controls and indications on front access door.

B. Circuit Breakers:

1. In accordance with NEMA AB 1.

2. 18,000 ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified.

3. Breakers, except Motor Branch Breakers: Molded case thermal magnetic.

4. 65,000 ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified in package systems equipment specification sections.

5. Tripping: Indicate with operator handle position.

C. Magnetic Motor Starters:

1. Full voltage, NEMA ICS 2, Class A, Size O minimum.

2. Include three-pole bimetallic or eutectic alloy thermal overload relays sized for each motor.

3. Manual reset type with reset button mounted on panel door.

D. Motor Control: 120V ac (except intrinsically safe circuits where applicable).

1. Power control Transformer:

a. Sufficient capacity to serve connected load, including 200VA for duplex outlet plus 100VA (minimum).

b. Limit voltage variation to 15 percent during contact pickup.

c. Fuse one side of secondary winding and ground the other.

d. Furnish primary winding fuses in ungrounded conductors

E. Power Monitoring Relay:

1. Protect three-phase equipment form single phasing, phase imbalance, or phase reversal.

2. Separate, isolated contact outputs to stop motors and activate alarm light during abnormal conditions.

3. Transient Voltage Protection: 10, 000 volts.

4. Manufacturer and Product: Furnas; Class 47.

F. Power Distribution Blocks: Furnish to parallel feed tap on branch circuit protective devices. Do not “leap frog” power conductors.

G. Terminations for Power Conductors: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

2.05 WIRING

A. AC Circuits:

1. Type: 600 volt, Type MTW stranded copper.

2. Size: For current to be carried, but not less than 14 AWG.

B. Analog Signal Circuits:

1. Type: 300 volt, Type 2 stranded copper, twisted shielded pairs.

2. Size: 18 AWG, minimum.

C. Other DC Circuits.

1. Type: 600 volt, Type NTW stranded copper.

2. Size: 16 AWG, minimum.

D. Color code wiring as follows:

Line and Load Circuits (ac or dc power)	Black
Neutral/Grounded Conductors	White
AC Control Circuits	Red
DC Control Circuits (+)	Blue
DC Control Circuits (-)	Blue/Black
Interlock Control Circuits on the panel energized from external source.	Yellow
Equipment Grounding Conductors	Green

1. Separate analog and other dc circuits at least 6 inches from any ac power and control wiring.

2. Enclose wiring in sheet metal raceways or plastic wiring ducts.

3. Wire Identification: Numbered and tagged at each termination.

a. Wire Tags: Machine printed, heat shrink.

b. Manufacturers:

1) Brady PermaSleeve.

2) Tyco Electronics.

E. Wiring Interface:

1. For analog and discrete signal, terminate at numbered terminal blocks.

2. For special signals, terminate power (240 volts or greater) at manufacturer's standard

connectors.

3. For panel, terminate at equipment on/with which it is mounted.

2.06 TERMINAL BLOCKS

A. Quantity:

1. For external connections.
2. Wire spare or unused panel mounted elements to their panels' terminal blocks.
3. Spare Terminals: 20 percent of connected terminals, but not less than 10.
4. General: Group to keep 120V ac circuits separate from 24V dc circuits.
5. Connection Type: Screw Connection clamp.
6. Compression Clamp:
    a. Hardened steel clamp with transversal grooves penetrating wire strands providing a vibration-proof connection.
    b. Guides strands of wire into terminal.
7. Screws: Hardened steel, captive, and self-locking.
8. Current Bar: Copper or treated brass.
9. Insulation:
    a. Thermoplastic rated for minus 55 to plus 110 degrees C.
    b. Two funnel shaped inputs to facilitate wire entry.
10. Mounting:
    a. Rail.
    b. Terminal block can be extracted from an assembly without displacing adjacent blocks.
    c. End Stops: One at each end of rail, minimum.
11. Wire Preparation: Stripping only.
12. Jumpers: Allow jumper installation without loss of space on terminal or rail.
13. Marking System:

a. Terminal number shown on both sides of terminal block.

b. Allow use of preprinted and field marked tags.

c. Terminal strip numbers shown on end stops.

d. Mark terminal block and terminal strip numbers as shown.

B. Terminal Block, 120 Volt Power:

1. Rated Voltage: 600 V ac.
2. Rated Current: 30 amp.
3. Wire Size: 22 through 10 AWG.
4. Rated Wire Size: 10 AWG.
5. Color: Gray body.
6. Spacing: 0.25 inch, maximum.
7. Manufacturer and Product: Entrelec; Type M4/6.

C. Terminal Block, Ground:

1. Wire Size: 22 through 12 AWG.
2. Rated Wire Size: 12 AWG.
3. Color: Green and yellow body.
4. Spacing: 0.25 inch, maximum.
5. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
6. Manufacturer and Product: Entrelec; Type M4/6.P.

D. Terminal Block, Blade Disconnect Switch:

1. Use: Provide one for each discrete input and output field interface wire.
2. Rated Voltage: 600V ac.
3. Rated current: 10 amp.
4. Wire Size: 22 through 12 SHE.
5. Rated Wire Size: 12 AWG.

6. Color: Gray body, orange switch.
7. Spacing: 0.25 inch, maximum.
8. Manufacturer and Product: Entrelec; Type M4/6. SN.

E. Terminal Block, Fused, 24V dc:

1. Rated Voltage: 600V dc.
2. Rated Current: 6.3 amp.
3. Wire Size: 22 through 12 AWG.
4. Rated Wire Size: 12 AWG.
5. Color: Gray Body.
6. Fuse: 5 by 20 GMA fuses.
7. Fuse Marking: Fuse amperage rating shown on top of terminal block.
8. Indication: LED diode 24V dc.
9. Leakage Current: 5.2 mA, maximum.
10. Spacing: 0.32 inch, maximum
11. Manufacturer and Product: Entrelec; Type M4/6. SFD>

F. Terminal Block, Fused, 120V ac:

1. Rated Voltage:600V ac.
2. Rated Current: 6.3 amp.
3. Wire Size: 22 through 12 AWG.
4. Rated Wire Size: 12 AWG.
5. Color: Gray body.
6. Fuse: 5 by 20 GMA fuses.
7. Fuse Marking: Fuse amperage rating shown on top of terminal block.
8. Indication: Neon lamp 110V ac.
9. Leakage current: 1.8 mA, maximum.

10. Spacing: 0.32 inch, maximum

11. Manufacturer and Product: Entrelec; Type M4/6.SFL.

G. Grounding: Internal copper grounding bus for ground connections on panels, consoles, racks, and cabinets.

2.07 RELAYS

A. General:

1. Relay Mounting: Plug-in type socket.

2. Relay Enclosure: Provide dust cover.

3. Socket Type: Screw terminal interface with wiring.

4. Socket Mounting: Rail.

5. Furnish holddown clips.

6. Control circuit Switching Relay, Nonlatching:

a. Type: Compact general purpose plus-in>

b. Contact Arrangement: 3 Form C contacts.

c. Contact Rating: 10A at 28V dc or 240V ac.

d. Contact Material: Silver cadmium oxide alloy.

e. Coil Voltage: As noted or shown.

f. Coil Power: 1.8 watts (dc), 2.7VA (ac).

g. Expected Mechanical Life: 10,000,000 operations.

h. Expected Electrical Life at Rated Load: 100,000 operations.

i. Indication Type: Neon or LED indicator lamp.

j. Push-to-test button.

k. Manufacturer and Product: Potter and Brumfield; Series KUP.

7. Control Circuit Switching Relay, Latching:

a. Type: Dual coil mechanical latching relay.

b. Contact Arrangement: 2 Form C contacts.

c. Contact Rating: 10A at 28V dc or 120V ac.

d. Contact Material: Silver cadmium oxide alloy.

e. Coil Voltage: As noted or shown.

f. Coil Power: 2.7 watts (dc), 5.3VA (ac).

g. Expected Mechanical Life: 500, 000 operations.

h. Expected Electrical Life at Rated Load: 50,000 operations.

i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.

8. Control Circuit Switching Relay, Time Delay:

a. Type: Adjustable time delay relay.

b. Contact Arrangement: 2 Form C contacts.

c. Contact Rating: 10A at 240V ac.

d. Contact Material: Silver cadmium oxide alloy.

e. Coil Voltage: As specified or shown.

f. Operating Temperature: Minus 10 to 55 degrees C.

g. Repeatability: Plus or minus 2 percent.

h. Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent or range.

i. Time Delay Setpoint: As specified or shown.

j. Mode of Operation: As specified or shown.

k. Adjustment Type: Integral potentiometer with knob external to dust cover.

l. Manufacturer and Projects: Potter and Brumfield.

1) Series CB for 0.1 second to 100 minute delay time ranges.

2) Series CK for 0.1 to 120 second delay time ranges.

2.08 INTRINSIC SAFETY BARRIERS

A. Intrinsically Safe Relays: Provide ISRs for protection of equipment mounted in hazardous classified areas in accordance with the Contract Drawings. ISRs must be 24V-DC or 120 V-AC powered by internal control panel power circuit. ISRs must be individually fuse protected. Coordinate power requirements with devices provided.

B. ISRs may be single or double channel devices. Corresponding output channels must have N.O. and N.C. contacts.

C. Monitor discrete signals that originate in hazardous area and are used in a safe area.

1. Manufacturer and Product: MTL, Inc.; Series MTL, Phoenix Contact or approved equal.

2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.

a. Manufacturer and Product: MTL, Inc.; Series MTL, Phoenix Contact or approved equal.

2.09 FRONT-OF-PANEL DEVICES USED IN CONJUNCTION WITH NEMA 250, TYPE 4X PANELS

A. Indication Lights, Watertight:

1. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, corrosion-resistant service, 30.5 mm.

2. Screwed on prismatic lenses and factory engraved legend plates for service legend.

3. Manufacturers and Products:

a. Square D; Type SK.

b. Allen-Bradley; Type 800H.

B. Pushbutton, Momentary, Watertight:

a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with corrosion-resistant service, 30.5 mm.

b. Standard size, black field, legend plates with white markings for service legend.

c. Manufacturers and Products:

1) Square D: Type SK.

2) Allen-Bradley: Type 800H.

C. Pushbutton, Maintained, Watertight (Mushroom Type):

1. Heavy-duty, NEMA 250 Type 4X, industrial type with maintained contacts and corrosion-resistant service, 30.5 mm.
2. Standard size, legend plates with white markings for service legend.
3. Push-Pull Type, Mushroom head.
4. Color, Red
5. Manufacturers and Products:
    a. Square D; Type SK.
    b. Allen-Bradley; Type 800H.

D. Selector Switch, Watertight:

1. Heavy-duty, NEMA 250, Type 4X watertight, industrial type corrosion-resistant service, 30.5 mm.
2. Standard size, black field, legend plates with white markings, for service legend.
3. Operators: Black knob type.
4. Single-hole mounting, accommodating panel thicknesses from 1/16th to 1/4 inch.
5. Manufacturer and Products:
    a. Square D; Class 9001, Type SK.
    b. Allen-Bradley; Type 800H.

2.10 FRONT-OF-PANEL DEVICES USED IN CONJUNCTION WITH NEMA 250, TYPE 7 HAZARDOUS (CLASS I, DIVISION 1) LOCATIONS PANELS

A. Indication Lights:

1. Heavy-duty, push-to-test type, NEMA 250, Type 7, industrial type and corrosion-resistant service.
2. Screwed on prismatic lenses and factory engraved legend plates for service legend.
3. Type #316 stainless steel operation shafts and an O-ring seal for corrosion resistance.
4. Flanged sealing wells.
5. Manufacturers and Products:
    a. Square D; Type SK.

b. Allen-Bradley; Type 800H.

B. Pushbutton, Momentary:

1. Heavy-duty, NEMA 250, Type 7, industrial type with momentary contacts and corrosion-resistant service.

2. Standard size, legend plates with white markings for service legend

3. Type #316 stainless steel operating shafts and an O-ring seal for corrosion resistance.

4. Flanged sealing wells.

5. Manufacturers and Products

a. Square D; Type SK.

b. Allen-Bradley; Type 800H.

C. Pushbutton, Maintained (Mushroom Type):

a. Heavy-duty, NEMA 250, Type 7, industrial type with maintained contacts and corrosion-resistant service.

b. Standard size, legend plates with white markings for service legend.

c. Push-Pull Type, Mushroom head.

d. Color, Red

e. Type #316 stainless steel operation shafts and an O-ring seal for corrosion resistance.

f. Flanged sealing wells.

g. Manufacturers and Products:

1) Square D; Type SK.

2) Allen-Bradley; Type 800H.

2. Selector Switch

a. Heavy-duty, NEMA 250, Type 7 industrial type with corrosion-resistant service.

b. Standard size, black field, legend plates with white markings, for service legend.

c. Operators: Black knob type.

d. Type #316 stainless steel operating shafts and an O-ring seal for corrosion resistance.

e. Flanged sealing wells.

f. Manufacturer and Products:

1) Square D; Class 9001, Type SK.

2) Allen-Bradley; Type 800H.

2.11 ELAPSED TIME METER

A. Device must have the following features:

1. Figures: 6-digits, 0.125”; hours – white on black, tenths – red on white

2. Voltage: 90-240VAC

3. NEMA 4X, 12 enclosure rating with gasket

B. Device must be Redington Counter Model 722-0001 with gasket kit and hardware.

2.12 DIGITAL DISPLAY ANALOG INPUT PANEL METER

A. Device must have the following features:

1. 5-digit minimum, red sunlight readable visual display

2. Input: 4-20mA analog signal

3. Voltage: 24VDC

4. Standard 1/8 DIN mounting size

5. Isolated 4-20mA analog output (retransmit)

6. NEMA 4X Sealed Front Bezel

B. Device must be Red Lion, Series PAX, Precision Digital, or approved equal.

2.13 NAMEPLATES, NAMETAGS, AND SERVICE LEGENDS

A. Nametags: Permanently mounted bearing entire ISA tag number.

1. Panel Mounted: Plastic, mounted to instrument behind panel face.

2. Field Mounted: Engraved Type 316 stainless steel, 22 gauge minimum thickness, attached with stainless steel.

B. Service Legends (Integrally Mounted with Instrument) and Nameplates:

1. Engraved, rigid, laminated plastic type with adhesive back.. Furnish service legends and nameplates to adequately describe functions of panel face mounted instruments.

    a. Color: White with black letters.

    b. Letter Height: 3/16 inch.

    c. For each panel, face mounted laminated nameplate inscribed with the panel name and tag number. Color must be white with black letters ½ inch high.

C. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions.

Tag	Inscription(s)	Color
ON	ON	Green
OFF	OFF	Red
OPEN	OPEN	Green
CLOSED	CLOSED	Red
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow
FORWARD	FORWARD	Red
REVERSE	REVERSE	Blue

1. Lettering: Black on white and amber lenses; white on red and green lenses.

2. Standard Pushbutton Colors and Inscriptions:

    a. Use following unless otherwise noted in individual Loop Specifications:

Tag Function	Inscription(s)	Color
OO	ON OFF	Black Black
OC	OPEN CLOSE	Black Black
OCA	OPEN CLOSE AUTO	Black Black Black
OOA	ON OFF AUTO	Black Black Black
MA	MANUAL AUTO	Black Black
SS	START STOP	Black Black
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

b. Lettering Color:

1) Black on white and yellow buttons.

2) White on black, red and green buttons.

2.14 ELECTRICAL SURGE AND TRANSIENT PROTECTION

A. General: Equip control panels with surge-arresting devices to protect equipment from damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

B. Suppressor Locations:

1. At point of connection between each equipment item, including ac powered transmitters and its power supply conductors (direct wired equipment).

2. On analog pairs at each end when the pair travels outside of building.

3. In other locations where equipment sensitivity to surges and transients requires additional

protection beyond that inherent to design of equipment.

C. Power Supply Suppressor Assemblies:

1. Suitable for connection to 120-volt, single-phase power supplies EDCO “HSP SERIES.”

2. Suitable for connection to 480-volt, three phase power supplies; Sqare DJ9200-9A.

D. Analog Signal Cable Suppressor Assemblies:

1. Epoxy encapsulated within a phenolic enclosure.

2. Flame retardant.

3. Four lead devices; include a threaded mounting/grounding stud.

4. Manufacturers and Products:

a. EDCO; SRA-64 Series.

b. Joslyn; Series 1800 and 1669.

E. Grounding: Coordinate surge suppressor grounding in field panels and field instrumentation as specified in SECTION 16060, GROUNDING AND BONDING, and suppressor manufacturer’s requirements. Furnish control panels with an integral copper grounding bus for connection of suppressors and other required instrumentations.

2.15 24VDC POWER SUPPLIES

A. 24 VDC Power supplies must be sized to meet power requirements plus an additional 50% capacity as shown on contract drawings. Power supplies must include the following features:

1. UL 508 listed, CE approved.

2. Removable, pluggable connections for input and output power.

3. Local output status indication light.

4. Overload protection – current limited to a preset value.

5. Nominal Input Voltage: 100-240 VAC.

6. Nominal Output Voltage: 24 VDC +/- 1%

7. Output Current: As indicated on the contract drawings.

8. DIN-rail mounted power supply.

9. Temperature range: -20 to 50 degrees C.

10. Mean lifetime of 500,000 hours.

11. Two-year warranty.

12. Ripple and Noise - 24 mV RMS, 200-mV peak to peak.

13. Fully enclosed, touch-safe.

B. Provide status contacts, associated with the power supplies as shown on the contract drawings, indicating operating conditions. All status contacts must be individually wired to PLC I/O for monitoring.

C. Provide circuit protection on inputs and outputs of all power supplies as shown on the contract drawings. Fuses must be sized in accordance with manufactures recommendations.

D. Manufacturer and Product:

1. Phoenix Contact, QUINT Series

2. Or approved equal.

E. Power supplies must be tied in redundant pairs with manufacturer's smart redundancy module as shown on contract drawings. Redundancy modules must be provided with Auto Current Balancing and Power Boost Technologies.

1. Redundancy module must be manufactured by;

a. Phoenix Contact – Quint Diode

b. Or approved equal

2.16 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Characteristics

1. Provide one online UPS for each PLC.

2. Minimum Watt Capacity - See "C" below.

3. Minimum Volt-ampere Capacity - See "C" below.

4. Four 120 volt, 5-15R, output receptacles, minimum.

5. Alarms - Battery backup operation, low run time remaining, and overload.

6. UPS must have an alarm relay card with dry contact outputs, capable of being hardwired to the PLC. The alarm relay card must provide the following minimum configurable outputs:

a. UPS General Alarm

b. UPS On Line Power/Battery Power

c. Low-Battery Alarm

7. Automatic current and over-voltage output protection.

8. Operating Input Voltage - 99 VAC - 138 VAC.

9. No interruption (no transfer time for normal power to battery backup) of power to the PLC system.

10. Efficiency - 95 percent.

11. Brownout protection for input voltages of 88 VAC without the use of the batteries.

12. Lightning and Surge Protection - ANSI/IEEE C62.41 Categories A and B with 0.3 percent to 0.7 percent.

13. Radio Frequency Noise Isolation - 38 dB common mode, 47 dB normal mode.

14. Power Reserve Time at Full Power Draw - One hour, minimum. See "C" below for power draw requirements. SCADA system supplier must submit calculations to substantiate sizing.

B. PLC power supply must be backed up by the UPS. The required capacity of the UPS must be determined by the load requirements of the PLC and its peripherals. As a minimum, the UPS must maintain power to the entire panel, all communication devices and modules, all relays, all loop power supplies, all indicators, the PLC, and all PLC I/O that is powered from the panel, setpoint station, but not the heating/cooling system for the panel.

C. It is preferred that the UPS be located in the same enclosure as the PLC, unless panel size or cooling requirements make it impractical. In that case, it must be located on a wall shelf located above the PLC enclosure. Shelf must be provided by the Contractor.

D. Manufacturer – Liebert GXT Series, Powerware Model 9125 or equal.

PART 3 - EXECUTION

3.01 ELECTRICAL POWER AND SIGNAL WIRING

A. Restrain control and signal wiring in control panels by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect bend area with a sleeve.

B. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.

C. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single crimp lug. No more than two lugs may be installed on a single screw terminal.

D. Do not splice or tap wiring except at device terminals or terminal blocks.

3.02 INSTALLATION

A. Contractor must assemble the enclosures according to the approved shop drawings in accordance with UL-508 and other specifications herein.

B. Install devices, equipment and control panels in accordance with the manufacturer's recommendations.

3.03 FIELD QUALITY CONTROL

A. The completely integrated control system, including control panels and all field devices or equipment must be tested as a system to verify that all equipment is operating in accordance with the contract documents.

B. Perform a test of the UPS, simulating a power outage, demonstrating that the control system components continue to function during this time period.

C. Adjust and calibrate the analog I/O of the control panel and the field devices or equipment.

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

E. Remove and replace malfunctioning devices and retest.

F. Engineer must witness the tests at the Owner's request.

END OF SECTION

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Geotechnical Report
for

Inland Bays Regional Wastewater Facility
Phase #2 Expansion

Prepared for

Sussex County, Delaware

January 2019

Whitman, Requardt & Associates, LLP

1915 100 YEARS 2015

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1.0 Introduction

The Inland Bays Regional Wastewater Facility Phase #2 Expansion project consists of the continued expansion of the existing wastewater treatment facility. The project includes the design and construction of a new headworks structure, grit facility, aeration distribution structure, pump and blower building, filtered irrigation pumping station building, two clarifiers, a new effluent lagoon, conversion of an existing overflow lagoon to two aeration lagoons; and associated pavements, access roadways, and utilities. The project site is located about 10 miles southeast of Georgetown in Sussex County, Delaware. A site vicinity map is included in Appendix A.

Whitman, Requardt and Associates, LLP (WRA) has been tasked with performing engineering services including geotechnical evaluation and design for the proposed facility expansion. This report addresses geotechnical related design and recommendations for the proposed new construction, including foundations and floor slabs for the proposed buildings, wastewater facility structures, and associated below-grade structures. The report includes boring information, characterization of soil and groundwater conditions, and recommendations related to pavements, earthwork, and construction.

This report includes subsurface information that was previously provided in the geotechnical report prepared by WRA in March 2018, titled "Inland Bays Regional Wastewater Facility – Regional Biosolids & Septage Facilities".

2.0 Site and Project Descriptions

2.1 Site Description

The site is an active wastewater treatment facility that is fenced and gated, with access provided from the east on Inland Bay Road. The site is developed with existing facilities including an Administration Building, septage receiving station, chlorination facilities, clarifiers, several process buildings, and other site improvements including storage lagoons, sludge lagoons, and aeration lagoons. A portion of the project area consists of cultivated agricultural fields. An existing site plan and project overview plan are included in Appendix A.

The site access roadway and parking lot is paved in the area of the Administration Building, but the remainder of the site access roadways are surfaced with gravel or asphalt millings.

In the area of proposed construction, the site is generally flat (with the exception of the lagoon embankments) and the ground surface elevations range from El. 27± feet to El. 29± feet. The area includes the existing pump and blower building, and clarifiers No. 1 and No. 2. To the south the area includes the existing overflow lagoon No. 1, and aeration lagoons No. 1 and No. 2. The existing lagoon embankments are constructed with a top at El. 41± feet, and outside slopes constructed at a slope ratio of 3(H):1(V). This area of proposed construction is bordered by the site access roadway along the west, north, and east sides of the site.

There are many buried utilities in the area of proposed construction. The buried utilities include electrical, sanitary sewer, force mains, and water lines.

2.2 Proposed Construction

The proposed construction includes the north headworks structure, grit facility, aeration distribution structure, pump and blower building No. 2, and a filtered irrigation pumping station building. The north headworks and grit facility structures will consist of cast-in-place reinforced concrete construction and mat slab foundations. The aeration distribution structure consists of a cast-in-place concrete structure that will be partially buried in the lagoon embankment and supported on a mat slab foundation. The pump and blower building and the filtered irrigation pumping station building will consist of CMU wall construction and will be supported on shallow foundations.

The placement of a compacted structural fill embankment up to about 12 feet in height is planned to establish the new proposed finished grades at the north headworks structure and grit facility. A new 23-acre effluent lagoon will be constructed to the north of the facility. The existing overflow lagoon will be modified to create two new aeration lagoons. The site access roadway will be constructed with flexible pavement consisting of hot-mix bituminous concrete.

3.0 Subsurface Exploration and Laboratory Testing

A subsurface exploration program was performed for the proposed project from October 11-16, 2017 by John D. Hynes & Associates, Inc. under the supervision of WRA. The boring locations were selected by WRA and were located and staked in the field by Adams-Kemp Associates, Inc. of Georgetown, Delaware. The boring locations are shown on the site plans included in Appendix A, and are summarized in the following table:

Table 3.1: Staked Boring Locations and Information

Boring Number	Northing (ft.)	Easting (ft.)	Ground Surface Elevation (ft.)	Total Boring Depth (ft.)
*AD-01	232234.82	709596.46	39.6	30.5
*AL-01	232180.32	709381.75	41.0	30.5
C-03	232387.80	709524.32	28.2	50.5
C-04	232510.69	709541.35	27.8	50.5
CD-01	232493.80	709232.34	28.9	30.5
CS-01	232584.29	708833.67	30.5	30.5
CS-02	232560.37	709092.57	28.2	30.5
HP-01	232581.39	709219.08	27.9	40.5
PB-01	232467.23	709457.53	27.7	30.5
SR-01	232115.11	708735.56	28.4	25.5
TS-01	232008.54	708793.76	29.1	15.5

*Test boring drilled on lagoon embankment.

Some of the test borings are for a previous design phase which is covered in the geotechnical report prepared by WRA dated March 2018. Test borings AD-01 and AL-01 were drilled on the aeration lagoon embankment. Test borings C-03 and C-04 were drilled for the proposed new Clarifier No. 3 and Clarifier No. 4. Test boring PB-01 was drilled for the future pump and blower building.

The test borings were drilled using a GeoProbe 7822DT track-mounted drilling rig with an automatic 140-pound drop hammer, and a Mobile B-47 trailer rig with a 140-pound safety hammer. The test borings were advanced using hollow stem augers with drilling mud added as needed to limit problems with running sands. At five (5) selected boring locations, a temporary piezometer pipe was installed in the borehole for short-term groundwater level measurements.

The test borings were advanced using 3-¼-inch I.D. hollow stem augers. Standard Penetration Testing (SPT) was performed in the test borings at three foot intervals to depths of 10 feet, and at five foot intervals for depths greater than 10 feet. Standard penetration testing consisted of driving a 2-inch O.D., 1-3/8-inch I.D. split spoon sampler 18 inches with a 140-pound hammer falling through a drop of 30 inches. For each 18-inch SPT sample taken, the blow counts were recorded on test boring logs for three 6-inch sampling increments. The SPT N-value for each sample is the

recorded number of hammer blows needed to drive the sampler the final 12 inches, and is expressed in blows per foot (bpf). Soil samples were recovered from the sampler and placed in sealed glass sample jars. The test boring logs were prepared by J.D. Hynes & Associates, and are included in Appendix B.

Depth to groundwater was noted during the drilling and sampling operations. Groundwater was encountered in all of the test borings. The depth to groundwater encountered during drilling ranges from 6 feet to 18 feet below the ground surface, and from El. 27 feet to El. 15 feet. A summary of the groundwater information collected in the test borings is provided in Table 3.2, as follows:

Table 3.2: Groundwater Information

Boring Number	Ground Surface Elevation (ft.)	Encountered Groundwater Depth (ft.)	Encountered Groundwater Elevation (ft.)	Piezometer Groundwater Depth (ft.)	Piezometer Groundwater Elevation (ft.)
AD-01	39.6	18.0	21.6	~~~	~~~
AL-01	41.0	14.0	27.0	~~~	~~~
C-03	28.2	10.0	18.2	~~~	~~~
C-04	27.8	9.0	18.8	8.5	19.3
CD-01	28.9	9.0	19.9	~~~	~~~
CS-01	30.5	12.0	18.5	11.4	19.1
CS-02	28.2	6.0	22.2	~~~	~~~
HP-01	27.9	9.0	18.9	9.5	18.4
PB-01	27.7	9.0	18.7	9.5	18.2
SR-01	28.4	11.0	17.4	9.6	18.8
TS-01	29.1	14.0	15.1	~~~	~~~

A more accurate determination of the hydrostatic water table would require the installation of perforated pipes or piezometers which can be monitored over a more extensive period of time. The actual level of the hydrostatic water table should be expected to fluctuate throughout the year depending upon variations in precipitation, drought conditions, surface run-off, infiltration, site topography and drainage.

4.0 Subsurface Conditions

4.1 Geologic Setting

Sussex County, Delaware is located in the Atlantic Coastal Plain physiographic province, which has an eastward-thickening wedge of sand, silt and clay that rests on bedrock. The top of the bedrock in the project area has been estimated to be approximately 6,500 feet below sea level. The

oldest Coastal Plain sediments in eastern Sussex County are several thousand feet of sediments ranging in age from Cretaceous to Eocene (Geologic formations discussed from oldest to youngest).

In Miocene time, the area was submerged by a shallow sea, and the Chesapeake Group was deposited. The Chesapeake Group consists of the Calvert Formation, the Choptank Formation, the St. Mary's Formation, the Manokin Formation, and the Bethany Formation. The Calvert Formation and the Choptank Formation were deposited in predominantly marine environments. The Calvert Formation is mostly gray sandy silt. The Choptank Formation consists of gray fine to coarse shelly sand. After part of the Choptank Formation was eroded, the St. Mary's Formation, the Manokin Formation, and the Bethany Formation were deposited by deltas. The St. Mary's Formation consists of bluish-gray fine sandy clay, with some interbeds of very fine to medium sand. The Manokin Formation consists of a lower unit of silty fine sand, which grades into an upper unit of gray fine to coarse sand. The Bethany Formation consists of gray clay or silt interbedded with fine to very coarse sand.

The sediments of the Columbia Group were deposited during the Pleistocene Epoch on top of the eroded surface of the Chesapeake Group. In the project area, the Columbia Group consists of the Beaverdam Formation and the Lynch Heights Formation. The Beaverdam Formation, which was deposited in a fluvial to estuarine environment, consists of pale white to buff to greenish-gray medium sand, with scattered beds of coarse sand, gravelly sand, and light gray to greenish-gray silty clay. The Lynch Heights Formation was deposited on top of the eroded surface of the Beaverdam Formation. The Lynch Heights Formation, which is up to 10 feet thick, consists of several lithologies, as follows: fine to coarse sand with trace silt, granules, and pebbles; fine to medium silty sand with trace granules; silty clay with a trace of sand; and clayey sandy silt.

4.2 Subsurface Conditions

Based on our review of the test borings, the subgrade soils consist primarily of sandy soils, with occasional silty or clayey seams. Based on the SPT sampling, the borings indicate variable results with regard to relative density versus depth, but the SPT N-values generally increase with depth. To define the subsurface conditions for geotechnical evaluation in the areas of proposed construction, we have divided the subgrade soils into the following generalized strata:

Surficial Layer: A surficial soil layer consisting of sand with organic materials was encountered in five of the test borings ranging in thickness from 1 inch to 6 inches.

Stratum I (varying approximately from 0.5 feet to 8 feet below ground surface): This stratum generally consists of moist to wet, very loose to medium dense, fine to coarse SAND, with little silt and trace clay, (SM). These soils are mostly low-plasticity materials with SPT N-values that range from 3 to 27 blows per foot (bpf), and average 9 bpf.

Stratum II (varying approximately from 8 feet to 30 feet below ground surface): This stratum includes groundwater at a depth of about 8.5 feet to 9.5 feet below the ground surface. This stratum generally consists of saturated, loose, fine to coarse sand with some fine gravel, trace of silt (SP). These soils are granular materials with SPT N-values that range from 5 to 25 blows per foot (bpf), and average 13 bpf.

Stratum III (varying approximately from 30 feet to 50 feet below ground surface): This stratum includes saturated, medium dense to dense, medium to coarse sand, with trace silt and fine gravel (SM, SP, SP-SM). These soils are granular materials with average SPT N-values of 24 bpf.

5.0 Evaluation and Recommendations

This project is to be constructed in general accordance with the Delaware Department of Transportation "Standard Specifications", dated August 2016 and "Standard Construction Details", dated 2014, including all revisions up to the date of advertisement, and as modified by the Contract Specifications.

5.1. Existing Utilities

It should be noted that in the areas of proposed construction there are existing buried utilities including electric, water, sanitary sewer, and force main systems. It will be important to determine the type and location of all utilities in the areas of work prior to construction.

All existing buried utilities within the proposed areas of construction should be removed, relocated, or properly abandoned prior to the start of new construction. Where existing buried utilities and other below-grade construction are removed or relocated for the new construction, provisions should be made in the construction specifications and budget to restore the subgrade to a stable condition. Excavations for removal of buried utilities must be backfilled with properly compacted fill materials, as described herein.

5.2. General Earthwork Recommendations

Topsoil, rootmat, organics, vegetation and other deleterious materials should be removed from the areas to be developed. These stripping operations should be performed in a manner consistent with good erosion and sediment control practices. It is anticipated that stripping operations in general will be limited to removal of the upper 6± inches in grassy areas. Stripping depths may increase to 12 inches in cultivated agricultural fields. In building and fill subgrade areas, the proposed subgrade material should be proof rolled with a large vibratory roller capable of exerting a dynamic force of at least 10 tons, or a loaded tandem axle dump truck. Soft areas should be undercut and replaced with compacted fill.

In-place densification of loose existing soils will be required to prepare some areas for subgrade preparation or fill placement. Adequate drainage should be provided during construction to minimize potential problems with soil moisture during excavation and earthwork operations. Overexcavated areas resulting from the removal of unsuitable material should be backfilled with properly compacted suitable fill material as described herein.

Earthwork operations including subgrade preparation, proof rolling, and fill placement should be performed under the direction of a Geotechnical Engineer or experienced Soils Technician representing the Geotechnical Engineer. Observation and monitoring of structural fill placement and compaction operations should be performed by an experienced Soils Technician on a full-time basis. The Soils Technician should verify that the proper materials and procedures are used and that deficiencies are corrected in accordance with Contract Specifications. Inspectors daily reports should be submitted within 24 hours of completion of daily work activity. A certification letter including the daily reports, field and laboratory test reports, and appropriate documentation should be submitted by the Geotechnical Engineer upon completion of fill placement, and prior to foundation construction.

5.3. Fill Selection, Placement and Compaction

We understand that this project requires the placement of fill and backfill material. The use of cut material or on-site excavation as fill or backfill is anticipated, and suitable on-site materials are considered acceptable for use. The use of off-site materials will be required for preparation of the site as recommended herein. Compacted structural fill should consist of granular soil meeting AASHTO soil classification type A-2-4 or better. Lagoon embankment fill should consist of materials meeting the requirements of Borrow Type C as defined in the DelDOT Standard Specifications.

All fill and backfill should be compacted to at least 95% of the maximum dry density as determined by Modified Proctor, AASHTO T-180. The moisture content of the fill material at the time of compaction should be within 2% of the optimum moisture content. A sufficient number of in-place density tests should be performed by an experienced Soils Technician on a full-time basis to verify that the proper degree of compaction is being obtained.

5.4. Foundation Recommendations

Considering the proposed site grading and slab elevations of the proposed structures, it appears that the foundations will be located within natural soils, existing embankment fill, and/or compacted structural fill. Where foundations will be placed on new structural fill, the fill should be placed and compacted in accordance with the recommendations herein, and as described in Section 5.3 of this report. Foundations should be located at a minimum depth of 2 feet below final exterior grades for adequate protection against frost heave.

All footing excavations and slab subgrades should be inspected by a Geotechnical Engineer or experienced Soils Technician representing the Geotechnical Engineer prior to the placement of concrete. The purpose of the footing inspection is to verify that the exposed materials will be capable of supporting the design footing pressure.

North Headworks Structure – We understand that the new North Headworks structure will be constructed to the north of existing Aeration Lagoon No. 1. The existing aeration lagoon embankment is constructed with the top of berm at El. ±41 feet and an exterior slope ratio of 3(H):1(V). The site grading requirements include the placement of about 12 feet of compacted structural fill in this area. This area of structural fill will have a footprint of approximately 185-ft. by 170-ft. and will be constructed to accommodate the new North Headworks structure, the new Grit Facility structure, associated piping, dumpsters, and an access roadway. The roadway will provide truck access for the dumpsters and for operation and maintenance purposes.

The North Headworks structure will consist of a cast-in-place reinforced concrete structure that may be supported on a shallow foundation consisting of a mat slab. Existing grade at the proposed structure location is at El. ±28 feet, and the proposed finished grade will be at El. 40 feet. The proposed top of structure is at El. 48 feet and the bottom of the foundation will be at El. ±33 feet. Therefore, the North Headworks structure mat slab foundation will be supported on about 5-ft. to 6-ft. of compacted structural fill.

Prior to placing the compacted structural fill, the area should be stripped of all topsoil and vegetation. The proposed subgrade material should be proof rolled with a vibratory roller. Soft areas should be undercut and replaced with compacted fill. All fill and backfill should be in accordance with the recommendations of Section 5.3 of this report. Compacted structural fill should be placed in horizontal, loose lifts 8-inches in thickness, and should be benched in to the existing lagoon embankment. The new structural fill embankment side slopes should be constructed with a minimum slope ratio of 3(H):1(V).

For the North Headworks structure a mat foundation should be used for support. A stone working platform with a minimum of 6 inches of densified No. 57 stone should be placed between the headworks structure foundation and the subgrade. As described, the headworks structure will be supported on compacted structural fill materials of about 5-ft. to 6-ft. in thickness. We recommend that a mat foundation with a net allowable bearing pressure of 2,000 psf be used to support the North Headworks structure. A modulus of subgrade reaction (k) of 70 pci, adjusted for slab size, may be used for the reinforced concrete mat foundation design.

Grit Facility - We understand that the Grit Facility structure will be constructed to the north of existing Aeration Lagoon No. 1, and to the south of the North Headworks structure. The site grading requirements include the placement of about 12 feet of compacted structural fill to accommodate the new construction as described above.

The Grit Facility will consist of a cast-in-place reinforced concrete structure that includes influent and effluent tanks, and a closed influent channel with a 15-degree slope. The structure may be supported on a shallow foundation consisting of a mat slab. Existing grade at the proposed structure location ranges from El. ±29 feet to El. ±35 feet, and the proposed finished grade will be at El. 40 feet. The proposed top of structure is at El. 47.5 feet and the bottom of the foundation will be stepped with foundations at El. ±38.0 feet and El. ±32.5 feet. Compacted structural fill should be placed and compacted as described above, and as described in Section 5.3 of this report.

For the Grit Facility structure, a mat foundation should be used for support. A stone working platform with a minimum of 6 inches of densified No. 57 stone should be placed between the structure foundation and the subgrade. As described, the Grit Facility structure will be supported on compacted structural fill materials ranging from about 4-ft. to 10-ft. in thickness. We recommend that a mat foundation with a net allowable bearing pressure of 2,000 psf be used to support the Grit Facility structure. A modulus of subgrade reaction (k) of 70 pci, adjusted for slab size, may be used for the reinforced concrete mat foundation design.

Aeration Lagoon Distribution Structure - The Aeration Lagoon Distribution structure will be located on the north embankment slope of the existing Overflow Lagoon No. #1 between the proposed Aeration Lagoons No. 3 and No. 4. The structure will be located on the embankment slope, about 20 feet north of the embankment centerline. The existing lagoon embankment is constructed with the top of berm at El. ±41 feet and an exterior slope ratio of 3(H):1(V).

The existing Overflow Lagoon No. #1 will be modified to serve as Aeration Lagoons No. 3 and No. 4 and the interior slope of the lagoon embankment will be steepened from 3(H):1(V) to 2(H):1(V). The Aeration Lagoon Distribution structure will be located adjacent to the new embankment that will be constructed to separate the new aeration lagoons. The Aeration Lagoon Distribution structure should be constructed when the existing lagoon has been drained and taken out of service for modification. We performed an evaluation of embankment stability with regard to the proposed embankment modifications. A factor of safety of FS = 1.49 was found for the existing embankment when steepened to a 2(H):1(V) slope. The results of this analysis are provided in Appendix D.

The distribution structure will consist of a cast-in-place concrete structure, with plan dimensions of 29.5-ft. by 11.5-ft. and it will be partially below-grade. It will be constructed with the top of structure at El. 44.75 feet and the bottom at El. ±23.5 feet. The distribution structure will receive wastewater flow from the grit facility and distribute flow to the aeration lagoons through a system of weirs, piping, and valves.

We understand that the existing lagoon is lined. The distribution structure will be constructed in the existing lagoon embankment above the anticipated level of static groundwater. The below-grade structure should be designed for lateral earth pressures with consideration of the sloping site

grades at 3(H):1(V), and external hydrostatic pressures under the assumption that groundwater is at the ground surface (El. ±28.5 feet) along the toe of the embankment. To reduce hydrostatic pressure on the below-grade structure granular backfill and a wall drainage system should be installed. A soil unit weight of 120 pcf, internal friction angle of 30 degrees, a coefficient of at-rest earth pressure Ka = 0.4, and a passive earth pressure coefficient Kp = 2.25, are recommended for design of the below-grade walls for the distribution structure.

For the distribution structure a mat foundation should be used for support. A stone working platform with a minimum of 12 inches of densified No. 57 stone should be placed between the distribution structure foundation and the subgrade. We recommend that a mat foundation with a net allowable bearing pressure of 1,500 psf be used to support the distribution structure. A modulus of subgrade reaction (k) of 70 pci, adjusted for slab size, may be used for the reinforced concrete mat foundation design.

Pump and Blower Building No. 2 - We understand that the new pump and blower building structure will be constructed to the northeast of the existing chlorine contact tank and to the west of the proposed secondary clarifiers No. 3 and No. 4.

The building structure will have overall plan dimensions of 47-ft. by 42-ft. in plan and will consist of concrete slab-on-grade and CMU wall construction, with hollow core precast concrete plank ceilings and light gage metal roof framing. The building structure will also have a 20-ft. roof extension on the south side for the future placement of three pad-mounted process blowers. The proposed finished floor elevation is at El. 28.50 feet. The pump and blower building wall loads are estimated at 4 kips/foot, and the floor slab loading is estimated at 250 psf.

Test boring PB-01 was taken at the proposed building location to obtain subsurface information for design. The boring encountered groundwater at a depth of 9.5 feet (El. 18.2 feet) below existing grade. Based on the test borings at the site, groundwater levels may be at depths as shallow as 6 feet below existing grade.

For the pump and blower building, spread footing foundations with an outside footing depth of a minimum of 2 feet below outside finished grade should be used. Ground supported floor slabs should be used. The proposed subgrade material should be proof rolled with a minimum of five passes of a large vibratory roller. Soft areas should be undercut 2 feet and replaced with No. 57 stone over geotextile. A stone working platform with a minimum of 6 inches of densified No. 57 stone should be placed to establish the pump and blower building foundation subgrade. Floor slabs should be supported on a granular base consisting of a minimum of 6 inches of No. 57 stone with a suitable moisture barrier placed under the concrete slab. We recommend that a modulus of subgrade reaction (k) of 125 pci be used for floor slab design. We recommend that spread footing foundations with a net allowable bearing pressure of 2,000 psf be used to support the pump and blower building.

Filtered Irrigation Pumping Station Building - We understand that the filtered irrigation pumping station building structure will be constructed to the west of the existing pump and blower building and to the northwest of the proposed North Headworks and Grit Facility.

The building structure will have overall plan dimensions of 92-ft. by 62-ft. in plan and will consist of concrete slab-on-grade and CMU wall construction, with hollow core precast concrete plank ceilings and light gage metal roof framing. The proposed finished floor elevation is at El. 27.50 feet. The filtered irrigation pumping station building wall loads are estimated at 4 kips/foot, and the floor slab loading is estimated at 250 psf. The proposed floor slab construction includes below-slab pipe trenches to depths of about 6 feet and widths of 4 feet, with reinforced concrete side walls and bottom slabs. The tops of the trench side walls will be tied to the floor slab.

Based on the groundwater depths encountered in the test borings at the site, groundwater is anticipated at depths ranging from about 6 feet to about 9 feet below existing grade.

The below-grade reinforced concrete pipe trenches should be designed for lateral earth pressure, hydrostatic pressure, floatation, and surcharge pressures. The below-grade walls should be designed for hydrostatic pressure under the assumption that groundwater is at the ground surface. A saturated unit weight of 125 pcf, friction angle of 28 degrees, and a coefficient of at-rest earth pressure Ko = 0.53, is recommended for design of the rigid below-grade trench retaining walls.

For the filtered irrigation pumping station building, spread footing foundations with an outside footing depth of a minimum of 2 feet below outside finished grade should be used. Ground supported floor slabs should be used. The proposed subgrade material should be proof rolled with a minimum of five passes of a large vibratory roller. Soft areas should be undercut 2 feet and replaced with No. 57 stone over geotextile. A stone working platform with a minimum of 6 inches of densified No. 57 stone should be placed to establish the filtered irrigation pumping station building foundation subgrade. Floor slabs should be supported on a granular base consisting of a minimum of 6 inches of No. 57 stone with a suitable moisture barrier placed under the concrete slab. We recommend that a modulus of subgrade reaction (k) of 125 pci be used for floor slab design. We recommend that spread footing foundations with a net allowable bearing pressure of 2,000 psf be used to support the filtered irrigation pumping station building.

An 8-ft. diameter precast concrete wet well will be constructed on the south side of the filtered irrigation pumping station building. The 12.5-ft. deep wet well will be constructed entirely below-grade with the bottom at El. ±13.5 feet. The wet well should be located so that a 1:1 line extending downward and outward from the bottom edge of the building foundation does not intersect the wet well structure wall or foundation. The wet well structure should be designed for lateral earth pressure, hydrostatic pressure, flotation, and any surcharge pressures that will be applied. The wet well structure should be designed under the assumption that groundwater is at the ground surface.

Clarifier No. 3 and Clarifier No. 4 - We understand that the new clarifiers will be constructed to the west of the existing clarifiers (No. 1 and No. 2). The design of the new clarifiers will be prepared by the Contractor under a performance specification and will be submitted for review and approval. The two new clarifier structures will each have an inside tank diameter of 85 feet and a finished bottom floor elevation sloping from El. 22.2 feet to El. 18.9 feet. The new clarifiers will consist of reinforced concrete construction and will be nearly identical to the existing clarifiers.

The below-grade structures should be designed for lateral earth pressure, hydrostatic pressure, flotation, and any surcharge pressures that will be applied. The clarifier structures should be designed under the assumption that groundwater is at the ground surface. A saturated unit weight of 125 pcf and a coefficient of active earth pressure, Ka = 0.33 is recommended for design of the below-grade walls for the clarifiers. Based on the design information previously provided for the existing clarifiers, it is expected that both clarifier foundations will have maximum design contact pressures of 1,500 psf.

For the clarifier structures a mat foundation should be used for support. A stone working platform with a minimum of 12 inches of densified No. 57 stone should be placed between the clarifier structure foundation and the subgrade. The foundation subgrade should be prepared by densifying with multiple passes of a large vibratory roller. We recommend that a mat foundation with a net allowable bearing pressure of 1,500 psf be used to support the clarifier structures. A modulus of subgrade reaction (k) of 70 pci, adjusted for slab size, may be used for the reinforced concrete mat foundation design.

5.5. Effluent Storage Lagoon No. 3

The proposed new 23-acre effluent storage lagoon will be formed by a 12.5-ft. high earthen embankment lined with an HDPE liner. The shape of the lagoon is an acute triangle with approximate dimensions of 1,200 feet along the west leg by 1,650 feet along the south leg, and 2,020 feet along the northeast side. The proposed bottom elevation of the lagoon is at El. 30.0 feet and the top elevation of the surrounding embankment is at El. 42.5 feet. The existing ground surface elevations of the proposed lagoon site range from about El. 27 feet to El. 45 feet. The lagoon embankment includes a 12-ft. wide access roadway along the crest. The side slopes of the embankment will be constructed at a minimum slope ratio of 3(H):1(V).

The earthen lagoon embankments may be constructed with granular soil materials meeting the requirements of Borrow Type C as defined in the DelDOT Standard Specifications. The earthwork should be performed in accordance with Section 5.2, and the embankment fill should be placed and compacted as described in Section 5.3 of this report.

After the interior grades are established and the subgrade is approved, the inside of the lagoon should be lined with a nonwoven needle punched geotextile with mass per unit area of at least 12 ounces per square yard. An HDPE textured geomembrane liner should be placed directly over the geotextile. We recommend that a textured 60-mil HPDE geomembrane be used for durability and puncture resistance during construction, and to increase the life expectancy of the finished lagoon. An anchor trench should be placed at the top of the embankment to support the geotextile and geomembrane liner. Gas vents should be placed along the top of the liner at 50-foot intervals to release gas that could collect beneath the liner.

5.6. Aeration Lagoons No. 3 and No. 4

The proposed Aeration Lagoons No. 3 & 4 are to be located within the existing Overflow Lagoon No. 1. The interior slope of the existing lagoon must be steepened from 3(H):1(V) to 2(H):1(V) to accommodate the new system. The existing bottom elevation of the overflow lagoon is at El. 24.0 feet and the proposed bottom elevation of the new aeration lagoons is at El. 28.0 feet. Therefore, the bottom of the existing lagoon will be raised 4-ft. with compacted fill. A new embankment will be constructed in the center of the existing lagoon to divide the lagoon into two new aeration lagoons. The side slopes of the new center embankment will be constructed at a minimum slope ratio of 2(H):1(V). The center embankment includes a 14-ft. wide access roadway along the crest.

A slope stability analysis was conducted to confirm that the interior lagoon slope can be steepened from a 3(H):1(V) slope to a 2(H):1(V) slope. A factor of safety of FS = 1.49 was found for the existing soil condition at a 2(H):1(V) slope. The results are provided in Appendix D.

The embankment fill needed to raise the bottom of the lagoon and the new center earthen embankment may be constructed with granular soil materials meeting the requirements of Borrow

Type C as defined in the DelDOT Standard Specifications. The earthwork should be performed in accordance with Section 5.2, and the embankment fill should be placed and compacted as described in Section 5.3 of this report.

After the interior grades are established and the subgrade is approved, the inside of the lagoon should be lined with a nonwoven needle punched geotextile with mass per unit area of at least 12 ounces per square yard. An HDPE textured geomembrane liner should be placed directly over the geotextile. We recommend that a textured 60-mil HPDE geomembrane be used for durability and puncture resistance during construction, and to increase the life expectancy of the finished lagoon. An anchor trench should be placed at the top of the embankment to support the geotextile and geomembrane liner. Gas vents should be placed along the top of the liner at 50-foot intervals to release gas that could collect beneath the liner.

5.7. Seismic Site Classification

Based on the subsurface conditions documented from the subsurface exploration, Seismic Site Class D is recommended for seismic design of the proposed structures. The Seismic Site Class estimation is based on SPT N-values within the upper 100 feet below the ground surface, and was determined using methods described in the International Building Code (IBC 2012). The site coefficients and design spectral response parameters were determined using the USGS Seismic Design Maps Tool, and are provided on the attached USGS Design Maps Report in Appendix C.

5.8. Bituminous Pavement and Concrete Aprons

The roadways and other areas of the facility that will require regular vehicular access will be surfaced with flexible bituminous pavement. At vehicular entrances to the new buildings and in areas of concentrated truck and equipment traffic the surface will be rigid pavement consisting of portland cement concrete pavement.

Pavement design recommendations have been prepared using the "AASHTO Guide for Design of Pavement Structures - 1993," and the "DelDOT Road Design Manual." The flexible pavement design recommendations are based on a minimum California Bearing Ratio (CBR) of 5, or a resilient modulus (Mr) of 7,500 psi, for the roadbed soil materials. The rigid pavement design recommendations are based on an effective modulus of subgrade reaction (k-value) of 125 pci, for the roadbed soils and subbase materials.

The following bituminous pavement section is recommended for roadways:

1.5"	Bituminous Concrete, SuperPave® 9.5 mm, Type C, 115 Gyrations, PG 64-22
2.0"	Bituminous Concrete, SuperPave® 12.5 mm, Type C, 115 Gyrations, PG 64-22
4.0"	Bituminous Concrete, SuperPave® 19.0 mm, Type B, 115 Gyrations, PG 64-22
4.0"	Bituminous Concrete, SuperPave® 19.0 mm, Type B, 115 Gyrations, PG 64-22

or Bituminous Concrete Base Course (BCBC), 115 Gyrations, PG 64-22
6.0" Graded Aggregate Base Course (GABC)

The following portland cement concrete section is recommended for ramps and aprons:

10.0" Portland Cement Concrete Pavement
6.0" Graded Aggregate Base Course (GABC)

5.9. Pavement Subgrade Requirements

The pavement subgrade should be prepared in accordance with Division 200 – Earthwork, of the Delaware Department of Transportation "Standard Specifications". In embankment fill sections, the roadway embankment should be constructed with roadbed materials consisting of Borrow Type A, placed and compacted to establish the pavement subgrade.

Where encountered in cut sections and at-grade, unsuitable materials and weak fine-graded subgrade soils should be undercut to a depth of 1 foot and replaced with Borrow Type A material. Placement of geotextile on the subgrade may be required to increase stability and prevent migration of the finer subgrade soils into the granular material.

5.10. Underdrain Recommendations

It is recognized that water in the pavement structure is a primary cause of pavement distress. We recommend a longitudinal underdrain collector system, which can provide positive drainage, for the roadway pavement construction.

The longitudinal underdrain should be 6-inch minimum diameter and should be placed along both sides of the roadway behind the curb in closed sections and at the outside edge of the shoulder in open sections. The underdrains should be outletted at low points and into other drainage structures. Based on maintenance considerations, the spacing of the outlets should be limited to 250 feet wherever possible. When two lines of pipe underdrain drain to a low point, each pipe should have its own outlet.

5.11. Dewatering and Drainage

Planned excavation depths for the proposed clarifiers and concrete wet well construction are below the static groundwater levels encountered in the test borings. Groundwater may also be encountered in other excavations including trenches associated with buried utility installations. It is possible that perched groundwater conditions will be encountered within the limits of the proposed excavations at the project site. Excavations should be kept free of water during construction, and groundwater levels should be maintained at a minimum of 12 inches below the

bottom of pipes and structures while under construction. Methods of dewatering excavations should be at the Contractor's discretion.

5.12. Temporary Excavation Support

Temporary excavation support and dewatering systems will be required to excavate for buried structures and utilities. Excavation support systems should be designed by a Professional Engineer licensed to practice in the State of Delaware and hired by the Contractor. The following soil parameters are recommended for use in designing the excavation support systems:

Soil unit weight (γ):	120 pcf
Buoyant unit weight (γb):	58 pcf
Internal friction angle (φ):	28°
Active pressure coef. (Ka):	0.361
Passive pressure coef. (Kp):	2.77
Groundwater:	Ground surface

If H-piles and lagging are used for the temporary excavation support system with dewatering, the soil buoyant weight does not apply, and groundwater should be taken to be at the bottom of the excavation support system.

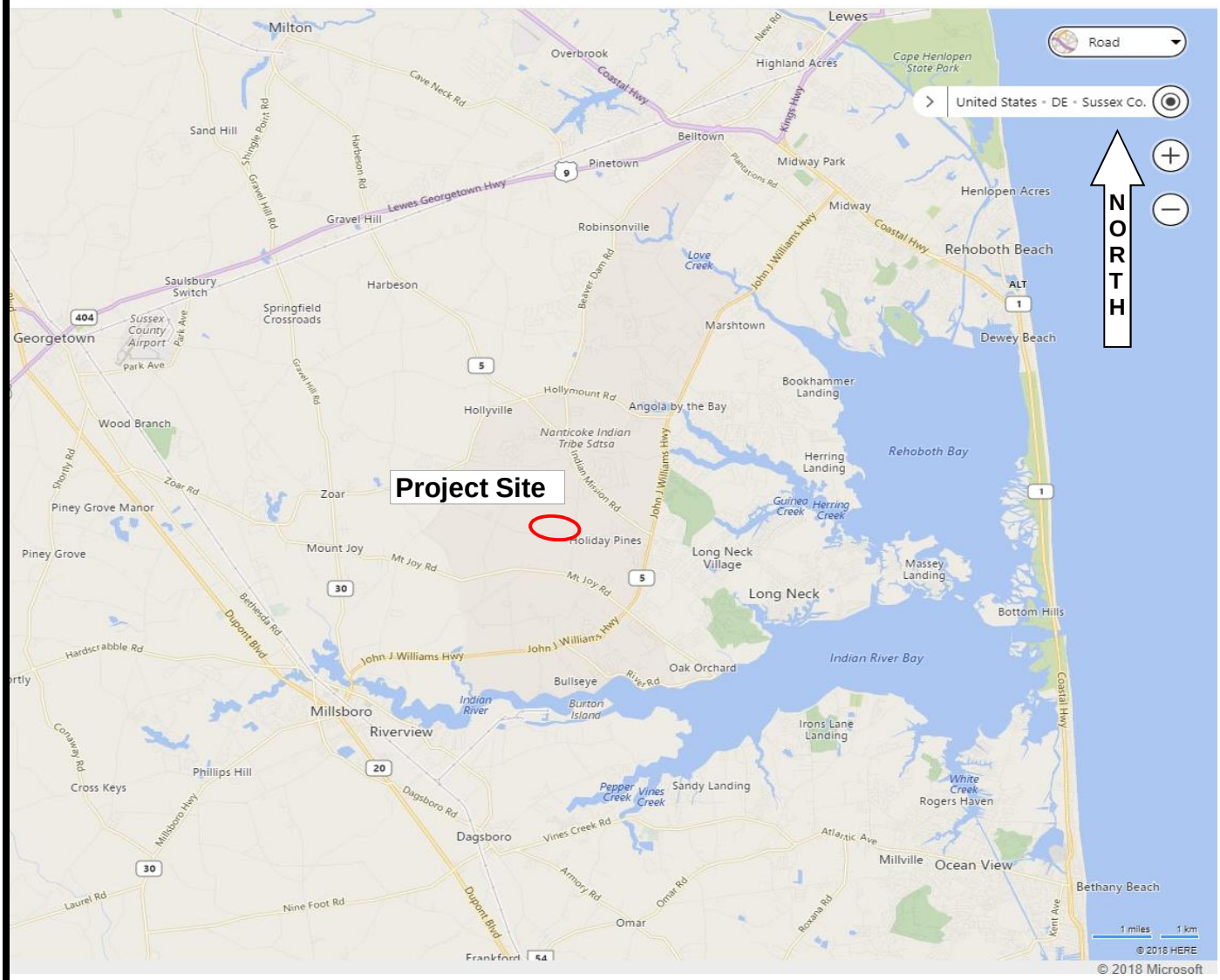
6.0 Basis of Recommendations

This report has been prepared to present geotechnical conditions in the areas of proposed construction and provide geotechnical analyses and recommendations. The recommendations contained in this report are based on our professional judgment and generally accepted principles of geotechnical engineering based on the information provided and the assumption that the soils related construction will be monitored and tested by a qualified engineering technician, under the supervision of a geotechnical Professional Engineer who is licensed to practice in the State of Delaware.

These analyses and recommendations are based on the information available at the time of writing this report and on the subsurface conditions that existed at the time that the borings were obtained. If additional data becomes available, it may be necessary to revise the analysis and recommendations. In addition, variations between borings may become evident during construction. If variations are encountered, it may become necessary to revise the analysis and recommendations provided.

APPENDIX A

DRAWINGS



VICINITY MAP

NTS

Whitman, Requardt & Associates, LLP
Engineers · Architects · Environmental Planners Est. 1915

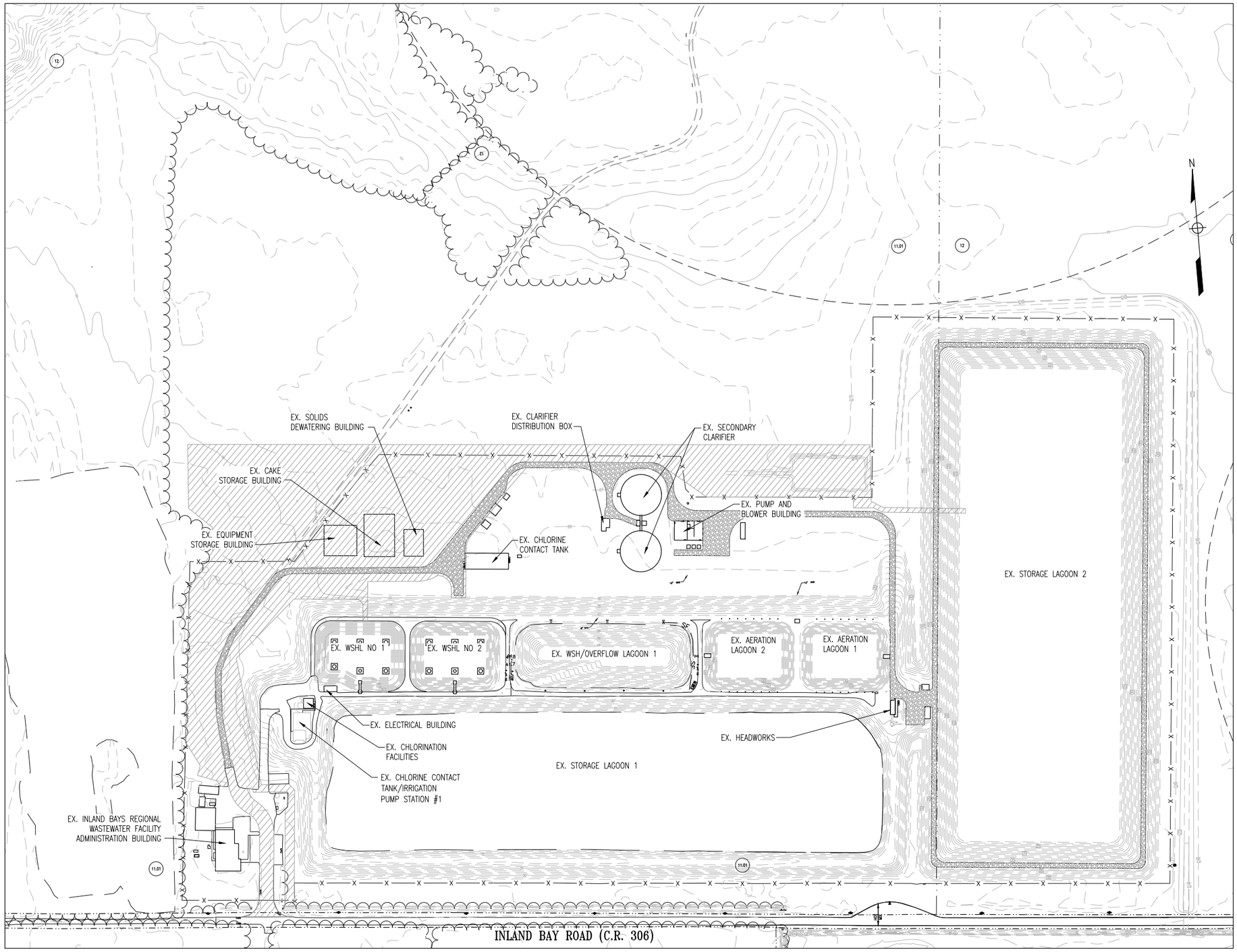
801 South Caroline Street
Baltimore, Maryland 21231
www.wrallp.com Phone: 410.235.3450

Sussex County
Inland Bays Regional Wastewater Facility

VICINITY MAP

FIGURE No.: 1

DRAWN BY:	APPROVED BY:	SCALE:	DATE:	WORK ORDER No.
JJB		NTS	02/23/18	14256.019



PROJECT EXTENTS OF CONTRACT 18-19

1 / C00.01 EXISTING SITE PLAN
SCALE: 1" = 100'

REVISIONS		

CLIENT INFORMATION

SUSSEX COUNTY, DE
ENGINEERING
DEPARTMENT

INLAND BAYS RWF
PHASE #2 EXPANSION:
CONTRACT S19-10

KEY PLAN

GRAPHIC SCALES

0 50' 100' 200'
SCALE: 1" = 100'

SIGNATURE

Whitman, Requardt & Associates, LLP
801 South Caroline Street, Baltimore, Maryland 21231

EXISTING SITE PLAN

DRAWING NO.

C00.01

SCALE: AS SHOWN		
DATE: DEC. 2018	SHEET 9 OF 217	
DES: FJB	DRAWN: JAM	CHECK: WFH

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X CONSTRUCTION NOTES

1. INSTALL 6' CHAIN LINK FENCE AROUND PROPOSED STORAGE LAGOON.
2. COORDINATE CONSTRUCTION WITH CONTRACT 18-19.

NORTH SPRAY FIELD

SEE DRAWING C02.04 FOR EXPANDED VIEW

EX. 12" FM TO NORTH SPRAY FIELD

EX. 2" ELEC. TO NORTH SPRAY FIELD

EX. 2" ELEC. TO NORTH BURTON FIELD

EX. 10" FM TO NORTH BURTON FIELD

EFFLUENT STORAGE LAGOON NO. 3

SECONDARY CLARIFIER NO. 4

SECONDARY CLARIFIER NO. 3

SLUDGE CAKE RECEIVING STATION (N.I.C.)

DRYER FACILITY (N.I.C.)

PUMP AND BLOWER BUILDING NO. 2

CLARIFIER DISTRIBUTION BOX EXPANSION

SEE DRAWING C02.04 FOR EXPANDED VIEW

SLUDGE CAKE STORAGE FACILITY (N.I.C.)

EX. INFILTRATION BASIN

EX. CLARIFIERS

FILTERED IRRIGATION PUMP STATION

EX. EQUIPMENT STORAGE BUILDING

NORTH HEADWORKS

GRIT FACILITY

EX. CAKE STORAGE BUILDING

EX. SOLIDS DEWATERING BUILDING

AERATION LAGOON DISTRIBUTION BOX

EX. PUMP AND BLOWER BUILDING

EX. CHLORINE CONTACT TANK

EX. WSHL NO. 1

EX. WSHL NO. 2

AERATION LAGOON NO. 4

AERATION LAGOON NO. 3

EX. AERATION LAGOON NO. 2

EX. AERATION LAGOON NO. 1

EX. STORAGE LAGOON

SEPTAGE RECEIVING STATION (N.I.C.)

EX. STORAGE LAGOON

EX. HEADWORKS

SEE DRAWING C02.02 FOR EXPANDED VIEW

SEE DRAWING C02.03 FOR EXPANDED VIEW

N

1 C02.01 OVERALL SITE PLAN
SCALE: 1" = 100'

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REVISIONS		

CLIENT INFORMATION

SUSSEX COUNTY, DE ENGINEERING DEPARTMENT

INLAND BAYS RWF PHASE #2 EXPANSION: CONTRACT S19-10

KEY PLAN

GRAPHIC SCALES

0 50' 100' 200'
SCALE: 1" = 100'

SIGNATURE

Whitman, Requardt & Associates, LLP
801 South Caroline Street, Baltimore, Maryland 21231

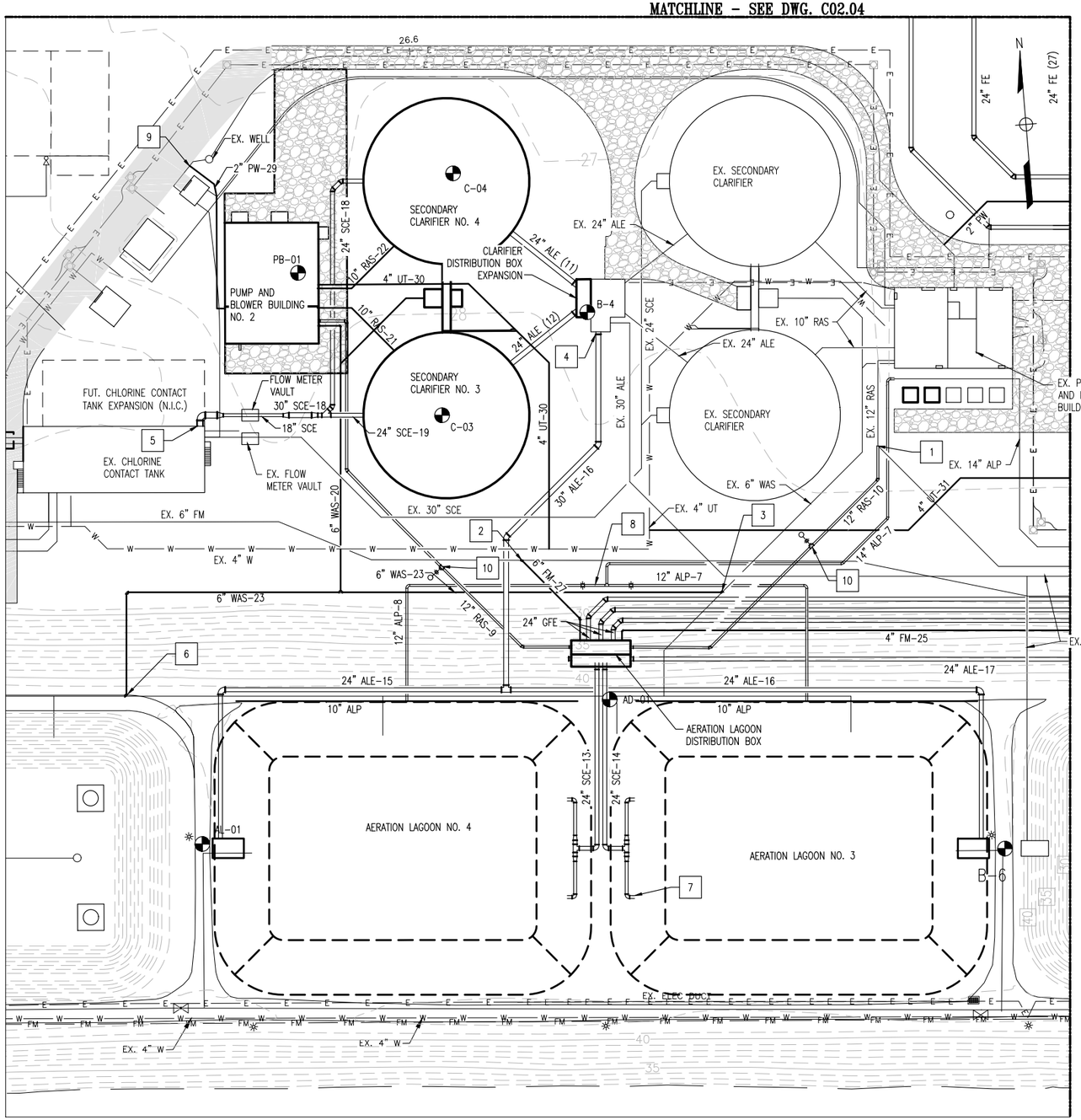
OVERALL SITE PLAN

DRAWING NO.

C02.01

SCALE: AS SHOWN		
DATE: DEC. 2018	SHEET 12 OF 217	
DES: FJB	DRAWN: JAM	CHECK: WFH

MATCHLINE - SEE DWG. C02.04



MATCHLINE - SEE DWG. C02.03

1 C02.02 SITE AND UTILITY PLAN
SCALE: 1" = 30'

X CONSTRUCTION NOTES

1. REMOVED EXISTING 45° HB AND CONNECT TO EXISTING 12" RAS LINE.
2. CONNECT TO EXISTING 6" FM WITH 45° HB.
3. CONNECT TO EXISTING 6" WAS WITH 45° HB.
4. REMOVE EXISTING CAP AND CONNECT TO CLARIFIER DISTRIBUTION BOX WALL CASTING.
5. CORE INTO CHLORINE CONTACT TANK.
6. CONNECT TO EXISTING 6" WAS LINE WITH 90° HB.
7. SEE DETAIL C05.01-G AND C05.01-H FOR LAGOON LINER PENETRATION (TYP.).
8. REFER TO DWG. M04.02 FOR PROCESS AIR FLOW METER AND VALVE ARRANGEMENT.
9. CONNECT TO EXISTING WATER LINE.
10. PROVIDE QUICK CONNECT FOR FLOW DIVERSION ASSEMBLY. SEE DETAIL C05.02-D ON DWG. C05.02.

REVISIONS		

CLIENT INFORMATION

SUSSEX COUNTY, DE
ENGINEERING
DEPARTMENT

INLAND BAYS RWF
PHASE #2 EXPANSION:
CONTRACT S19-10

KEY PLAN

GRAPHIC SCALES

0 15' 30' 60'
SCALE: 1" = 30'

SIGNATURE

Whitman, Requardt & Associates, LLP
801 South Caroline Street, Baltimore, Maryland 21231

SITE AND UTILITY PLAN

DRAWING NO.

C02.02

SCALE: AS SHOWN		
DATE: DEC. 2018	SHEET 13 OF 217	
DES: FJB	DRAWN: JAM	CHECK: WFH

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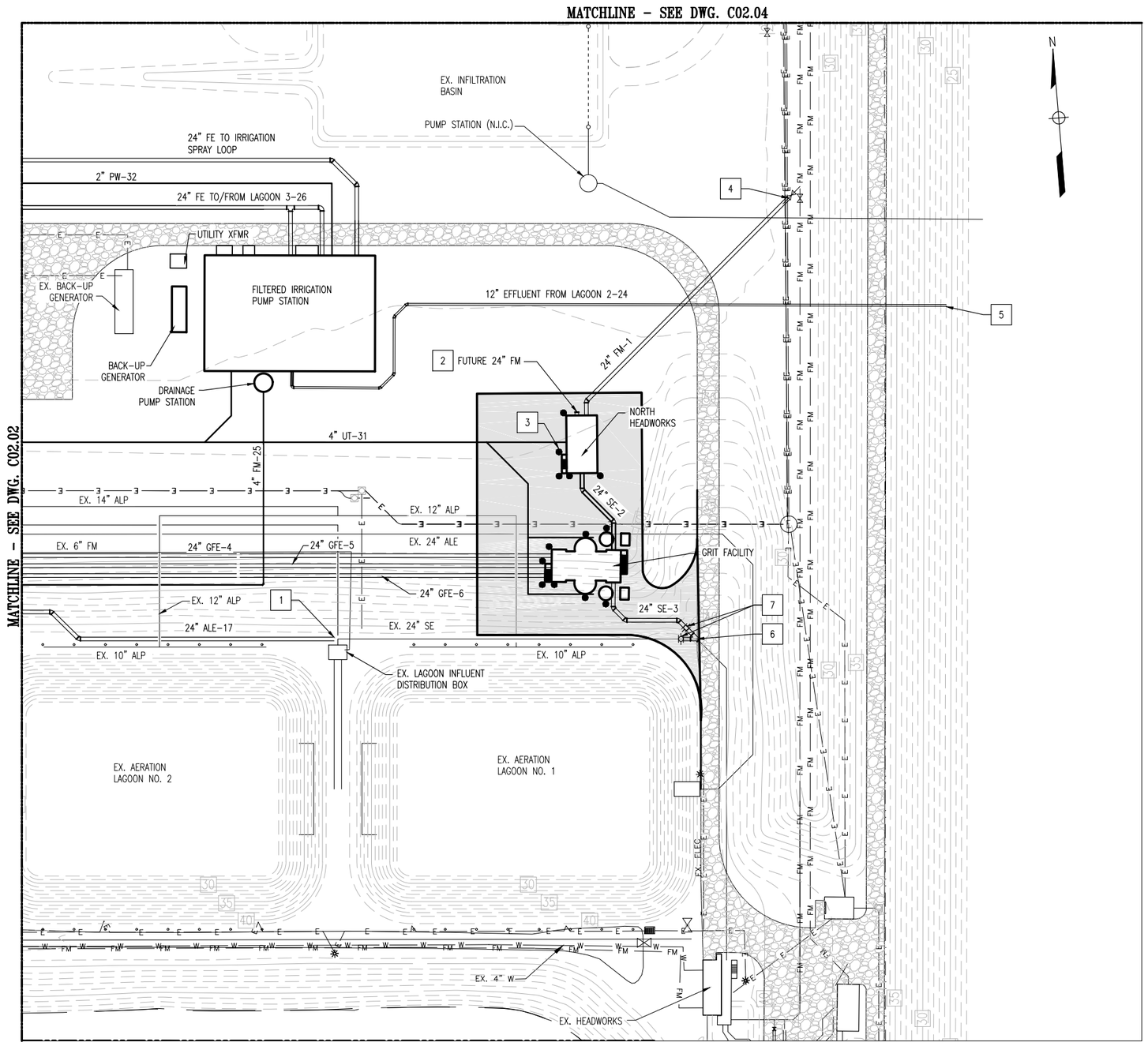

1 C02.03 SITE AND UTILITY PLAN
SCALE: 1" = 30'

X CONSTRUCTION NOTES

1. REMOVE EXISTING CAP AND CONNECT TO TEE.
2. PROVIDE CAP FOR FUTURE EXTENSION.
3. PROVIDE BOLLARD (TYP.). SEE DETAIL S00.05-C.
4. REMOVE EXISTING PLUG AND CONNECT TO EXISTING 24" GATE VALVE.
5. SEE DETAIL C05.01-G AND C05.01-H FOR LAGOON LINER PENETRATION (TYP.).
6. REMOVE EXISTING 45° HB AND CONNECT TO 24" SE LINE WITH 24" WYE AND SOLID SLEEVE.
7. INSTALL 24" PLUG VALVE. SEE DETAIL C05.02-B.
8. SEE ELECTRICAL DRAWINGS.

REVISIONS		

CLIENT INFORMATION

SUSSEX COUNTY, DE ENGINEERING DEPARTMENT

INLAND BAYS RWF PHASE #2 EXPANSION: CONTRACT S19-10

KEY PLAN

GRAPHIC SCALES

0 15' 30' 60'
SCALE: 1" = 30'

SIGNATURE

WRA
Whitman, Requardt & Associates, LLP
801 South Caroline Street, Baltimore, Maryland 21231

SITE AND UTILITY PLAN

DRAWING NO.

C02.03

SCALE: AS SHOWN		
DATE: DEC. 2018		SHEET 14 OF 217
DES: FJB	DRAWN: JAM	CHECK: WFH

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MATCHLINE A-A - SEE DRAWING C03-03

EFFLUENT STORAGE LAGOON NO.3
GRADING PLAN

1 / C03.02 SCALE: 1" = 60'

REVISIONS		

CLIENT INFORMATION

SUSSEX COUNTY, DE
ENGINEERING
DEPARTMENT

INLAND BAYS RWF
PHASE #2 EXPANSION:
CONTRACT S19-10

KEY PLAN

GRAPHIC SCALES

0 30' 60' 120'
SCALE: 1" = 60'

SIGNATURE

WRA
Whitman, Requardt & Associates, LLP
801 South Caroline Street, Baltimore, Maryland 21231

EFFLUENT STORAGE LAGOON NO. 3
GRADING PLAN

DRAWING NO.

C03.02

SCALE: AS SHOWN		
DATE: DEC. 2018	SHEET 17 OF 217	
DES: FJB	DRAWN: JAM	CHECK: WFH

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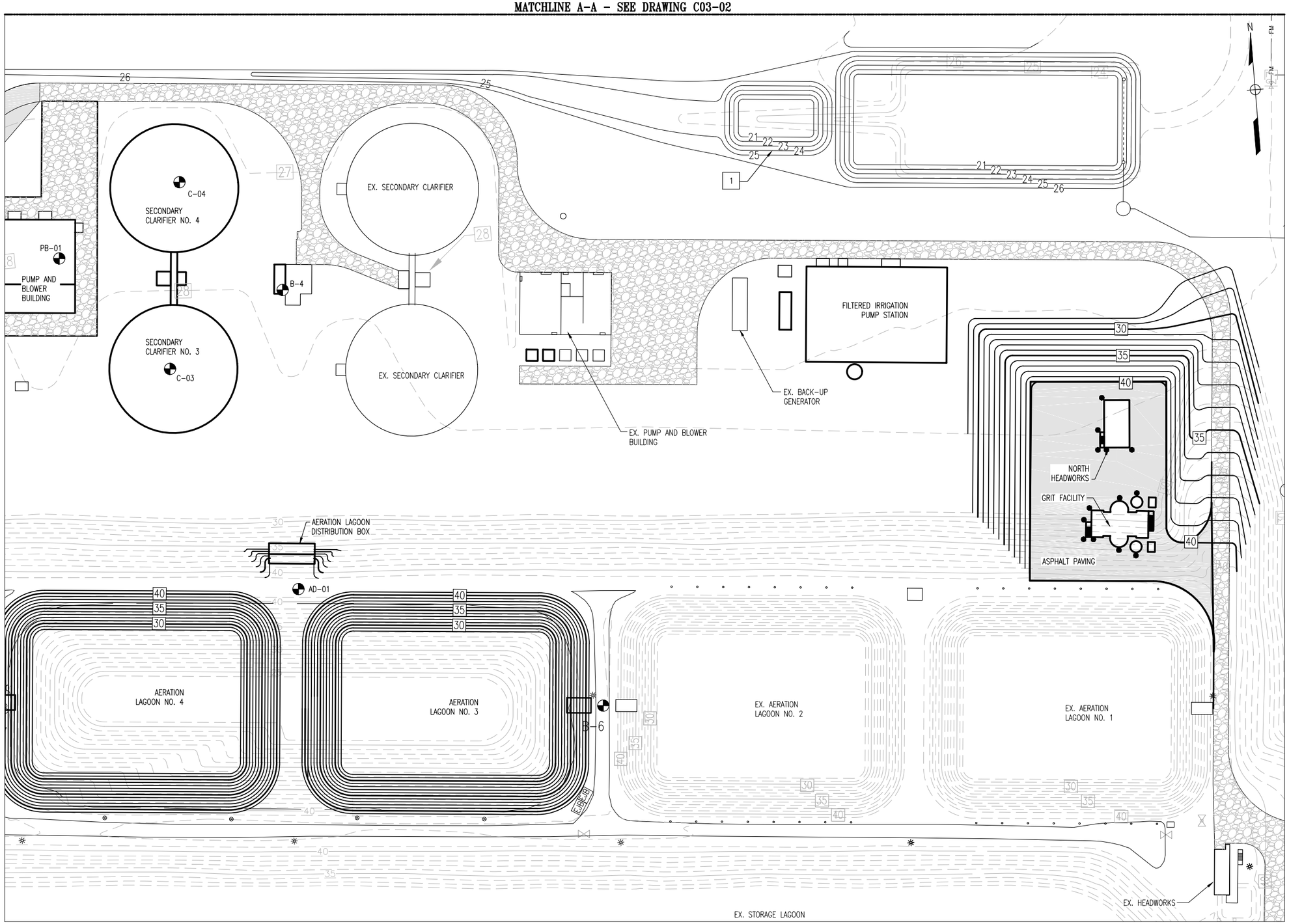
MATCHLINE A-A - SEE DRAWING C03-02



1 C03.03 GRADING PLAN
SCALE: 1" = 30'

X CONSTRUCTION NOTES

1. GRADING BY OTHERS

REVISIONS		

CLIENT INFORMATION

SUSSEX COUNTY, DE ENGINEERING DEPARTMENT

INLAND BAYS RWF PHASE #2 EXPANSION: CONTRACT S19-10

KEY PLAN

GRAPHIC SCALES

0 15' 30' 60'

SCALE: 1" = 30'

SIGNATURE

Whitman, Requardt & Associates, LLP
801 South Caroline Street, Baltimore, Maryland 21231

GRADING PLAN

DRAWING NO.

C03.03

SCALE: AS SHOWN		
DATE: DEC. 2018	SHEET 18 OF 217	
DES: FJB	DRAWN: JAM	CHECK: WFH

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APPENDIX B

TEST BORING LOGS

HYNES & ASSOCIATES

LOG OF BORING AD-01

(Page 1 of 1)

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 11, 2017
Logged By: : C. Johnston
Drilled By: : B. Hynes
Drilling Method: : HSA/Mud (Geoprobe 7822 DT)
Total Depth: : 30.5 feet

Depth in Feet	Surf. Elev. 39.6	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	39.6	Brown, wet, medium dense, fine to coarse SAND, with little silt, trace gravel		SM	1	5-7-8	Scale 1" ~ 7.75 feet
2	37.6	Light brown, wet, medium dense, fine to coarse SAND, with little silt, trace clay		SM	2	8-8-9	No organic bearing soil was encountered at the ground surface.
4	35.6	Brown, wet, medium dense, fine to coarse SAND, with little silt, trace clay		SM	3	6-7-9	Groundwater was encountered at 18 feet during drilling operations.
6	33.6	Brown, wet, medium dense, fine to coarse SAND, with little silt, trace clay		SM	4	8-9-7	Boring offset 4 feet West due to buried utilities.
8	31.6	Brown, wet, medium dense, fine to medium SAND, with little to some silt		SM	5	10-13-17	Northing: 232234.82 Easting: 709596.46
10	29.6	Light brown, wet to saturated, loose, fine to medium SAND, with little to some silt, trace clay		SM	6	4-3-4	"Mud" = Drilling mud was used in the augers after sample 6 was driven.
12	27.6	Light brown, saturated, loose, fine to medium SAND, with little to some silt		SM	7	3-3-3	Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
14	25.6	Light brown, saturated, very loose, fine to medium SAND, with little to some silt		SM	8	1-1-4	Boring grouted with bentonite and cement from a depth of 13.7 feet to the surface on 10/16/17.
16	23.6	Boring terminated at 30.5 feet.					
18	21.6						
20	19.6						
22	17.6						
24	15.6						
26	13.6						
28	11.6						
30	9.6						
32	7.6						
34	5.6						
36	3.6						
38	1.6						
40	-.4						
42	-2.4						
44	-4.4						
46	-6.4						
48	-8.4						
50	-10.4						
52							

HYNES & ASSOCIATES

LOG OF BORING AL-01

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 16, 2017
Logged By: : C. Johnston
Drilled By: : B. Hynes
Drilling Method: : HSA/Mud (Geoprobe 7822 DT)
Total Depth: : 30.5 feet

Depth in Feet	Surf. Elev. 41.0	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	41	Brown, wet, medium dense, fine to coarse SAND, with little silt, trace clay		SM	1	3-4-8	Scale 1" ~ 7.75 feet
2	39	Light brown, wet, very stiff, clayey SILT, with trace fine to coarse sand		ML	2	16-9-8	Approximately 2 inches of gravel was encountered at the ground surface.
4	37						
6	35	Light brown, wet, medium dense, fine to coarse SAND, with little silt, trace clay		SM	3	5-9-10	Groundwater was encountered at 14 feet during drilling operations.
8	33						
10	31	Brown, wet, medium dense, fine to coarse SAND, with little silt		SM	4	7-7-5	Boring caved in at 15 feet.
12	29						Northing: 232180.32 Easting: 709381.75
14	27	Gray to brown, wet to saturated, medium dense, fine to coarse SAND, with little silt		SM	5	9-9-10	"Mud" = Drilling mud was used in the augers after sample 6 was driven.
16	25						
18	23	Light brown, saturated, medium stiff, silty CLAY, with little fine to coarse sand		CL	6	4-4-3	Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
20	21						
22	19						Boring grouted with bentonite and cement from 15 feet.
24	17	Light brown, saturated, very loose, fine to medium SAND, with little to some silt, trace clay		SM	7	1-1-2	
26	15						
28	13	Light brown, saturated, medium dense, fine to medium SAND, with trace to little silt		SP-SM	8	5-5-6	
30	11						
32	9	Boring terminated at 30.5 feet.					
34	7						
36	5						
38	3						
40	1						
42	-1						
44	-3						
46	-5						
48	-7						
50	-9						
52							

HYNES & ASSOCIATES

LOG OF BORING C-03

(Page 1 of 1)

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 13, 2017
Logged By: : C. Johnston
Drilled By: : J. Briddell
Drilling Method: : HSA/Mud (Mobile B-47 HD)
Total Depth: : 50.5 feet

Depth in Feet	Surf. Elev. 28.2	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	28.2	Brown, wet, loose, fine to coarse SAND, with trace to little silt		SP-SM	1	2-4-5	Scale 1" ~ 7.75 feet
2	26.2	Light brown, wet, loose, fine to coarse SAND, with trace silt		SP	2	3-4-6	No organic bearing soil was encountered at the ground surface.
4	24.2	Light brown, wet, medium dense, fine to coarse SAND, with little to some silt, trace clay		SM	3	4-7-7	Groundwater was encountered at 10 feet during drilling operations.
6	22.2	Light brown, wet to saturated, medium dense, fine to coarse SAND, with little to some silt, trace clay		SM	4	5-5-7	Northing: 232387.80 Easting: 709524.32
8	20.2	Light brown, saturated, medium dense, fine to coarse SAND, with trace to little silt		SP-SM	5	3-5-8	"Mud" = Drilling mud was used in the augers after sample 6 was driven.
10	18.2						Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
12	16.2						
14	14.2						
16	12.2						
18	10.2				6	4-7-9	Boring grouted with bentonite and cement from bottom of boring.
20	8.2						
22	6.2	Light brown, saturated, medium dense, fine to coarse SAND, with trace silt, trace fine gravel		SP	7	4-9-9	
24	4.2						
26	2.2						
28	.2	Light brown, saturated, medium dense, fine to coarse SAND, with trace to little silt		SP-SM	8	5-9-10	
30	-1.8						
32	-3.8	Light brown, saturated, dense, fine to coarse SAND, with trace silt		SP	9	6-16-18	
34	-5.8						
36	-7.8						
38	-9.8	Orange-brown, saturated, dense, medium to coarse SAND, with trace silt, trace fine gravel		SP	10	11-16-19	
40	-11.8						
42	-13.8	Light orange-brown, saturated, dense, fine to coarse SAND, with trace silt		SP	11	13-25-20	
44	-15.8						
46	-17.8						
48	-19.8	Light brown, saturated, medium dense, medium to coarse SAND, with trace silt		SP	12	7-7-10	
50	-21.8						
52		Boring terminated at 50.5 feet.					

HYNES & ASSOCIATES

LOG OF BORING C-04

(Page 1 of 1)

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 11, 2017
Logged By: : C. Johnston
Drilled By: : B. Hynes
Drilling Method: : HSA/Mud (Geoprobe 7822 DT)
Total Depth: : 50.5 feet

Depth in Feet	Surf. Elev. 27.8	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	27.8	Brown, wet, medium dense, fine to medium SAND, with little silt		SM	1	5-5-4-7	Scale 1" ~ 7.75 feet
2	25.8	Light orange-brown, wet, loose, fine to medium SAND, with little silt, trace clay		SM	2	3-2-4	Approximately 1 inch of organic bearing soil was encountered at the ground surface.
4	23.8	Light brown, wet, loose, fine to coarse SAND, with little silt, trace clay		SM	3	6-5-4	Groundwater was encountered at 9 feet during drilling operations.
6	21.8	Light brown, wet to saturated, loose, fine to medium SAND, with little to some silt, trace clay		SM	4	3-3-3	Boring caved in at 7 feet.
8	19.8						Temporary piezometer placed to 13 feet below the ground surface.
10	17.8						
12	15.8	Light brown, saturated, loose, fine to coarse SAND, with trace to little silt		SP-SM	5	2-3-5	Groundwater was at 8.5 feet on 10/16/17.
14	13.8						
16	11.8						Northing: 232510.69 Easting: 709541.35
18	9.8				6	2-3-4	"Mud" = Drilling mud was used in the augers after sample 6 was driven.
20	7.8						
22	5.8	Light brown, saturated, loose, fine to coarse SAND, with little silt		SM	7	2-4-6	Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
24	3.8						
26	1.8						
28	-.2				8	2-4-5	Boring was grouted with bentonite and cement after piezometer removal.
30	-2.2						
32	-4.2						
34	-6.2				9	2-4-6	
36	-8.2						
38	-10.2	Light brown, saturated, medium dense, fine to coarse SAND, with trace to little silt		SP-SM	10	3-5-8	
40	-12.2						
42	-14.2	Orange-brown, saturated, medium dense, medium to coarse SAND, with trace silt, trace gravel		SP	11	3-7-8	
44	-16.2						
46	-18.2						
48	-20.2	Light brown, saturated, medium dense, medium to coarse SAND, with trace silt		SP	12	8-8-11	
50	-22.2						
52		Boring terminated at 50.5 feet.					

HYNES & ASSOCIATES

LOG OF BORING CD-01

(Page 1 of 1)

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 13, 2017
Logged By: : C. Johnston
Drilled By: : J. Briddell
Drilling Method: : HSA/Mud (Mobile B-47 HD)
Total Depth: : 30.5 feet

Depth in Feet	Surf. Elev. 28.9	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	28.9	Brown, wet, medium dense, fine to medium SAND, with little to some silt, trace clay		SM	1	4-13-14	Scale 1" ~ 7.75 feet
2	26.9	Orange-brown, wet, medium dense, fine to coarse SAND, with little to some silt, trace clay		SM	2	15-9-10	No organic bearing soil was encountered at the ground surface.
4	24.9	Light brown, wet, medium dense, fine to coarse SAND, with little to some silt, trace clay		SM	3	14-9-6	Groundwater was encountered at 9 feet during drilling operations.
6	22.9	Light brown, wet to saturated, medium dense, fine to coarse SAND, with trace to little silt		SP-SM	4	14-12-11	Boring offset 11 feet north due to buried utilities.
8	20.9	Light brown, saturated, medium dense, fine to coarse SAND, with trace silt		SP	5	5-12-13	Northing: 232493.80 Easting: 709232.34
10	18.9	Light brown, saturated, medium dense, fine to medium SAND, with little silt		SM	6	3-6-9	"Mud" = Drilling mud was used in the augers after sample 6 was driven.
12	16.9						Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
14	14.9						
16	12.9				7	4-8-11	Boring grouted with bentonite and cement from bottom of boring.
18	10.9						
20	8.9						
22	6.9						
24	4.9						
26	2.9						
28	.9	Light brown, saturated, medium dense, medium to coarse SAND, with trace silt		SP	8	14-10-12	
30	-1.1	Boring terminated at 30.5 feet.					
32	-3.1						
34	-5.1						
36	-7.1						
38	-9.1						
40	-11.1						
42	-13.1						
44	-15.1						
46	-17.1						
48	-19.1						
50	-21.1						
52							

HYNES & ASSOCIATES

LOG OF BORING CS-01

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 11, 2017
Logged By: : C. Johnston
Drilled By: : B. Hynes
Drilling Method: : HSA/Mud (Geoprobe 7822 DT)
Total Depth: : 30.5 feet

Depth in Feet	Surf. Elev. 30.5	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	30.5	Orange-brown, wet, very loose, fine to medium SAND, with little to some silt, trace clay		SM	1	2-1-2	Scale 1" ~ 7.75 feet
2	28.5	Light orange-brown, wet, medium stiff, clayey SILT, with trace fine to medium sand		ML	2	2-3-6	Approximately 6 inches of organic bearing soil was encountered at the ground surface.
4	26.5						
6	24.5	Orange-brown, wet, loose, fine to medium SAND, with little to some silt, trace clay		SM	3	2-3-5	Groundwater was encountered at 12 feet during drilling operations.
8	22.5						
10	20.5	Light brown, wet to saturated, loose, fine to medium SAND, with little silt, little clay		SM	4	4-4-4	Temporary piezometer placed to 14 feet below the ground surface.
12	18.5						Groundwater was at 11.4 feet on 10/16/17.
14	16.5	Light brown, saturated, medium dense, fine to coarse SAND, with trace to little silt		SP-SM	5	5-6-5	Northing: 232584.29 Easting: 708833.67
16	14.5						
18	12.5	Light brown, saturated, medium dense, fine to coarse SAND, with trace silt		SP			"Mud" = Drilling mud was used in the augers after sample 6 was driven.
20	10.5				6	4-4-4	
22	8.5						Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
24	6.5				7	2-4-7	
26	4.5						Boring was grouted with bentonite and cement after piezmeter removal.
28	2.5	Brown, saturated, medium dense, fine to medium SAND, with little silt, little fine gravel		SP-SM			
30	.5				8	8-7-9	
32	-1.5	Boring terminated at 30.5 feet.					
34	-3.5						
36	-5.5						
38	-7.5						
40	-9.5						
42	-11.5						
44	-13.5						
46	-15.5						
48	-17.5						
50	-19.5						
52							

HYNES & ASSOCIATES

LOG OF BORING CS-02

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 16, 2017
Logged By: : C. Johnston
Drilled By: : B. Hynes
Drilling Method: : HSA/Mud (Geoprobe 7822 DT)
Total Depth: : 30.5 feet

Depth in Feet	Surf. Elev. 28.2	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	28.2	Orange-brown, wet, very loose, fine to coarse SAND, with little to some silt, trace clay		SM	1	3-2-3	Scale 1" ~ 7.75 feet
2	26.2	Light orange-brown, wet, loose, fine to medium SAND, with little to some silt, little clay		SM	2	2-2-6	Approximately 6 inches of organic bearing soil was encountered at the ground surface.
4	24.2						
6	22.2	Light gray, wet to saturated, silty CLAY, with little fine to coarse sand		CL	3	2-3-4	Groundwater was encountered at 6 feet during drilling operations.
8	20.2						
10	18.2				4	1-2-4	Boring caved in at 14 feet.
12	16.2						Northing: 232560.37 Easting: 709092.57
14	14.2	Light brown, saturated, loose, fine to coarse SAND, with trace to little silt		SP-SM	5	3-4-5	"Mud" = Drilling mud was used in the augers after sample 6 was driven.
16	12.2						
18	10.2	Light brown, saturated, medium dense, fine to coarse SAND, with trace to little silt		SP-SM	6	2-5-6	Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
20	8.2						
22	6.2						Boring grouted with bentonite and cement from 14 feet.
24	4.2	Light brown, saturated, loose, fine to coarse SAND, with trace to little silt		SP-SM	7	4-4-4	
26	2.2						
28	.2	Light gray, saturated, medium dense, fine to coarse SAND, with trace silt		SP	8	3-5-6	
30	-1.8	Boring terminated at 30.5 feet.					
32	-3.8						
34	-5.8						
36	-7.8						
38	-9.8						
40	-11.8						
42	-13.8						
44	-15.8						
46	-17.8						
48	-19.8						
50	-21.8						
52							

HYNES & ASSOCIATES

LOG OF BORING HP-01

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 11, 2017
Logged By: : C. Johnston
Drilled By: : B. Hynes
Drilling Method: : HSA/Mud (Geoprobe 7822 DT)
Total Depth: : 40.5 feet

Depth in Feet	Surf. Elev. 27.9	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	27.9	Brown, wet, medium dense, fine to coarse SAND, with little silt, trace clay		SM	1	5-7-7	Scale 1" ~ 7.75 feet
2	25.9	Light orange-brown, wet, loose, fine to coarse SAND, with little silt, trace clay		SM	2	4-3-3	Approximately 2 inches of organic bearing soil was encountered at the ground surface.
4	23.9	Light brown, wet, very loose, fine to medium SAND, with little to some silt, little clay		SM	3	3-2-3	Groundwater was encountered at 9 feet during drilling operations.
6	21.9	Light brown, wet to saturated, medium dense, fine to coarse SAND, with little to some silt		SM	4	4-6-5	Boring caved in at 14 feet.
8	19.9	Light brown, saturated, loose, fine to coarse SAND, with trace silt		SP	5	3-4-5	Temporary piezometer placed to 13 feet below the ground surface.
10	17.9	Light brown, saturated, loose, fine to coarse SAND, with trace to little silt		SP-SM	6	2-3-3	Groundwater was at 9.5 feet on 10/16/17.
12	15.9	Light brown, saturated, very loose, fine to coarse SAND, with trace to little silt		SP-SM	7	2-1-3	Northing: 232581.39 Easting: 709219.08
14	13.9	Orange-brown, saturated, medium dense, medium to coarse SAND, with trace silt		SP	8	8-8-9	"Mud" = Drilling mud was used in the augers after sample 6 was driven.
16	11.9	Orange-brown, saturated, medium dense, fine to coarse SAND, with trace silt		SP	9	4-5-9	Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
18	9.9				10	7-8-9	Boring was grouted with bentonite and cement after piezmeter removal.
20	7.9						
22	5.9						
24	3.9						
26	1.9						
28	-.1						
30	-2.1						
32	-4.1						
34	-6.1						
36	-8.1						
38	-10.1						
40	-12.1						
42	-14.1	Boring terminated at 40.5 feet.					
44	-16.1						
46	-18.1						
48	-20.1						
50	-22.1						
52							

HYNES & ASSOCIATES

LOG OF BORING PB-01

(Page 1 of 1)

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 11, 2017
Logged By: : C. Johnston
Drilled By: : B. Hynes
Drilling Method: : HSA/Mud (Geoprobe 7822 DT)
Total Depth: : 30.5 feet

Depth in Feet	Surf. Elev. 27.7	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	27.7	Brown, wet, medium dense, fine to medium SAND, with little silt, trace clay		SM	1	9-11-15	Scale 1" ~ 7.75 feet
2	25.7	Orange-brown, wet, loose, fine to coarse SAND, with little silt, trace clay		SM	2	7-4-3	No organic bearing soil was encountered at the ground surface.
4	23.7	Light brown, wet, loose, fine to coarse SAND, with trace to little silt		SP-SM	3	3-3-3	Groundwater was encountered at 9 feet during drilling operations.
6	21.7	Light brown, wet to saturated, very loose, fine to coarse SAND, with little to some silt, trace clay		SM	4	2-2-3	Boring caved in at 7 feet.
8	19.7	Light brown, saturated, loose, fine to coarse SAND, with trace to little silt		SP-SM	5	2-3-3	Temporary piezometer placed to 13 feet below the ground surface.
10	17.7				6	2-3-4	Groundwater was at 9.5 feet on 10/16/17.
12	15.7						Northing: 232467.23 Easting: 709457.53
14	13.7						"Mud" = Drilling mud was used in the augers after sample 6 was driven.
16	11.7						Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
18	9.7						Boring was grouted with bentonite and cement after piezmeter removal.
20	7.7						
22	5.7	Light brown, saturated, loose, medium to coarse SAND, with trace silt		SP	7	2-4-6	
24	3.7						
26	1.7						
28	-.3	Light brown, saturated, medium dense, fine to coarse SAND, with trace silt		SP	8	3-5-6	
30	-2.3	Boring terminated at 30.5 feet.					
32	-4.3						
34	-6.3						
36	-8.3						
38	-10.3						
40	-12.3						
42	-14.3						
44	-16.3						
46	-18.3						
48	-20.3						
50	-22.3						
52							

HYNES & ASSOCIATES

LOG OF BORING SR-01

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 13, 2017
Logged By: : C. Johnston
Drilled By: : J. Briddell
Drilling Method: : HSA/Mud (Mobile B-47 HD)
Total Depth: : 25.5 feet

Depth in Feet	Surf. Elev. 28.4	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	28.4	Light orange-brown, wet, medium dense, fine to coarse SAND, with little to some silt, little clay		SM	1	4-7-11	Scale 1" ~ 7.75 feet
2	26.4						
4	24.4				2	5-11-11	No organic bearing soil was encountered at the ground surface.
6	22.4	Light gray, wet, medium dense, fine to medium SAND, with little to some silt, trace clay		SM	3	5-7-11	Groundwater was encountered at 11 feet during drilling operations.
8	20.4						
10	18.4	Orange-brown, wet to saturated, medium dense, fine to coarse SAND, with trace to little silt		SP-SM	4	5-8-10	Temporary piezometer placed to 13 feet below the ground surface.
12	16.4						Groundwater was at 9.6 feet on 10/16/17.
14	14.4	Light brown, saturated, medium dense, fine to coarse SAND, with trace silt		SP	5	9-12-14	Northing: 232115.11 Easting: 708735.56
16	12.4						
18	10.4						"Mud" = Drilling mud was used in the augers after sample 6 was driven.
20	8.4				6	7-8-10	Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
22	6.4						
24	4.4	Light brown, saturated, medium dense, fine to coarse SAND, with trace silt		SP	7	7-16-17	Boring was grouted with bentonite and cement after piezmeter removal.
26	2.4	Boring terminated at 25.5 feet.					
28	.4						
30	-1.6						
32	-3.6						
34	-5.6						
36	-7.6						
38	-9.6						
40	-11.6						
42	-13.6						
44	-15.6						
46	-17.6						
48	-19.6						
50	-21.6						
52							

HYNES & ASSOCIATES

LOG OF BORING TS-01

Whitman, Requardt & Associates, LLP
801 South Caroline Street
Baltimore, Maryland 21231

Inland Bays Wastewater Facility Phase 2

Project No.: JDH-10/17/422

Date Completed: : October 16, 2017
Logged By: : C. Johnston
Drilled By: : B. Hynes
Drilling Method: : HSA/Mud (Geoprobe 7822 DT)
Total Depth: : 15.5 feet

Depth in Feet	Surf. Elev. 29.1	DESCRIPTION	GRAPHIC	USCS	Sample No.	Blows per 6 inches	Remarks
0	29.1	Brown, wet, very loose, fine to medium SAND, with little silt, trace clay		SM	1	2-2-3	Scale 1" ~ 7.75 feet
2	27.1	Orange-brown, wet, medium stiff, silty CLAY, with trace fine to medium sand		CH	2	3-2-4	Approximately 6 inches of organic bearing soil was encountered at the ground surface.
4	25.1	Orange-brown, wet, loose, fine to medium SAND, with little to some silt, trace clay		SM	3	4-4-6	Groundwater was encountered at 14 feet during drilling operations.
6	23.1	Orange-brown, wet, medium dense, fine to medium SAND, with little silt		SM	4	5-6-7	Boring caved in at 12 feet.
8	21.1	Orange-brown, wet to saturated, medium dense, fine to coarse SAND, with little silt		SM	5	4-9-10	Northing: 232008.54 Easting: 708793.76
10	19.1	Boring terminated at 15.5 feet.					"Mud" = Drilling mud was used in the augers after sample 6 was driven.
12	17.1						Note: Ground surface elevations were provided by Whitman, Requardt & Associates, LLP and rounded to tenths.
14	15.1						Boring grouted with bentonite and cement from 12 feet.
16	13.1						
18	11.1						
20	9.1						
22	7.1						
24	5.1						
26	3.1						
28	1.1						
30	-.9						
32	-2.9						
34	-4.9						
36	-6.9						
38	-8.9						
40	-10.9						
42	-12.9						
44	-14.9						
46	-16.9						
48	-18.9						
50	-20.9						
52							

APPENDIX C

USGS DESIGN MAPS REPORT

USGS Design Maps Summary Report

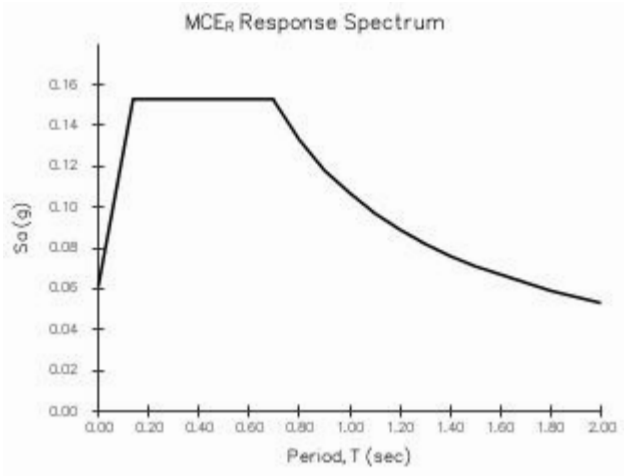
User–Specified Input

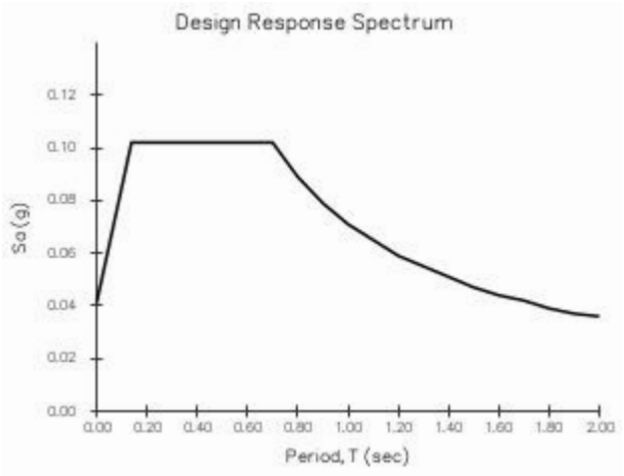
Report Title	Inland Bays Regional Wastewater Facility Wed February 7, 2018 18:25:39 UTC
Building Code Reference Document	2012/2015 International Building Code (which utilizes USGS hazard data available in 2008)
Site Coordinates	38.63664°N, 75.2323°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

USGS–Provided Output

S_S =	0.096 g	S_{MS} =	0.153 g	S_{DS} =	0.102 g
S_1 =	0.044 g	S_{M1} =	0.107 g	S_{D1} =	0.071 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied, as to the accuracy of the data contained therein. This tool is not a substitute for technical subject-matter knowledge.

Design Maps Detailed Report

2012/2015 International Building Code (38.63664°N, 75.2323°W)

Site Class D – "Stiff Soil", Risk Category I/II/III

Section 1613.3.1 — Mapped acceleration parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2012/2015 International Building Code are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 1613.3.3.

From Figure 1613.3.1(1) [1]	S_S = 0.096 g
From Figure 1613.3.1(2) [2]	S_1 = 0.044 g

Section 1613.3.2 — Site class definitions

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Section 1613.

2010 ASCE-7 Standard – Table 20.3-1
SITE CLASS DEFINITIONS

Site Class	$\overline{v}_s$	$\overline{N}$ or $\overline{N}_{ch}$	$\overline{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index PI > 20, • Moisture content w ≥ 40%, and • Undrained shear strength $\overline{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 1613.3.3 — Site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters

TABLE 1613.3.3(1)
VALUES OF SITE COEFFICIENT F_a

Site Class	Mapped Spectral Response Acceleration at Short Period				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = D and S_s = 0.096 g, F_a = 1.600

TABLE 1613.3.3(2)
VALUES OF SITE COEFFICIENT F_v

Site Class	Mapped Spectral Response Acceleration at 1–s Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = D and S_1 = 0.044 g, F_v = 2.400

Equation (16-37): $S_{MS} = F_a S_S = 1.600 \times 0.096 = 0.153$ g

Equation (16-38): $S_{M1} = F_v S_1 = 2.400 \times 0.044 = 0.107$ g

Section 1613.3.4 — Design spectral response acceleration parameters

Equation (16-39): $S_{DS} = ⅔ S_{MS} = ⅔ \times 0.153 = 0.102$ g

Equation (16-40): $S_{D1} = ⅔ S_{M1} = ⅔ \times 0.107 = 0.071$ g

Section 1613.3.5 — Determination of seismic design category

TABLE 1613.3.5(1)
SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD (0.2 second) RESPONSE ACCELERATION

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 0.102 g, Seismic Design Category = A

TABLE 1613.3.5(2)
SEISMIC DESIGN CATEGORY BASED ON 1-SECOND PERIOD RESPONSE ACCELERATION

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067g$	A	A	A
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.071 g, Seismic Design Category = B

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 1613.3.5(1) or 1613.3.5(2)" = B

Note: See Section 1613.3.5.1 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 1613.3.1(1)*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(1).pdf
2. *Figure 1613.3.1(2)*: https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(2).pdf

APPENDIX D

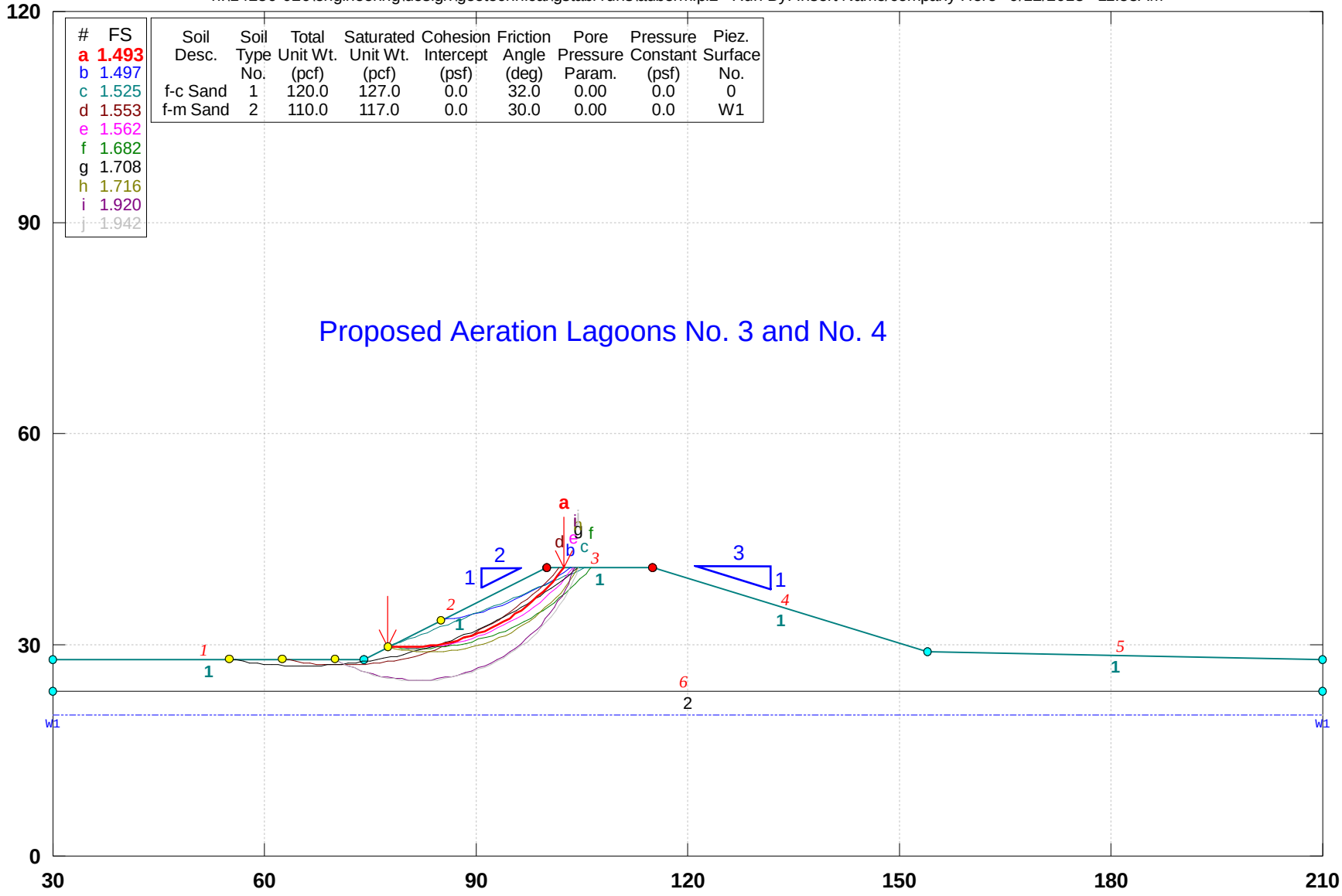
STABILITY ANALYSIS

IBRWF berm

n:\14256-026\engineering\design\geotechnical\gstabl runs\adberm.pl2 Run By: Insert Name/company Here 9/12/2018 11:53AM

#	FS
a	1.493
b	1.497
c	1.525
d	1.553
e	1.562
f	1.682
g	1.708
h	1.716
i	1.920
j	1.942

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
f-c Sand	1	120.0	127.0	0.0	32.0	0.00	0.0	0
f-m Sand	2	110.0	117.0	0.0	30.0	0.00	0.0	W1



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Safety Factors Are Calculated By The Modified Bishop Method

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