CITY OF NORFOLK DEPARTMENT OF UTILITIES
DESIGN AND CONSTRUCTION STANDARDS
Appendix H - Standard Instrumentation, SCADA and VFD Specifications

July 2025

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SECTION 00 01 10

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STANDARD INSTRUMENTATION, SCADA AND VFD SPECIFICATIONS

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SECTION 26 29 23

LOW VOLTAGE VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, connect, test and place in satisfactory operating condition all variable frequency drives (VFDs) as specified herein and indicated on the Drawings.

B. The Contractor is responsible for coordinating with the driven equipment manufacturer and the VFD manufacturer to ensure that the VFD is sized properly to meet all of the requirements herein. This includes, but is not limited to, accounting for motor RPM and variable or constant torque applications. The Contractor is responsible for including any costs related to equipment upsizing, conduit and wire upsizing, etc. that results from selecting equipment with a higher full load amp rating than was specified or used as the basis for design.

C. The variable frequency drives shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

1.02 CODES AND STANDARDS

A. VFDs shall be designed, manufactured, and/or listed to the following standards as applicable:

1. NEMA 250 – Enclosure for Electrical Equipment
2. IEEE 519 – Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
3. NEMA ICS 7 – Adjustable-Speed Drives
4. NEMA ICS 61800-2 – Rating Specifications for Low Voltage Adjustable Frequency AC Power Drive Systems
5. UL 508A – Standard for Industrial Control Panels
6. UL 508C – Standard for Power Conversion Equipment

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1.03 DEFINITIONS

A. The following definitions are provided for clarity with regard to the language used in this Specification:

7. Variable Frequency Drive (VFD) – The complete custom-engineered VFD as packaged within an overall enclosure, including the VFD unit and all other components within that enclosure as specified herein.

8. VFD Unit – The solid-state power electronic device or devices within the VFD.

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in General Conditions and Section 01 30 00 – Submittal Procedures, the Contractor shall obtain from the equipment manufacturer and submit the following:

9. Shop Drawings

10. Operation and Maintenance Manuals

11. Spare Parts List

12. Reports of Certified Shop and Field Tests

13. Manufacturer's Field Start-up Report

14. Manufacturer's Representative's Installation Certification

1.05 PRE-EQUIPMENT-SELECTION HARMONIC STUDY

D. A comprehensive pre-equipment-selection harmonic study shall be prepared by the Contractor. The results of this pre-equipment selection study shall be submitted to the Engineer as part of the submittals specified herein. Should this study indicate the need for additional tuned filters, line reactors, isolation transformers, or other harmonic distortion suppression equipment, these shall be supplied and included in the Bid. Indicate the location of the harmonic suppression equipment in the submittal data. Location is subject to acceptance by the Engineer.

E. The harmonic distortion values resulting from operation of all or any variable frequency drive-driven motor-load combinations operating at full load shall be as defined in latest edition of IEEE Standard 519.

F. System single line diagrams and field access to the plant site will be provided to the Contractor for the purpose of providing this study. Contractor shall obtain from others other information that may be necessary to perform this study. Input data and other pertinent information used in harmonic study shall be coordinated by the Contractor with the following:

15. Input data/information/results of the short circuit fault analysis specified herein.

16. Electrical system configuration and electrical equipment shop drawing submittal data including, but not being limited to new non-linear loads, new linear loads, and new capacitors.

1.06 SHOP DRAWINGS

G. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

H. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

I. Shop drawings **for each VFD** shall include but not be limited to:

17. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this Specification Section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

18. Complete bill of material and catalog data sheets for all equipment and devices comprising the VFD.

19. Product data sheets for **all** system components, including but not limited to:

    a. VFD units

    b. RVSS units and motor overloads

    c. Harmonic correction devices and/or equipment, e.g. line reactors, passive filters, and 18-pulse phase-shifting transformers

    d. Output reactors and/or output filters

    e. Pilot lights and pilot devices

    f. Control and timing relays

g. Enclosure fans

g. Contactors

h. Power supplies

i. Control power transformers

j. Current transformers

k. Potential transformers

l. Circuit breakers and/or motor circuit protectors

m. Fuses

n. Terminal blocks (power, control, and shorting)

o. Surge protective devices

4. Layout drawings of the VFD that include:

p. All cabinet or enclosure dimensions, access details, and weights.

q. Required clearances around the enclosure, e.g. ventilation.

r. Conduit entry areas and/or stub-up locations.

s. Nameplate sizes, colors, and locations.

t. Physical arrangement of door mounted devices located on the variable frequency drive enclosure.

u. Physical arrangement of **all** interior components, including DIN-rail-mounted devices.

General "catalog data sheet" layout drawings which are not specific to the systems specified herein are not acceptable.

5. Custom schematic and interconnection wiring diagrams of all electrical work, including but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, terminal blocks and identification numbers, wire numbers, and other equipment comprising the complete system.

a. These drawings shall be circuit specific for each motor-load combination (e.g. Blended Sludge Transfer Pumps, WAS Storage Aeration Blower, GBT

Feed Pumps, etc.). Specific equipment names consistent with the Drawings shall appear on each respective diagram.

b. Indicate all devices, regardless of their physical location, on the schematic diagrams.

v. Electrical ratings of all equipment and devices shall be clearly indicated on the schematic diagrams.

Standard schematics and wiring diagrams that are not custom created by the manufacturer for the variable frequency drives for this project are not acceptable.

6. Confirmation of spare parts requirements as specified herein.

20. Table listing all motor loads connected to the VFD. Table shall include the full load amps of the APPROVED motors. Final approval of VFD shop drawings cannot be given until all motor loads for each VFD have been reviewed, approved, and shown in this table.

D. The shop drawing information shall be completed and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are to provide are acceptable and shall be submitted.

1.07 OPERATION AND MAINTENANCE MANUALS

J. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions, Section 01 30 00 – Submittal Procedures and Section 46 00 00 – Equipment General Provisions.

K. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each VFD. These final drawings be included in the O&M manuals and an additional copy that is plastic laminated and securely placed inside each VFD.

L. The O&M manual shall include the “as-commissioned” parameters of each VFD in both print and digital formats.

M. If the VFDs require computer software or configuration, the O&M manual shall include copies of all programming guides/manuals.

1.08 SPARE PARTS

A. The VFDs and accessories shall be furnished with all spare parts as recommended by the equipment manufacturer. In addition to the manufacturer recommended spare parts, the Contractor shall furnish the following spare parts:

21. Two (2) sets of fuses for each size and type of fuse provided.

22. One (1) HMI per type of HMI provided.

23. One (1) set of enclosure air filters for each VFD.

24. For each VFD unit **without** field-replaceable internals, furnish one (1) spare VFD unit per size provided.

25. For each VFD unit **with** field-replaceable internals, furnish one (1) fully functional main control circuit board per VFD unit size provided.

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

N. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the Work, at which time they shall be delivered to the Owner.

O. Spare parts lists included with the shop drawing submittal shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

P. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.09 WARRANTY

A. Contractor shall warrant that the material and workmanship of all components and the operation of the VFDs and auxiliary equipment is in accordance with the latest design practices and meets the requirements of this Specification.

B. Warranty shall include, but not be limited to the following:

26. Replace components found to be faulty and make changes in equipment arrangement or make adjustments necessary to meet the equipment or functional requirements or this Specification.

27. System rewiring and component substitution/rebuild.

28. All accessories and appurtenances provided by the VFD manufacturer.

C. Warranty shall be in effect for a period of 24 months following final acceptance of each VFD.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

Q. The equipment covered by this Specification is intended to be equipment of proven performance. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

R. The Contractor shall obtain the VFDs from one manufacturer who shall also manufacture and assemble the enclosure and major equipment components including, but not limited to the VFD unit and bypass starters. The manufacturer shall have five years minimum of experience in the manufacture of similar units and shall have a general distribution to the electrical trade. **Subcontracting of wiring and/or third-party assembly is not acceptable.**

S. The VFDs shall be manufactured by Eaton, the Square D Company, Rockwell Automation (Allen-Bradley),or Toshiba.

T. The VFD manufacturer shall be responsible for the successful application and operation of the entire drive and control system serving the motor and driven equipment. This includes the responsibility for obtaining all load, torque, speed and performance requirements from the appropriate sources and integrating these into a VFD that fulfills the requirements of this Specification.

2.02 VFD SYSTEMS

A. Operating Conditions

1. The following operating conditions are applicable for all equipment of this Specification.

   w. Humidity: 0-95%.

   x. Ambient Temperature: 0 degrees Celsius to plus 40 degrees Celsius.

   y. Altitude: up to 3,300 feet

B. Basic Design and Performance

29. Each VFD shall be a complete alternating current electric drive system including all hardware and software necessary to accomplish variable speed operation of a motor and load combination. VFDs shall be provided in accordance with the requirements indicated on the Drawings and as described in these Specifications.

30. Each VFD shall be suitable for operation as part of a 480 VAC, 3-phase, 60 Hertz power distribution system. The complete VFD system shall have a minimum short circuit current rating of 65,000 amperes symmetrical at rated voltage.

3. **The Contractor** is fully responsible for the review of the full Contract Documents to determine specified motor speed, horsepower and full load ampere requirements for each motor-driven load. In addition, the Contractor shall size and select the VFD and components as follows:

   z. Each VFD shall provide, continuously, motor load current equal to 100% of the direct on-line motor nameplate full load current.

   aa. Each VFD shall be selected for Variable Torque (Normal Duty) or Constant Torque (Heavy Duty) based on its respective load type served as shown in the Load Type tables below.

Variable Torque (Normal Duty) Load Types	**Constant Torque (Heavy Duty) Load Types**
Vertical Turbine Pumps OR [Not Included Under this Contract]	Rotary Lobe Pumps OR [Not Included Under this Contract]
Horizontal Non-Clog Pumps	Progressive Cavity Pumps
Horizontal Self-Priming Centrifugal Pumps	Horizontal Centrifugal Chopper Pumps
Submersible Non-Clog Pumps	Positive Displacement Blower Packages
Vertical Non-Clog Pumps	Dewatered Sludge Screw Conveyors
Vertical Turbine Mixers	Screw Pumps
Submersible Propeller (Window) Pumps	[etc]
[etc]	-

   bb. The Load Type tables above are intended to exhaustively cover all possible equipment controlled by VFDs to be provided under Division 26 for this Contract. If a piece of equipment is found that is not explicitly listed in these tables, this discrepancy shall be brought to the attention of the Engineer (in writing) immediately for resolution **prior to submitting the Bid for this Contract.**

4. Each VFD shall be suitable to operate, at times, on a limited power source engine-generator set. The VFD shall be provided with equipment and devices to prevent waveform distortion as specified herein.

31. Each VFD shall be provided with control and sequence logic as specified herein and indicated on the Drawings. Control and sequence logic shall be designed such that the motor-load combination can be operated in the manual mode upon control and sequence logic failure, including all necessary personnel and equipment safety interlocks. Each VFD shall be designed such that specific control and protection functions can be attained through simple programming by either factory engineers or Owner's trained operating personnel.

7. Unless otherwise accepted in writing by the Engineer, VFDs shall be provided with output reactors or filters to prevent elevated voltage levels at the motor terminals that exceed the ratings of the inverter duty rated motor winding insulation.

   The Contractor is responsible for providing the VFD manufacturer with estimated and field-verified cable lengths between each VFD and its respective motor. The VFD manufacturer shall select and size the output reactors or filters based on the cable lengths provided by the Contractor. Any change in output filter or reactor selection and/or size from the Bid shall be immediately brought to the attention of the Engineer in writing for resolution.

   The output filters or reactors shall be as manufactured by TCI, MTE Corporation, Mirus International, or engineer approved equal.

32. Motor control circuits shall be wired in accordance with the requirements specified herein and/or indicated on the Drawings.

C. Components

33. Each VFD shall contain the number of VFD units, reduced voltage solid state (RVSS) bypass starters, and full voltage non-reversing (FVNR) bypass starters as shown on the Drawings and required for the applications. RVSS and FVNR bypass starters shall be as specified [elsewhere in this Specification] [in Section 26 29 13.16 – Low-Voltage Enclosed Motor Controllers-Reduced Voltage].

    a. Each bypass starter shall be incorporated into the VFD by the Manufacturer such that the VFD is still installed as a single overall lineup. This lineup shall allow qualified plant personnel to safely test, maintain, and work on the VFD or the bypass starter while the motor is running; that is, plant personnel should be able to safely work on the bypass starter while the load is running via the VFD and safely work on the VFD while the load is running via the bypass starter.

34. Each VFD shall contain and/or be furnished with the harmonic correction equipment as shown on the Drawings and required for the applications. Harmonic correction equipment shall be as specified elsewhere in this Specification.

35. Each VFD shall contain the number of auxiliary contacts, control power transformer(s), pilot devices and indicating lights, control relays, elapsed time meters, and other devices as specified herein, shown on the Drawings and req11uired for the applications. The following components shall meet the requirements of Section 40 78 00 Panel Mounted Instruments:

    cc. Pilot devices (switches, indicating lights, etc.)

    dd. Relays and timers

c. Terminal blocks

5. Each VFD shall be provided with full-capacity-rated contactors as shown on the Drawings. Contactors shall be as specified [elsewhere in this specification][in 26 29 13.16 – Low Voltage Enclosed Motor Controllers – Reduced Voltage] and shall be electrically and mechanically interlocked as shown on the Drawings.

36. Power terminal blocks for VFD output to the motor shall be fixed-mounted to a backplane or the enclosure. Mounting the terminal blocks on DIN rails is not acceptable.

37. Electrical bus, including ground bus, shall be tin-plated copper. Power and control wiring shall be copper, color coded and identified in accordance with these Specifications.

38. Each VFD shall be of modular construction allowing normal maintenance and repair to be done with ordinary hand tools. Design and install power electronic component assemblies so that, where practicable, components can be individually removed and replaced.

39. Auxiliaries, including fans, that are required for rated load operation at maximum ambient temperature, shall be 100% redundant. New and unused spare replacement fan(s) or air conditioning unit(s), shipped in original carton, may be provided in lieu of 100% redundant auxiliaries if accepted in writing by the Engineer.

40. Circuit boards and electrical components shall meet the corrosion protection requirements specified in these Specifications. Varnished or epoxy encapsulated circuit boards and tropicalized contactors suitable for corrosive environments shall be furnished.

41. Motor Circuit Protectors

ee. [Where indicated on the Drawings,] Each VFD shall be protected by a motor circuit protector (MCP).

ff. Motor circuit protectors shall be completely enclosed molded case devices with a current sensing coil in each of the 3 poles and have a magnetic trip adjustment located on the front. The motor circuit protector shall be manually operable. The protector shall be designed to meet the NEC requirement concerning motor full load and locked-rotor current. Ampere ratings shall be clearly visible. Contacts shall be of non-welding silver alloy. Arc extinction must be accomplished by means of arc chutes, consisting of metal grids mounted in an insulating support.

gg. The motor circuit protector shall be operated by a toggle type handle and shall have a quick make, quick break overcenter switching mechanism that

is mechanically trip free from the handle, so that the contacts cannot be held closed against short circuits and abnormal currents. Tripping shall be clearly indicated by the handle automatically assuming a position midway between the manual ON and OFF positions. All latch surfaces shall be ground and polished. All poles shall be so constructed that they open, close, and trip simultaneously.

d. Each pole of these motor circuit protectors shall provide instantaneous short circuit protection by means of an adjustable magnetic only element.

hh. Motor circuit protector ratings, modifications, etc., shall be as specified herein and as required for the VFD and motor load combination. MCP ratings shall be determined by the VFD manufacturer.

11. Circuit Breakers

ii. [Where indicated on the Drawings,] Each VFD shall be protected by a circuit breaker.

jj. Unless otherwise indicated, circuit breakers shall be manually operable and shall provide [thermal-magnetic, inverse-time-limit overload, and instantaneous short-circuit protection.][the protective features shown on the Drawings.]

kk. Circuit breakers shall be molded case type, rated 480 VAC, 3 pole and have 100 ampere or larger frames. The interrupting rating shall match that of the VFD short circuit rating at 480V.

ll. Overload protection shall be provided on all poles with trip settings as indicated on the Drawings. Breakers of 225-ampere frames and larger shall have interchangeable [thermal-magnetic][solid-state electronic] trip units.

mm. Where indicated on the Drawings, shunt trip devices shall be provided to trip a circuit from a remote location by means of a trip coil energized from a separate circuit. A 120V shunt trip shall be capable of operating 55% or more of rated voltage. All other shunt trips shall be capable of operating at 75% or more of rated voltage.

12. Where indicated on the Drawings, VFDs shall be provided with surge protective devices that meet the requirements of Section 26 43 13 – Surge Protection Devices.

13. Motor Protection Relays

a. Where indicated on the Drawings, VFDs shall be furnished with motor management and protection relays as specified elsewhere in this Specification.

D. Controls

42. Each VFD shall be provided with automatic and manual controls as shown on the Drawings and as required to comply with all Specifications. Controls and indicators to accomplish operation and maintenance shall be located on the variable frequency drive equipment assembly as specified herein and indicated on the Drawings.

43. The Elementary Control Schematics shown on the Drawings are **representative of design intent only.** The manufacturer shall be responsible for providing all additional components, controls, and internal wiring necessary to meet the design intent.

44. VFD circuitry shall be designed such that the enclosure cooling fans only run when the VFD unit is producing output power. Designs that allow the enclosure cooling fans to run continuously when the VFD unit is energized but not producing output power are not acceptable. Fans that are used exclusively to provide cooling for the VFD unit (and not the overall enclosure) are permitted to run continuously if required by the VFD manufacturer's design standards/practices.

E. Enclosures

1. Equipment within the VFD enclosure shall be arranged so that it does not interfere with the entry of conduits and cables into the enclosure.

   Unless otherwise indicated on the Drawings, VFDs in non-hazardous locations, shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

Area Designation	Enclosure Type and Material
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-Process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

2. VFDs shall not be installed in hazardous locations.

45. NEMA 1 and NEMA 12 VFD enclosures shall be force ventilated with front accessibility and the following:

    a. Enclosures shall be provided with washable enclosure air intake filters that can be replaced while the enclosure door remains closed.

c. Enclosures shall be designed for bottom or top entry of conduits and cables as required.

nn. Enclosures shall be finished in ANSI-61 gray enamel or in a color to match the complete line-up of equipment as indicated on the Drawings and accepted by the Engineer.

4. NEMA 4X VFD enclosures shall be air conditioned, dead-front, with front accessibility and the following:

oo. The air conditioning system shall utilize a heat-exchange method that allows for cooling of the enclosure interior without circulating outside air through the enclosure.

pp. Enclosures shall be furnished with tubular type enclosure space heaters. Space heaters shall be rated at 500V or 250V and operated at 240V or 120V, respectively.

qq. VFDs shall be furnished with an additional control power transformer sized to provide power for the air conditioning system and enclosure space heater.

rr. VFDs shall be furnished with a tamper-resistant hinged cover with a clear polycarbonate viewing window over the door-mounted pilot devices.

ss. VFDs shall be designed for bottom entry of cables only.

5. Each VFD shall be designed such that rear access to the enclosure is not required for operations, maintenance, or repair tasks.

6. The Contractor shall reference the table listed below for maximum dimensions of the VFDs.

10HP VFD package	48” X 36” X 12”
25HP VFD package	48” X 36” X 12”
50HP VFD package	60” X 36” X 16”
100HP VFD package	90” X 36” X 20”
150HP VFD package with Soft Start Bypass	90” X 72” X 24”
200HP VFD package with Soft Start Bypass	90” X 72” X 24”
250HP VFD package with Soft Start Bypass	90” X 72” X 24”
300HP VFD package with Soft Start Bypass	90” X 120” X 24”
400HP VFD package with Soft Start Bypass	90” X 120” X 24”

7. Integrating VFDs into a motor control center assembly is not permitted unless specifically shown as integrated on the Drawings.

46. Enclosure doors shall have full length piano type hinges and shall be braced to prevent sag when fully open.

47. Each VFD enclosure shall be supplied with an industrial, heavy-duty flange-mount handle mechanism for the operation of the VFDs disconnecting means as follows:

    tt. The mechanism shall be engaged with the disconnect device at all times as an integral part of the unit regardless of the unit door position.

    uu. The operator handle shall have an up-down motion with the down position as off. The ON-OFF condition of the disconnecting means shall be permanently marked on the handle operator.

    vv. It shall be possible to lock the handle in the "OFF" position with up to three (3) 3/8-inch diameter shackle padlocks and in the "ON" position with one (1) 3/8-inch diameter shackle padlock.

    ww. The operator handle shall be mechanically interlocked such that the disconnecting means cannot be closed with the enclosure door open, nor can the enclosure door be opened when the disconnecting means is closed. A defeater mechanism shall be provided so that qualified personnel can bypass these interlocks for maintenance and testing purposes. The defeater

mechanism shall allow the enclosure door to be opened without interrupting the operation of the VFD.

F. Nameplates and Legend Plates

48. Provide engraved plastic nameplates and legend plates to identify each VFD and associated door mounted devices and internal components.

49. Equipment names and/or numbers and device identification text shown on the Drawings shall be used as the basis to engrave the nameplates and legend plates. Where the equipment identification text would exceed the capacity of the VFD manufacturer's standard nameplate/legend plate size, the manufacturer shall provide larger nameplates and/or additional nameplates as necessary. Abbreviating equipment names/numbers and device identification text is not acceptable.

50. Control components mounted as part of the assembly, such as fuse blocks, control relays, pushbuttons, switches, and similar devices, shall be suitably marked with identification corresponding to appropriate designations on the manufacturer's wiring diagrams.

2.03 VFD UNITS

U. The VFD unit shall be the Eaton DG1/SVX series, Square D Altivar 600 Series, Allen-Bradley Power-Flex 750 series, ABB ACS800 series, or Toshiba AS3/W7 series.

V. Basic Design and Performance

51. Each VFD unit shall be of adjustable frequency, adjustable voltage, pulse width modulated (PWM) design. The units shall be microprocessor controlled, fully digitally programmable, and capable of precise and repeatable speed regulation of three phase 480 VAC NEMA Design A or B induction motors. Units for other than NEMA Design A or B induction motors (e.g. NEMA Design C) shall be coordinated with the requirements of that respective load.

52. Each VFD unit shall consist of a semiconductor rectifier system, direct current link, and pulse width modulated inverter. The inverter shall invert the direct current voltage into an alternating current voltage at a frequency which shall be proportional to the desired speed. This alternating current voltage and frequency shall both vary simultaneously at a constant "Volts-Per-Hertz" ratio to operate the motor at the desired speed.

53. Each VFD unit shall operate the motor and produce full rated nameplate horsepower at the motor output shaft without exceeding motor nameplate full load current and with the motor not exceeding rated total temperature not including the additional temperature increment that constitutes the motor service factor. Motor shall retain its service factor when operated by the variable frequency drive.

6. The overall efficiency of each VFD unit shall be a minimum of 95% when operating the specified motor-load combination at rated voltage, frequency, and current.

54. Each VFD unit shall provide smooth, stepless changes in motor speed and acceleration over the entire operating speed range from minimum to maximum speed. The VFD unit shall be provided with adjustable maximum and minimum frequency limits.

55. Each VFD unit shall maintain a desired output frequency (setpoint) with a steady state accuracy of 0.5% of rated frequency of 60 Hertz for a 24-hour period and a repeatability of 0.1% of rated frequency of 60 Hertz.

56. Each VFD unit shall be capable of operating the specified load continuously at any speed within the operating speed range of 10% to 100% of rated speed. The minimum and maximum continuous operating speeds shall each be adjustable within this speed range. The variable frequency drive shall provide for field adjustment of these setpoints.

57. Each VFD unit shall be capable of controlled linear acceleration and deceleration. Each VFD unit shall be capable of ramping the speed of the motor-load combination from the minimum selected operating speed to the maximum selected operating speed in a minimum of 30 seconds. Each VFD unit shall have two (2) field-adjustable speed setpoints for the variable frequency drive to skip equipment resonant frequencies. The acceleration and deceleration time limits shall be field adjustable to values up to 120 seconds.

58. Voltage or current unbalance between phases of the VFD unit output voltage shall not exceed 3% of the instantaneous values. The VFD unit shall continuously monitor the output voltages and generate an alarm condition when the unbalance exceeds 3%. The system shall detect and generate a separate alarm for loss of any output phase voltage (single phasing). Phase unbalance shall be as defined by NEMA Standard MG-1.

59. Each VFD unit shall operate continuously without interruption of service or damage to equipment during transient input voltage variations of plus or minus 10% for a duration of 15 cycles. Unacceptable voltage fluctuations on the supply bus shall cause under or overvoltage protection to trip and remove supply voltage from the drive system. VFD unit output voltage regulation shall be plus or minus 2%.

C. Features and Characteristics

1. Each VFD unit shall be furnished with a Human Machine Interface (HMI) to provide controls and indication to accomplish maintenance and operational functions as specified herein and shown on the Drawings. The HMI shall be password protected after startup to prevent unauthorized personnel from making changes. The HMI shall at minimum provide indication of the following:

xx. Input Voltage

yy. Output Voltage

zz. Output Current

aaa. Output Frequency

bbb. Output Speed from 0-100%

ccc. Alarm Read-out

3. Each VFD unit shall provide a 4-20 mADC output signal that is proportional to the drive output frequency for use as speed feedback and remote speed indication.

60. Each VFD unit shall accept a 4-20 mADC input command signal to control the output frequency in the automatic and/or manual control modes as specified herein or indicated on the Drawings. The system shall accept the input increase/decrease command with a resolution that permits incremental changes in speed equal to or less than 0.1% of rated speed.

    a. Where shown on the Drawings, VFD units shall also accept the input from speed potentiometer(s) for manual speed control. Each VFD unit shall be capable of automatically switching between the input command signals as shown on the Drawings.

61. When operating in the automatic mode, the VFD unit shall shut down during a power outage or sustained undervoltage event. A sustained undervoltage event is defined as voltage that is less 75% of nominal, for more than 0.5 seconds. Upon restoration of normal power and after an adjustable time delay (0-2 minutes; motor has coasted to zero speed and there is no backspin), the VFD unit shall automatically restart and then ramp up to speed as required by the control system. Personnel shall not be required to reset the system manually after a shutdown caused by a power outage or sustained undervoltage event.

62. Each VFD unit shall have a multiple attempt restart feature.

63. Each VFD unit shall have an automatic current limit feature to control motor currents during startup and provide a "soft start" torque profile for the motor-load combination. The VFD unit shall also limit current due to motor winding or motor lead phase-to-phase short circuit or phase-to-ground short circuit. The current limit protection setting shall be field adjustable.

64. Each VFD unit shall be furnished with programmable electronic overload and torque limits.

8. Each VFD unit shall have an automatic trip feature which will remove the drive output from the motor and allow it to decelerate safely. This automatic system shall lock-out the VFD unit and indicate the fault only upon the following conditions:

   ddd. Output voltage unbalance (trip threshold field set).

   eee. Open phase.

   fff. Motor overload.

   ggg. Motor stator winding fault (phase-to-ground, phase-to-phase).

   hhh. Unacceptable voltage variation.

   iii. High variable frequency drive equipment temperature.

   jjj. VFD failure as determined by the manufacturer.

   kkk. Component failure.

   lll. Overcurrent.

9. Provide each VFD unit with transmitted and received radio interference protection. In addition, provide protection against starting a rotating motor, both directions (coasting to zero speed and backspin). In the event that a motor automatic restart feature (catch the motor "on-the-fly") is provided in the VFD unit as standard, this feature shall be capable of being disabled.

10. Each VFD unit shall include on-line diagnostics, with an automatic self-check feature that will detect a variable frequency drive failure which in turn affects motor operation and generates an alarm contact output rated for 125 VDC suitable for interfacing with the control system.

    mmm. Diagnostics shall operate a visual alarm indicator that is visible on the variable frequency drive equipment cabinets without opening the cabinet doors.

    nnn. Diagnostics shall provide an easily readable output that can be used to isolate a failure.

    ooo. Provide an event and diagnostic recorder to printout in narrative English of the specific fault(s) and the sequence in which the faults occurred. An indication of the "First Out" failure is a minimum for fault sequence detection.

    ppp. Provide a normally open dry contact for each alarm function to enable remote indication.

11. Each VFD unit shall communicate the following parameters to the Pump Station PLC via [Ethernet/IP] [Modbus RTU] protocol. Provide any necessary hardware gateways to provide this communication capability. The following parameters, at a minimum, shall be communicated:

    qqq. Current (all phases)

    rrr. Voltage (all phases)

    sss. KW, KVAR, KVA

    ttt. Power Factor

12. Each VFD unit shall be provided with input/output (I/O) expansion cards as necessary to facilitate connection of all I/O specified herein and shown on the Drawings.

2.04 HARMONIC CORRECTION

A. Harmonic correction devices for each VFD shall be as specified herein and located as shown on the Drawings.

B. Input Line Reactors

1. 6-pulse VFD units shall be provided with input line reactor and/or integral DC link reactor. Total reactor impedance shall be a minimum of 3% and shall not exceed 5%.

C. Passive Filters

65. Where indicated on the Drawings or where additional harmonic correction is required, 6-pulse VFD units shall be provided with a passive harmonic filter in addition to the integral DC link reactor specified above (if present.)

66. Passive harmonic filters shall be sized to attenuate harmonics resulting from operation of the VFD-driven motor load to no more than 5% THID when operating at full load, and no more than 8% THID when operating at 30% of full load. The filter shall be equipped with power contactors configured to remove the capacitors from the circuit when the VFD-driven loads are not in operation. The harmonic filters shall be as manufactured by TCI, MTE Corporation, Mirus International, or Engineer approved equal.

67. Passive filters shall be integrated into the VFD unless accepted in writing by the Engineer or shown as separately mounted from the VFD on the Drawings.

D. 18-Pulse and Active Front End (AFE) VFDs

1. Where indicated on the Drawings, VFDs shall consist of either:

uuu. an 18-pulse VFD unit with an 18-pulse phase-shifting transformer, or

vvv. a VFD unit with an IGBT-based active front end (AFE).

2. AFE VFDs may be provided in lieu of 18-pulse VFDs (or vice-versa) **if accepted in writing by the Engineer.**

PART 3 – EXECUTION

3.01 INSTALLATION

W. The VFDs shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.

X. Install VFDs to allow complete door swing required for component removal.

3.02 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions.. The following tests are required:

1. Witnessed Shop Tests

www. None required.

xxx. The VFDs specified in this Section shall be witness shop tested and inspected in accordance with the equipment manufacturer's standard procedures and the certified shop testing described below. The testing and inspection procedures shall demonstrate that the equipment tested conforms to the requirements specified, all other applicable requirements, and shall be approved by the Engineer. At least 10 days' notice shall be given the Engineer prior to such tests and inspection dates.

2. Certified Shop Tests and Reports

yyy. Submit description of proposed testing methods, procedures, and apparatus.

zzz. Factory test the complete VFD in accordance with IEEE and NEMA standards.

aaaa. Submit factory bench-test data to indicate that the manufacturer's proposed equipment has been tested in the specified arrangement and found to achieve specified accuracy.

3. Field Tests

bbbb. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 01, and NETA acceptance testing .

cccc. The Contractor shall field measure actual harmonic distortion with tests performed by an independent testing agency acceptable to the Owner after satisfactory full-load operation. The Contractor shall provide the harmonic distortion reports with the O&M Manual.

dddd. Unless otherwise indicated on the Drawings, the harmonic distortion measurements shall be made at each load center where VFDs are present.

eeee. Harmonic distortion measurements shall be made after VFD installation. One set of measurements shall be made with the VFD loads inactive, and one set of measurements shall be made with the VFD loads running at design capacity.

C. Acceptance of a shop test does not relieve Contractor from requirements to meet field installation tests under specified operating conditions, nor does the inspection relieve the Contractor of responsibilities.

Y. Certification on materials and records of shop tests necessary for the inspector to verify that the requirements of the Specifications are met, shall be made available to the inspector.

Z. Submit signed and dated certification that all of the factory inspection and testing procedures described herein have been successfully performed by the Contractor prior to shipment.

3.03 SERVICES OF A MANUFACTURER'S REPRESENTATIVE

AA. The Contractor shall provide the services of a qualified manufacturer's factory-trained technical representative who shall adequately supervise the installation and startup of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.

BB. The manufacturer's technical representative shall perform all startup and field acceptance testing as specified herein.

CC. The Contractor shall provide training for the Owner's personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct Owner's personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for two (2) sessions of four (4) hours each. Training shall not take place until after the VFDs have been installed and tested. Training shall be conducted at times coordinated with the Owner.

D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

68. One (1) trip of one (1) working day during installation of the motor controllers.

69. One (1) trip of one (1) working day to perform startup and field acceptance testing of the motor controllers.

70. One (1) trip of one (1) working day to perform training as specified herein.

71. One (1) trip of one (1) working day two (2) months before the expiration of the warranty to identify any issues to be corrected under warranty.

E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

3.04 PAINTING

A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

END OF SECTION

SECTION 40 61 13
PROCESS CONTROL SYSTEM GENERAL PROVISIONS

PART 1 – GENERAL

1.01 SCOPE

DD. The Contractor shall provide, through the services of an instrumentation and control system subcontractor, components, system installation services, as well as required and specified ancillary services in connection with the Instrumentation, Control and Information System.

EE. The System includes materials, labor, tools, fees, charges, and documentation required to furnish, install, test and place in operation a complete and operable instrumentation, control and information system.

FF. The system shall include measuring elements, signal converters, transmitters, local control panels, digital hardware and software, remote telemetry units, signal and data transmission systems, interconnecting wiring, and pertinent accessories.

GG. The scope of the work to be performed under this Division includes but is not limited to the following:

72. The Contractor shall retain overall responsibility for the instrumentation and control system as specified herein.

73. Furnish and install process instrumentation and associated taps and supports as scheduled or shown on the Drawings, unless otherwise noted or supplied by equipment vendors.

74. Furnish and install local control panels, field panels and associated cabinets and panels as shown on the Drawings and as specified in Sections 40 60 00 through 40 79 99, inclusive and where included.

75. Furnish and install digital control system hardware and software as specified in Sections 40 60 00 through 40 79 99, inclusive and where included.

76. Final termination and testing of instrumentation and control system signal wiring and power supply wiring at equipment furnished under Sections 40 60 00 through 40 79 99, inclusive and where included.

77. Furnish, install, and terminate special cables for devices (e.g., instruments, printers, radios). Furnish and terminate control system communication network cables.

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8. Furnish and install surge protection devices for digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division, including connections to grounding system(s) provided under Division 26.

78. Coordinate grounding requirements with the electrical subcontractor for digital equipment, local control panels, remote telemetry units, and instrumentation provided under this Division. Terminate grounding system cables at equipment provided under this Division.

79. Provide system testing, calibration, training and startup services as specified herein and as required to make systems fully operational.

E. It is the intent of the Contract Documents to construct a complete and working installation. Items of equipment or materials that may reasonably be assumed as necessary to accomplish this end shall be supplied whether or not they are specifically stated herein.

1.02 RELATED ITEMS

A. Field mounted switches, torque switches, limit switches, gauges, valve and gate operator position transmitters, sump pump controls, and other instrumentation and controls furnished with mechanical or electrical equipment not listed in the instrument schedule shall be furnished, installed, tested, and calibrated as specified under other Divisions unless otherwise indicated.

1.03 GENERAL INFORMATION AND DESCRIPTION

HH. Where manufacturers are named for a particular item of equipment, it is intended as a guide to acceptable quality and performance and does not exempt such equipment from the requirements of these Specifications or Drawings.

II. In order to centralize responsibility, it is required that equipment (including field instrumentation and control system hardware and software) offered under this Division shall be furnished and installed by the instrumentation subcontractor, or under the supervision of the instrumentation subcontractor, who shall assume complete responsibility for proper operation of the instrumentation and control system equipment, including that of coordinating signals, and furnishing appurtenant equipment.

JJ. The Contractor shall retain total responsibility for the proper detailed design, fabrication, inspection, test, delivery, assembly, installation, activation, checkout, adjustment and operation of the entire instrumentation and control system as well as equipment and controls furnished under other Divisions of the Specifications. The Contractor shall be responsible for the delivery of detailed drawings, manuals and other documentation required for the complete coordination, installation, activation and operation of mechanical equipment, equipment control panels, local control panels, field instrumentation, control systems and related equipment/systems and shall provide for

the services of a qualified installation engineer to supervise activities required to place the completed facility in stable operation under full digital control.

D. The instrumentation and control system shall be capable of simultaneously implementing all real time control and information system functions, and servicing all operator service requests as specified, without degrading the data handling and processing capability of other system components.

KK. Control system inputs and outputs are listed in Section 40 61 93 – Process Control System Input/Output List. This information, together with the functional control descriptions, process and instrumentation diagrams, and electrical control schematics, describes the real time monitoring and control functions to be performed. In addition, the system shall provide various man/machine interface and data reporting functions as specified in the software sections of this Specification.

LL. The mechanical, process, and electrical drawings indicate the approximate locations of field instruments, control panels, systems and equipment as well as field mounted equipment provided by others. The instrumentation subcontractor shall examine the mechanical, process and electrical drawings to determine actual size and locations of process connections and wiring requirements for instrumentation and controls furnished under this Contract. The instrumentation subcontractor shall inspect equipment, panels, instrumentation, controls, and appurtenances, either existing or furnished on the Project to determine requirements for interfacing with the control and information system. The Contractor shall coordinate the completion of required modifications with the associated supplier of the item furnished.

MM. The instrumentation subcontractor shall review and approve the size and routing of instrumentation and control cable and conduit systems furnished by the electrical subcontractor for suitability for use with the associated cable system.

NN. The Contractor shall coordinate the efforts of each supplier to aid in interfacing systems. This effort shall include, but shall not be limited to, the distribution of approved shop drawings to the electrical subcontractor and to the instrumentation subcontractor furnishing the equipment under this Division.

OO. The Contractor shall be responsible for providing a signal transmission system free from electrical interference that would be detrimental to the proper functioning of the instrumentation and control system equipment.

PP. The Owner shall have the right of access to the subcontractor's facility and the facilities of his equipment suppliers to observe materials and parts; witness inspections, tests and work in progress; and examine applicable design documents, records, and certifications during all stages of design, fabrication, and tests. The instrumentation subcontractor and his equipment suppliers shall furnish office space, supplies, and services required for these observation activities.

K. The terms "Instrumentation," "Instrumentation and Control System," and "Instrumentation, Control and Information System" shall hereinafter be defined as equipment, labor, services, and documents necessary to meet the intent of the Specifications.

1.04 INSTRUMENTATION AND CONTROL SYSTEM SUBCONTRACTORS

QQ. Instrumentation and control system subcontractors shall be regularly engaged in the detailed design, fabrication, installation, and startup of instrumentation and control systems for water and wastewater treatment facilities, remote telemetry systems for water supply/distribution systems, and remote telemetry systems for wastewater collection systems. Instrumentation and control system subcontractors shall have a minimum of five years of such experience and shall have completed a minimum of three projects of similar type and size as that specified herein. Where specific manufacturers/models of major hardware or software products (PLC, HMI software, network, etc.) are specified to be used on this project, the instrumentation and control system subcontractor shall have completed at least one project using that specified hardware or software. As used herein, the term “completed” shall mean that a project has been brought to final completion and final payment has been made.

RR. Acceptable instrumentation and control system subcontractors shall be Systems East, Inc.; E-Merge Systems, Inc.; CEC (Wood Equipment) or SL Controls (Sherwood Logan).

1.05 DEFINITIONS

A. function of a circuit abbreviations: Specification abbreviations include the following:

80. A - Availability

81. ADC - Analog to Digital Converter

82. AI - Analog Input

83. AO - Analog Output

84. AVAIL - Available

85. BCD - Binary Coded Decimal

86. CSMA/CD - Carrier Sense Multiple Access/Collision Detect

87. CPU - Central Processing Unit

88. CRC - Cyclic Redundancy Check

89. CS - Control Strategy

11. DAC - Digital to Analog Converter

90. DBMS - Data Base Management System

91. DI - Discrete Input

92. DMA - Direct Memory Access

93. DO - Discrete Output

94. DPDT - Double Pole, Double Throw

95. DVE - Digital to Video Electronics

96. EPROM - Erasable, Programmable Read Only Memory

97. FDM - Frequency Division Multiplexing

98. FSK - Frequency Shift Keyed

99. HMI - Human Machine Interface (Software)

100. I/O - Input/Output

101. LAN - Network and Communication Equipment

102. LCD - Liquid Crystal Display

103. LDFW - Lead Follow

104. MCC - Motor Control Center

105. MTBF - Mean Time Between Failures

106. MTTR - Mean Time to Repair

107. OS - Operating System

108. PAC - Programmable Automation Controller

109. PCB - Printed Circuit Board

110. PID - Proportional Integral and Derivative Control

111. PLC - Programmable Logic Controller or Programmable Controller

112. PROM - Programmable Read Only Memory

35. RAM - Random Access Memory

113. RDY - Ready

114. RMSS - Root Mean Square Summation

115. RNG - Running

116. ROM - Read Only Memory

117. RTU - Remote Telemetry Unit

118. SPDT - Single Pole, Double Throw

119. ST/SP - Start/Stop

120. TDM - Time Division Multiplexing

121. UPS - Uninterruptible Power Supply

122. VFD - Variable Frequency Drive

B. To minimize the number of characters in words used in textual descriptions on displays, printouts and nameplates, abbreviations may be used subject to the Engineer's approval. If a specified abbreviation does not exist for a particular word, an abbreviation may be generated using the principles of masking and or vowel deletion. Masking involves retaining the first and last letters in a word and deleting one or more characters (usually vowels) from the interior of the word.

1.06 ENVIRONMENTAL CONDITIONS

SS. Instrumentation equipment and enclosures shall be suitable for ambient conditions specified. All system elements shall operate properly in the presence of telephone lines, power lines, and electrical equipment.

TT. Inside control rooms and climate-controlled electrical rooms, the temperature will normally be 20 to 25 degrees C; relative humidity 40 to 80 percent without condensation and the air will be essentially free of corrosive contaminants and moisture. Appropriate air filtering shall be provided to meet environmental conditions (e.g., dust).

UU. Other indoor areas may not be air conditioned/heated; temperatures may range between 0 and 40 degrees C with relative humidity between 40 and 95 percent.

VV. Field equipment including instrumentation and panels may be subjected to wind, rain, lightning, and corrosives in the environment, with ambient temperatures from -20 to 40 degrees C and relative humidity from 10 to 100 percent. All supports, brackets, interconnecting hardware, and fasteners shall be aluminum, type 316 stainless steel, or

metal alloy as otherwise suitable for chemical resistance within chemical feed/storage areas shown on the installation detail drawings.

PART 2 – EXECUTION

2.01 SCHEDULE OF PAYMENT

A. Payment to the Contractor for Control and Information System materials, equipment, and labor shall be in accordance with the General and Supplementary Conditions. The schedule of values submitted as required by the General and Supplementary Conditions shall reflect a breakdown of the work required for completion of the Control and Information System. The breakdown shall include sufficient detail to permit the Engineer to administer payment for the Control and Information System.

2.02 CLEANING

WW. The Contractor shall thoroughly clean soiled surfaces of installed equipment and materials.

XX. Upon completion of the instrumentation and control work, the Contractor shall remove surplus materials, rubbish, and debris that has accumulated during the construction work. The entire area shall be left neat, clean, and acceptable to the Owner.

2.03 FINAL ACCEPTANCE

A. Final acceptance of the Instrumentation, Control and Information System will be determined complete by the Engineer, and shall be based upon the following:

123. Receipt of acceptable start up completion and availability reports and other documentation as required by the Contract Documents.

124. Completion of the Availability Demonstration.

125. Completion of control system training requirements.

126. Completion of punch-list items that are significant in the opinion of the Engineer.

B. Final acceptance of the System shall mark the beginning of the warranty period.

END OF SECTION

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SECTION 40 61 15

PROCESS CONTROL SYSTEM SUBMITTALS

PART 1 – GENERAL

1.01 THE REQUIREMENT

YY. The Contractor shall submit for review complete Shop Drawings for all equipment in accordance with the General and Supplemental Conditions and Division 1 of the Specifications. All submittal material shall be complete, legible, and reproducible, and shall apply specifically to this project.

ZZ. All submittal materials shall be tailored to this project by highlighting relevant items or crossing out non-applicable items. Generic submittals without identified options will be returned the Contractor without review.

AAA. Compliance, Deviations, and Exceptions (CD&E) Letter:

1. Where a named manufacturer and product is specified and a substitution or an “or equal” product is submitted, the submittal shall be accompanied by a “Compliance, Deviations, and Exceptions (CD&E) letter.” If the required submittal is submitted without the letter, the submittal will be rejected.

2. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor, subcontractor (if applicable), and the equipment Manufacturer/Supplier. This letter shall include a copy of the Specification Section to which the submittal pertains. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in.

   ffff. The letter "C" shall be for full compliance with the requirement.

   gggg. The letter "D" shall be for a deviation from the requirement.

   hhhh. The letter "E" shall be for taking exception to a requirement.

3. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions shall not be acceptable.

4. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

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1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01 33 00 – Submittals

B. Section 40 61 13 – Process Control System General Provisions

1.03 DIGITAL HARDWARE SUBMITTALS

A. Submit system block diagram(s) showing:

127. All equipment to be provided.

128. All interconnecting cable.

129. Equipment names, manufacturer, and model numbers.

130. Equipment locations.

B. Submit information for all digital equipment including, but not limited to, the following:

131. Bill of materials with equipment names, manufacturers, complete model numbers and locations.

132. Catalog cuts, including complete part number breakdown information.

133. Complete technical, material and environmental specifications.

134. Assembly drawings.

135. Mounting requirements.

136. Color samples.

137. Nameplates.

138. Environmental requirements during storage and operation.

1.04 SOFTWARE SUBMITTALS

A. Software submittals shall include the following as a minimum:

139. Bill of materials with software names, vendors, and complete listings of included software modules.

140. Standard manufacturer's literature describing the products.

141. Description of function of software in Control and Information System.

142. Limitations or constraints of software.

143. Minimum system (processor and memory) requirements.

6. Operation and maintenance requirements.

B. Submit information on the following software:

1. Third-party software, including:

iiii. Operating system.

jjjj. Communication software, including all applicable local and wide area network software.

kkkk. Programmable controller programming software (where applicable) and shall not contain protected code.

2. Software configuration, including:

a. Equipment backup configuration and requirements.

C. Control Strategies

1. Description of automatic logic and all non-standard manual logic using plain English, for non-technical persons, and written in Contractor's own words. The write-up shall include references to associated I/O, tag/loop numbers, alarming/interlocks.

D. Application Software

1. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.

llll. Application software includes all custom routines developed specifically for this project, or pre-written routines used for accomplishing specified functions for this project and shall not contain protected code.

mmmm. Contractor shall provide a copy of the PLC program to the City's SCADA support personnel ONLY, before the station start-up and testing is started.

2. This shall include any add-in custom software.

1.05 CONTROL PANEL SUBMITTALS

A. Submittals shall be provided for all control panels, and shall include:

1. Exterior panel drawings with front and side views, to scale.

4. Interior layout drawings showing the locations and sizes of all equipment and wiring mounted within the cabinet, to scale.

144. Panel area reserved for cable access and conduit entry.

145. Location plans showing each panel in its assigned location.

B. Submit information for all exterior and interior panel mounted equipment including, but not limited to, the following:

146. Bill of materials with equipment names, manufacturers, complete model numbers and locations.

147. Catalog cuts, including complete part number breakdown information.

148. Complete technical, material and environmental specifications.

149. Assembly drawings.

150. Mounting requirements.

151. Color samples.

152. Nameplates.

153. Environmental requirements during storage and operation.

C. Submit panel wiring diagrams showing power, signal, and control wiring, including surge protection, relays, courtesy receptacles, lighting, wire size and color coding, etc.

1.06 INSTRUMENT SUBMITTALS

A. Submit information on all field instruments, including but not limited to the following:

154. Product (item) name and tag number used herein and on the Contract Drawings.

155. Catalog cuts, including complete part number breakdown information.

156. Manufacturer's complete model number.

157. Location of the device.

158. Input output characteristics.

159. Range, size, and graduations.

9. Physical size with dimensions, NEMA enclosure classification, and mounting details.

160. Materials of construction of all enclosures, wetted parts and major components.

161. Instrument or control device sizing calculations where applicable.

162. Certified calibration data on all flow metering devices.

163. Environmental requirements during storage and operation.

164. Associated surge protection devices.

165. Installation drawings/details.

1.07 WIRING AND LOOP DIAGRAMS

BBB. Submit interconnection wiring and loop diagrams for all panels and signals in the Control and Information System.

CCC. Electrical interconnection diagrams shall show all terminations of equipment, including terminations to equipment and controls furnished under other Divisions, complete with equipment and cable designations. Where applicable, interconnection wiring diagrams shall be organized by input/output card. Interconnecting diagrams shall be prepared in a neat and legible manner on 11 X 17-inch reproducible prints.

DDD. Loop drawings shall conform to the latest version of ISA Standards and Recommended Practices for Instrumentation and Control. Loop Drawings shall conform to ISA S5.4, Figures 1-3.

EEE. Loop drawings shall not be required as a separate document provided that the interconnecting wiring diagrams required in Paragraph B., above, contain all information required by ISA 5.4.

1.08 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall deliver equipment operation and maintenance manuals. Operation and maintenance (O&M) manuals shall consist of two basic parts:

166. Manufacturer standard O&M manuals for all equipment and software furnished under this Division.

167. Custom O&M information describing the specific configuration of equipment and software, and the operation and maintenance requirements for this particular project.

B. The manuals shall contain all illustrations, detailed drawings, wiring diagrams, and instructions necessary for installing, operating, and maintaining the equipment. The illustrated parts shall be numbered for identification. All modifications to manufacturer standard equipment and/or components shall be clearly identified and shown on the drawings and schematics. All information contained therein shall apply specifically to the equipment furnished and shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.

C. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc. that are required to instruct operation and maintenance personnel unfamiliar with such equipment. The maintenance instructions shall include troubleshooting data and full preventive maintenance schedules. The instructions shall be bound in locking 3-D-ring binders with bindings no larger than 3.5 inches. The manuals shall include 15% spare space for the addition of future material. The instructions shall include drawings reduced or folded and shall provide the following as a minimum.

168. A comprehensive index.

169. A functional description of the entire system, with references to drawings and instructions.

170. A complete "as built" set of all approved shop drawings, which shall reflect all work required to achieve final system acceptance.

171. A complete list of the equipment supplied, including serial numbers, ranges, and pertinent data.

172. Full specifications on each item.

173. Detailed service, maintenance, and operation instructions for each item supplied.

174. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.

175. Complete parts lists with stock numbers and name, address, and telephone number of the local supplier.

176. References to manufacturers' standard literature where applicable.

177. Warning notes shall be located throughout the manual where such notes are required to prevent accidents or inadvertent misuse of equipment.

D. The operating instructions shall clearly describe the step by step procedures that must be followed to implement all phases of all operating modes. The instructions shall be in

terms understandable and usable by operating personnel and maintenance crews and shall be useful in the training of such personnel.

E. The maintenance instructions shall describe the detailed preventive and corrective procedures required, including environmental requirements during equipment storage and system operation, to keep the System in good operating condition. All hardware maintenance documentation shall make reference to appropriate diagnostics, where applicable, and all necessary wiring diagrams, component drawings and PCB schematic drawings shall be included.

F. The hardware maintenance documentation shall include, as a minimum, the following information:

178. Operation Information: This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.

179. Preventive Maintenance Instructions: These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines, and the adjustments necessary for periodic preventive maintenance of the System.

180. Corrective Maintenance Instructions: These instructions shall include guides for locating malfunctions down to the card replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause, and instructions for remedying the malfunction.

181. Parts Information: This information shall include the identification of each replaceable or field repairable component. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross references between equipment numbers and manufacturer's part numbers shall be provided.

G. Software documentation shall conform to a standard format and shall include, but not be limited to, the following:

1. A program abstract that includes:

nnnn. Program Name - The symbolic alphanumeric program name.

oooo. Program Title - English text identification.

pppp. Program Synopsis - A brief text shall be provided that specifies the need for the program, states when it shall be used and functionally describes all inputs, outputs and functions performed. This descriptive text shall be written in a language that is understandable by non-programming-oriented readers.

2. A program description that shall include, but not be limited to, the following:

qqqq. Applicable Documents - List all documents (standard manufacturer's literature, other program descriptions, etc.) by section, if practical, that apply to the program. One complete copy of all applicable reference material shall be provided.

rrrr. Input Output - Identify each input and output parameter, variable, and software element used by the program. State the purpose of all inputs, outputs, and variables.

ssss. Processing - This section shall contain a description of the overall structure and function of the program. Describe the program run stream and present a detailed description of how the program operates. Describe the timing and sequencing of operations of the program relative to other programs. Describe all interactions with other programs. Processing logic that is not readily described without considerable background information shall be handled as a special topic with references to an appendix or to control strategy document that details the necessary information. Reference shall also be made to an appendix or control strategy document for equation and program algorithm derivations.

tttt. System Configuration - Describe in detail the system configuration or status required for program implementation, if appropriate.

uuuu. Limitations and Constraints - Summarize all known or anticipated limitations of the program, if appropriate.

vvvv. Storage - Define program storage requirements in terms of disk or RAM memory allocation.

wwww. Verification - Describe, as a minimum, a test that can be used by the operator to assure proper program operation. Define the required system configuration, input requirements and criteria for successful test completion.

xxxx. Diagnostics - Describe all program diagnostics, where applicable. Descriptions shall list each error statement, indicate clearly what it means, and specify what appropriate actions should be taken.

yyyy. Malfunction Procedures - Specify procedures to follow for recovering from a malfunction due to either operator error or other sources.

1.09 FINAL SYSTEM DOCUMENTATION

FFF. All documentation shall be delivered to the Owner prior to final system acceptance in accordance with the Contract Documents. As a minimum, final documentation shall contain all information originally part of the control system submittals.

GGG. Provide a complete set of detailed electrical interconnection diagrams required to define the complete instrumentation and control system. All diagrams shall be 11 X 17-inch original reproducible prints. All diagrams shall be corrected to describe final "as built" hardware configurations and to reflect the system configuration and control methodology adopted to achieve final system acceptance.

HHH. Provide system software documentation for the operation and maintenance of all system software programs provided as a part of the digital system. All system software documentation shall be amended as required to delineate all modifications and to accurately reflect the final as built software configurations.

III. Provide application software documentation that contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.

JJJ. Provide control strategy documentation which shall include control strategy (block oriented or ladder logic) diagrams to describe the control of all processes. Control strategy documentation shall reflect the system configuration and control methodology adopted to achieve final system acceptance. Control strategy documentation shall conform to the submittal requirements listed hereinabove.

KKK. O&M documentation shall be amended with all final, adjusted values for all setpoints and other operating parameters for Owner reference.

LLL. The Owner recognizes the fact that not all possible problems related to real time events, software interlocks, and hardware maintenance and utilization can be discovered during the Acceptance Tests. Therefore, the instrumentation subcontractor through the Contractor shall investigate, diagnose, repair, update, and distribute all pertaining documentation of the deficiencies that become evident during the warranty period. All such documentation shall be submitted in writing to the Owner within 30 days of identifying and solving the problem.

1.10 PROGRAMS AND SOURCE LISTINGS

MMM. Provide one copy of all standard, of-the-shelf system and application software (exclusive of firmware resident software) on original media furnished by the software manufacturer.

NNN. Provide one copy of source listings on digital media, acceptable to Engineer, for all custom software/logic written specifically for this facility, all database files configured for this facility, and all control strategies. All source listings shall include a program abstract, program linkage and input/output data. Comments describing the program flow shall be frequently interspersed throughout each listing.

C. All software/logic shall be in both its native format and in Adobe Portable Document Format.

1.11 SUBMITTAL/DOCUMENTATION FORMAT

OOO. All drawing-type submittals and documentation shall be rendered and submitted in the latest version of AutoCAD.

PPP. All textual-type submittals and documentation shall be rendered and submitted in the latest version of Microsoft Word or in searchable Adobe Portable Document Format (PDF). Raster scans will not be accepted.

1.12 ELECTRONIC O&M MANUALS

QQQ. Subject to acceptance by the Engineer, the O&M information may be submitted in part or in whole in an electronic format on digital media.

RRR. Electronic O&M manuals shall contain information in standard formats (searchable Adobe PDF, Word, AutoCAD, HTML, etc.) and shall be easily accessible using standard, “off-the-shelf” software such as an Internet browser. Raster scans will not be accepted.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 40 63 43
PROGRAMMABLE LOGIC CONTROLLERS

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation all programmable logic controllers, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

SSS. Section 40 66 00 – Process Control System Networks

TTT. Section 40 67 63 – Uninterruptible Power Systems

UUU. Section 40 67 00 – Control System Equipment Panels and Racks

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. The following specific spare parts items shall be provided:

182. One of each type and size of module for PLC equipment furnished under this Contract.

183. One of each type and size of PLC and equipment power supply furnished under this Contract.

PART 2 – PRODUCTS

2.01 PROGRAMMABLE LOGIC CONTROLLERS - GENERAL

A. The instrumentation subcontractor shall furnish programmable controllers (PLCs) as specified herein and as shown on the Drawings for the pump control panel. PLCs shall be provided complete with backplane, power supply, I/O cards, special function cards, instructions, memory, input/output capacity, and appurtenances to provide all features and functions as described herein. Acceptable manufacturers shall be Schneider Electric Modicon 340(with conformal coating and rated for hazardous conditions)for all pump stations, with no substitutions allowed. Water purification plant or raw water pumping facilities unless designed as a RIO (Remote Input/Output) shall utilize a fully redundant pair of Schneider Electric M-580 PLC.

B. All components of the PLC system shall be of the same manufacturer, who shall have fully tested units like those being furnished in an industrial environment with associated electrical noise. The PLC system shall have been tested to meet the requirements of NEMA Standard ICS 2-230 (Arc Test) and IEEE C37.90.1 (SWC). The processing unit shall perform all the operations functionally described herein based on the program stored in memory and the status of the inputs and outputs.

2.02 COMMUNICATIONS

VVV. PLC communications shall be provided as specified in Section 40 66 00 – Process Control System Networks and as shown on the Control System Architecture Drawing.

WWW. In addition to a communications port for the control system network, communication ports shall be provided for any other devices required (i.e., VFD's, wireless communications) plus an additional communication port for connection to a notebook computer. Within plant operation facilities, switch of the same type and manufacturer of other existing switches shall be required.

XXX. The PLC shall be able to support various types of fieldbus communication systems for data links to field instruments (where specified) in addition to connected equipment such as power monitors, VFDs, motor protection monitors, etc. As a minimum, Ethernet over I/P where required by field equipment, TCP/IP Ethernet, MODBUS over IP always shall be supported. The Contractor shall coordinate the efforts of the necessary parties (instrumentation subcontractor and equipment suppliers) to accomplish the required device and data table addressing between each PLC and the associated connected equipment.

YYY. Contractor is to provide additional communication modules or protocol gateways may be required to support specific communication protocols required under this Contract and shall be supplied at no extra cost to the Owner.

2.03 INPUT/OUTPUT SUBSYSTEMS

A. Input/output hardware shall be plug-in modules in associated I/O backplane/chassis or DIN-rail mounting assemblies. Each unit shall handle the required number of process inputs and outputs plus a minimum of 10 percent active pre-wired spares for each I/O type furnished, plus a minimum of 20 percent spare I/O module space for the addition of future circuit cards or modules.

D. Discrete inputs shall be 24 VDC from dry field contacts. Discrete outputs shall be 24 outputs sourced from the PLC, or dry relay contacts (2A minimum) as required. Refer to Section 40 61 23 – Signal Coordination Requirements for further details of discrete signal type and voltage requirements. The PLC shall provide momentary and latched outputs as required to interface with motor controls and external devices. Interposing relays shall be provided where required to interface with field equipment. Interposing relays shall be as specified in Section 40 78 00. Electrical isolation shall be provided where required. Maximum density for discrete I/O modules shall be 32 per input module and 16 per output module.

ZZZ. Analog input circuits shall be isolated, minimum 16-bit resolution type. Analog input hardware shall be provided as required for all types of analog inputs being transmitted to the PLC. In general, analog input modules shall be capable of receiving 4-20 mA signals. Analog outputs shall be coordinated with the receivers but shall generally be isolated 24 VDC 4-20 mA outputs powered from the PLC. Each input/output circuit shall have optical isolation to protect the equipment against high voltage transients. Optical isolation shall be rated at not less than 1500 V RMS. Lightning/surge protection shall be provided as specified in Section 40 78 56 – Isolators, Intrinsically-Safe Barriers, and Surge Suppressors. Maximum density for analog I/O modules shall be 8 per module.

AAAA. Input/output modules shall be configured for ease of wiring and maintenance. The modules shall be connected to wiring arms that can be disconnected to permit removal of a module without disturbing field wiring. Covers shall be provided to prevent operator personnel from inadvertently touching the terminals. The process interface modules shall be provided with screw-type terminal blocks with barriers between adjacent terminals for connection of field inputs. Terminals shall be suitable for accepting up to and including No. 14 AWG wire. All DC output circuits to the field shall include fuses, either integral or at the terminal strip. Output failure mode shall be selectable so that upon station or communication system failure all outputs shall be placed either in the non-conducting mode or remain as were prior to failure. Light-emitting diodes shall be provided for status indication for each input and output point.

BBBB. Redundant external power supplies and redundant diode modules (Phoenix Contact Part No. 2907719) shall be provided with the PLC as required to meet specified installed I/O power requirements plus spares. Power supplies shall be modular units, shall be fully redundant and shall alarm the PLC upon failure. Power supplies shall have a line regulation of 0.05% and meet the environmental and power requirements specified herein for the PLC.

2.04 INPUT/OUTPUT CIRCUIT ARRANGEMENT

A. Signal and control circuitry to individual input/output boards shall be arranged such that board failure shall not disable more than one half of the control loops within any group of controlled equipment (e.g., one pump out of a group of three pumps, two pumps out of four, etc.). Where possible, individual control loops and equipment shall be assigned to

individual boards such that failure of the board will disable only one loop or piece of equipment.

2.05 PROGRAMMING SOFTWARE

CCCC. The PLC programming and configuration software shall be the manufacturer's latest, full-featured version, Windows-based, and shall be fully compliant with IEC 61131-3 standards. The software package shall consist of all programming, configuration, and documentation software needed to place the control and information system in satisfactory operation. The software shall allow on-line and off-line program development and documentation. PLC programming software shall include documentation on optical media.

DDDD. A minimum of one copy of the PLC programming software shall be purchased by the instrumentation subcontractor and registered to the Owner, specifically handed over to Chris Saunders or an individual in the SCADA department.

EEEE. If available, the configuration and programming software shall support communication over the network specified in Section 40 66 00 – Network and Communication Equipment.

PART 3 – EXECUTION

3.01 REQUIREMENTS

FFFF. PLC programming shall be furnished to perform all functions in function block diagrams where sequential function charts are necessary. In addition, PLCs shall be programmed to provide additional functions described, if applicable, in other sections of this Division.

GGGG. PLC programming shall make use of the various IEC languages as appropriate to the specific task and shall be performed in a modular style making extensive use of function block diagrams where sequential function charts are necessary for specific equipment. It is the intent of this requirement to allow for enhanced readability and ease of modification of the program code through the elimination of multiple instances of repeated code for the same function in a “hard-coded” style.

HHHH. Extensive comments shall be placed in the program code to describe the functions of all elements of the program code. PLC code that does not contain comments shall be rejected.

END OF SECTION

SECTION 40 66 00

NETWORK AND COMMUNICATIONS EQUIPMENT

PART 1 – GENERAL

1.01 THE REQUIREMENT

IIII. The Contractor shall furnish, test, install and place in satisfactory operation IEEE 802.3 Ethernet local area network(s) for communications among plant devices.

JJJJ. Local area network shall be provided with all spare parts, accessories, and appurtenances as herein specified.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 40 63 43 – Programmable Logic Controllers

1.03 TOOLS, SUPPLIES AND SPARE PARTS

A. The following specific spare parts items shall be provided:

1. One spare switch of each type furnished under this Contract.

PART 2 – PRODUCTS

2.01 LOCAL AREA NETWORK (LAN)

KKKK. An IEEE 802.3 Ethernet local area network shall be used for communications between the pump control panel, VFDs and the Owner's SCADA system using the MODBUS TCP/IP protocol with the 40XXXX addressing only.

LLLL. Network wiring shall be unshielded, twisted-pair copper cables for connections within buildings. Cables shall be as specified herein.

MMMM. The Contractor may provide a network configuration different from that shown in the Contract Drawings with written approval of the Engineer, but the Contractor shall coordinate with all affected trades and pay for all additional charges incurred.

NNNN. The Contractor shall supply all hardware, cables, connectors, and software to implement a network as specified herein and shown on drawings.

OOOO. The Contractor shall supply a new industrial Ethernet network switch in the station control panel cabinet, as specified herein.

2.02 VFDs

A. The Contractor shall provide Ethernet CAT6 cabling from the pump VFDs to the station control panel Ethernet switch for monitoring of VFD parameters. Contractor shall provide communication and data being transmitted, as well as properly displayed on Owner's existing SCADA system.

2.03 INDUSTRIAL ETHERNET NETWORK SWITCHES

PPPP. Except where specifically allowed on the Control System Architecture Drawing, industrial Ethernet network switches shall be provided for each device connected to the process control system network. The switches shall create switched Ethernet networks that conform to the IEEE 802.3 and 802.3u standards using copper wires or optical fibers in a bus, tree or ring network topology as shown on the Drawings. Ethernet network switches shall be standard DIN-rail mounted within the PLC cabinet.

QQQQ. Ethernet network switches shall support ring, bus, tree, or point-to-point network topologies. On-line signal monitoring shall be provided to detect and locate impending faults. Ethernet network switches shall be replaceable on-line without disrupting the network. The Ethernet network switches shall be integrated into the in-plant Ethernet network to form a redundant ring network with self-healing communication recovery. Switches shall support the non-proprietary Media Redundancy Protocol (MRP) and Rapid Spanning Tree Protocol (RSTP) in addition to the switch manufacturer's standard redundant ring network protocol, all of which shall provide self-healing communication recovery.

RRRR. Ethernet network switches shall meet the following minimum performance requirements:

184. Functions: Modular managed switch with store and forward switching mode, 10 Mbps Ethernet, or 100 Mbps Fast-Ethernet, or gigabit Ethernet support, multi-address capability, auto-crossing, auto-negotiation, auto-polarity. Port speed and duplex auto-negotiation shall be configurable. Each network switch shall manage up to sixteen (16) ports possible via integrated media modules specified below.

185. Management: Simple Network Management Protocol (SNMP) (v1/v2/v3) and Common Industrial Protocol (CIP) support; IGMP filtering and snooping.

186. Power Requirements: Redundant 24 VDC power supply

187. Operating Temperature: 0 to 60 degrees C

188. Relative Humidity: 10 - 95%

189. Network Size: Up to 50 nodes in ring structure

190. Port Type & Quantity (at each PLC location): minimum of eight (8) 10/100Base-TX, twisted pair cable, RJ-45 sockets, 0-100 meters LAN segment.

D. Acceptable industrial Ethernet network switches shall be as manufactured by Cisco Systems Model number IE-3400-8T2S-E or equal.

2.04 UNSHIELDED TWISTED PAIR CABLE

A. Unshielded twisted pair cable for drops within buildings shall consist of 4 pair of 24 AWG copper conductors in a flame-retardant jacket. Cable shall be plenum rated (UL 910) and meet EIA/TIA-568 Category 6 specifications. Unshielded twisted pair cable shall be Hyper Grade Extended Distance cable as manufactured by Berk-Tek, Belden equivalent, or equal. Connectors shall be modular RJ-45 plug.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. The destination of all network data cables leaving an enclosure, patch panel, or building shall be labeled at each end using industry-standard wire markers.

END OF SECTION

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SECTION 40 66 53

CELLULAR COMMUNICATION SYSTEM

PART 1 – GENERAL

1.01 THE REQUIREMENT

SSSS. The Contractor shall furnish and program the cellular communication system as specified herein.

TTTT. Contractor shall furnish, test, install and place in satisfactory operation the cellular communication system, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

UUUU. The cellular communication system shall utilize 4G LTE cellular Ethernet. Contractor shall construct the system in accordance with all applicable FCC rules. In addition, Contractor shall prepare and submit any other documentation as required.

1.02 RELATED WORK SPECIFIED ELSEWHERE

VVVV. Section 40 61 13 – Control and Information System Scope and General Requirements

WWWW. Section 40 67 00 – Enclosures, General

XXXX. Section 40 78 56 – Surge Protection Devices

1.03 TOOLS, SUPPLIES AND SPARE PARTS

YYYY. The following tools shall be provided:

1. Cellular router remote management software as described herein.

ZZZZ. The following spare parts shall be provided:

1. One (1) spare 4G LTE router.

PART 2 – PRODUCTS

2.01 CELLULAR GATEWAY

AAAAA. Acceptable Manufacturers:

1. Sierra Wireless Airlink RV50X or equivalent

BBBBB. Cellular WAN:

1. North American Model

2. Carrier Approvals: Verizon

1. LTE

2. SIM Interface (2FF)

C. Host Interfaces:

3. 10/100 Base-T RJ45 Ethernet Port.

4. RS-232 Serial Port.

5. USB 2.0 Client (Micro-B Connector).

6. 3 SMA Antenna Connectors

D. LAN (Ethernet/USB)

7. DNS, DNS Proxy

8. DHCP Server

9. IP Passthrough

10. VLAN

11. Host Interface Watchdog

12. PPPoE

E. Serial

13. TCP/UDP PAD Mode

14. Modbus (ASCII, RTU, Variable)

15. PPP

16. Reverse Telnet

17. Garmin FMI

F. WI-FI

18. IEEE 802.11 b/g/n

19. Adjustable output Power

20. Access point for up to 8 clients

21. Simultaneous access point/client mode

5. WEP, WPA-PSK, WPA2-PSK Security

G. Network and Routing

22. Network Address Translation

23. Port Forwarding

24. Host Port Routing

25. NEMO/DMNR

26. VRRP

27. Reliable Static Route

28. Dynamic DNS

H. VPN

29. IPsec, GRE, and SSL VPN Client

30. Up to 5 concurrent tunnels

31. Split Tunnel

32. Dead Peer Detection

33. Multiple subnets

34. VPN Failover

I. Security

35. Remote Authentication (LDAP, RADIUS, and TACAC+)

36. DMZ

37. Inbound and Outbound Port Filtering

38. Inbound and Outbound Trusted IP

39. MAC Address Filtering

40. PCI V3.0 compatible

J. Satellite Navigation

41. 12 Channel GPS and GLONASS Receiver

42. Acquisition Time: 1s Hot Start

3. Accuracy: <2m (50%), <5m (90%)

43. Tracking Sensitivity: -145dBm

44. GNSS Watchdog

K. Events Engine

45. Custom event triggers and reports

46. Configurable interface, no programming

47. Event Types: RAP, SMS, Email, SNMP Trap

48. Event Actions: Drive Relay Output

L. Management Interface

49. Web-Based User Interface

50. Device Configuration Templates

51. Over-the -air software and radio module firmware updates

52. AT Command Line Interface

53. SMS Commands

54. SNMP

M. Power: 9 to 36 VDC

N. Environmental

55. Operating Temperature: -22°F to +158°F

56. Humidity: 90% RH @ 60°C

57. MIL-STD-810G conformance to shock, vibration, thermal shock, and humidity

58. IP64 rated ingress protection.

O. Industry Certifications

59. Safety: IECEE Certification Bodies Scheme UL 60950

60. Hazardous Environments: Class 1 Div 2

61. Environmental: RoHS, REACH, WEEE

P. Support and Warranty

1. 3-year standard warranty

Q. Accessories:

62. External antennas: 2- LAIRD Antennas Model No. TRAB821/18503P, no substitutions permitted. Shall meet 3 DBI rating

63. Antenna Cable: TESSCO Model No. SMA-M-N-MxxFT (xx for length of cable).

64. Surge protection

65. Coax

1.04 SUBMITTALS

A. In addition to submittals required under Section 40 61 15 – Process Control System Submittals, submit antenna installation details for antenna installations required under this Contract. The details shall include scaled drawings of the antenna, antenna mounting hardware and support structures, coaxial cables, connectors, ground clamps, fasteners, and lightning surge protectors. An equipment list shall be included identifying each component. Submit product literature for each component.

1.05 TELEMETRY SYSTEM EQUIPMENT LOCATIONS

A. Cellular router shall be mounted on a DIN rail in the wastewater pump station control panel PS156-SCP. Refer to the Drawings for the cellular antenna locations.

PART 2 – EXECUTION

2.01 CELLULAR ROUTER TESTING

A. After the cellular routers have been installed, Contractor shall test the following items and make all necessary adjustments to maximum performance of the communication links:

191. Signal strength

192. Cellular protocol mode (LTE, 4G, 3G, etc.)

193. Software revision

194. Hardware revision

B. Contractor shall test the integrity of the antenna cable after installation to ensure that the insertion losses do not exceed 2.0 dB.

C. Contractor shall submit all test results of the above-described test for approval by the Engineer. Contractor shall provide a copy of the approved test results in the final O&M Manuals.

3.02 WARRANTY

CCCCC. Cellular routers shall be furnished with a minimum 5-year manufacturer's warranty. The warranty shall cover hardware and software provided by the manufacturer.

DDDDD. The warranty period shall begin upon Final Acceptance as described in Part 3 of Section 17000.

END OF SECTION

SECTION 40 67 00

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

PART 1 – GENERAL

1.01 THE REQUIREMENT

EEEEE. The Contractor shall furnish, test, install and place, in satisfactory operation the control enclosures, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

FFFFF. Control enclosures shall be assembled, wired, and tested in the instrumentation subcontractor's own facilities, unless specified otherwise. All components and all necessary accessories such as power supplies, conditioning equipment, mounting hardware, signal input and output terminal blocks, and plug strips that may be required to complete the system shall be provided.

GGGGG. Either manufacturer's standard or custom enclosures may be furnished subject to the requirements of the Contract Documents and favorable review by the Owner.

HHHHH. Due consideration shall be given to installation requirements for enclosures in new and existing structures. The Contractor shall examine plans and field inspect new and existing structures as required to determine installation requirements and shall coordinate the installation of all enclosures with the Owner and all affected contractors. The Contractor shall be responsible for all costs associated with installation of enclosures, including repair of damage to structures (incidental, accidental or unavoidable).

IIIII. The terms enclosure, cabinet, and panel shall be considered the same product and are used interchangeably.

1.02 SUBMITTALS

JJJJJ. Thermal calculations.

KKKKK. Proof of circuit breaker selective coordination.

1.03 RELATED WORK SPECIFIED ELSEWHERE

LLLLL. Section 26 29 23 – Low-Voltage Frequency Motor Controllers

MMMMM. Section 40 63 43 – Programmable Logic Controllers

NNNNN. Section 40 78 56 – Isolators, Intrinsically-Safe Barriers, and Surge Suppressors

D. Section 40 67 63 – Uninterruptible Power Systems

1.04 PANEL LOCATION AND TYPE

A. For locations in storage/feed areas for chlorine or other applicable corrosive chemicals, panel shall be of non-metallic construction, rated NEMA 4X, and be fully compatible with the associated chemical.

B. For locations within climate controlled (i.e., heated, and air-conditioned) electrical or control rooms, panel shall be a painted steel fully enclosed NEMA 12 units with gasketed doors.

C. For locations outdoor, panel shall be Stainless Steel, rated NEMA 4X.

PART 2 – PRODUCTS

2.01 CABINETS AND PANELS

OOOOO. Cabinets and panels shall be formed or welded construction, reinforced with Unistrut, Powerstrut, or equal to facilitate mounting of internal components or equipment. Sufficient access plates and doors shall be provided to facilitate maintenance and testing of the cabinet's equipment. Doors shall be removable. Panels shall be provided with continuous hinge. Cabinets and panels with any dimension 36 inches or greater shall be provided with removable lifting lugs designed to facilitate safe moving and lifting of the panel during installation. All doors shall be fitted with common-keyed locks.

PPPPP. Cabinets and panels shall be minimum 14 USS gauge. Cabinets and panels with any dimension greater than 36 inches shall be 12 USS gauge.

QQQQQ. Cabinets and panels shall have doors on the front and shall be designed for front access. NEMA 12 cabinets shall be fitted with three-point door latches. Doors for NEMA 4X cabinets shall be all stainless steel with three-point latches.

RRRRR. Panels and cabinets located outside fence-secured areas shall be fitted with padlockable latch kits. Coordinate keying with Owner.

SSSSS. All cabinets and panels shall be provided with drawing pockets for as-built panel drawings. One copy of the appropriate panel as-built drawings shall be furnished and left in the pocket of each panel.

TTTTT. Panels with any dimension greater than 36 inches that contain a programmable controller (PLC) shall be provided with a folding laptop programmer shelf on the inside of the door. When deployed, the laptop shelf shall not be greater than 48 inches above finished floor. Laptop shelf shall be fitted to door with factory applied weld-studs. Weld discoloration and enclosure penetrations will not be accepted.

G. Unless otherwise noted, panel-mounted control devices (OIUs, hand switches, etc.) requiring operator access shall be mounted between 48 and 60 inches above the floor or work platform.

UUUUU. Cabinets and panels shall be prefabricated cabinets and panels by Hoffman or equal. The Contractor may optionally provide cabinets that are custom fabricated by the instrumentation subcontractor or by a reputable panel fabrication shop acceptable to the Engineer.

2.02 FIELD PANELS

A. Field panels for outdoor service shall be suitable for wall or pipe mounting. Panels shall have the following features:

195. Hinged and foamed-in-place continuous gasketed door(s). Door material shall match enclosure and shall have piano hinge(s) and three-point latches.

196. Field panels located outside fence-secured areas shall be fitted with staple and hasp. Provide padlock and coordinate keying with Owner.

197. Thermal insulation and thermostatically controlled space heaters where required to prevent condensation or maintain environmental conditions for installed components.

198. External sun shields or shades constructed of the same materials as the associated enclosure, unless otherwise specified. Sun shield or shade shall be fitted to enclosure supports and not to enclosure. Sun shield or shade shall have a slightly sloped top to shed water and shall extend past the front of the enclosure by at least 6 inches and extend down the side and back of enclosure.

B. All external sample/process piping, including valves and appurtenances, shall be insulated with weather-proof insulation and heat-taped to prevent freezing. Heat taping shall be thermostatically controlled and self-regulating and shall adjust its heat output to the temperature of the lines. Heat tape shall be powered from an equipment-safety GFCI circuit from within panel, unless otherwise shown or specified on its own individual circuit breaker.

C. Field panels shall be adequately sized to house instruments, power supplies, surge protection, and appurtenant equipment required for operation. Sufficient space shall be provided for servicing instruments without removal of equipment from the enclosure.

D. Field panels shall be as manufactured by Hoffman, Saginaw Control & Engineering (SCE), or equal.

2.03 TERMINAL BLOCKS

VVVVV. Terminal blocks shall be assembled on non-current carrying aluminum DIN mounting rails (Part No. DN-R35HS1-2) securely bolted to the cabinet subpanel. Terminals shall be of the screw down pressure plate type as manufactured by Phoenix Contact or equal.

WWWWW. Power terminal blocks for both 120 VAC and 24 VDC power shall be single tier with a minimum rating of 600 volts, 30 amps, manufactured by Phoenix Contact (Part No.3044102)

XXXXX. Digital terminal blocks shall be double tier W/O Ground for digital wiring, manufactured by Phoenix Contact (Part No. 2774017). Single-Tier terminal blocks shall be used where possible, Phoenix Contact (Part No. 3044076)

YYYYY. Analog terminal blocks shall be triple tier w Ground for analog wiring, manufactured by Phoenix Contact (Part No. 2718206). Single-Tier terminal blocks shall be used where possible, Phoenix Contact (Part No. 3044076)

ZZZZZ. End covers shall be Phoenix Contact (Part No. 2770024)

AAAAAA. Spacer plates shall be Phoenix Contact (Part No. 2770794)

BBBBBB. Ground terminals shall be Phoenix Contact (Part No. 3044128)

CCCCCC. End Caps shall be Phoenix Contact (Part No. 3047028)

DDDDDD. Red Bridge inserts shall be Phoenix Contact (Part no. 3030271)

EEEEEE. Insertion Bridges shall be Phoenix Contact (Part No. 0201139)

FFFFFF. End Brackets shall be Phoenix Contact (Part No. 0800886)

GGGGGG. Fused Terminals shall be Phoenix Contact (Part No. 3046032)

2.04 NAMEPLATES

HHHHHH. Items of equipment installed in control panels shall be identified with nameplates. Each nameplate shall be located so that it is readable from the normal observation position and is clearly associated with the device or devices it identifies. Nameplates shall be positioned so that removal of the device for maintenance and repair shall not disturb the nameplate. Nameplates shall include, as necessary, the equipment identification number, description, calibrated range, and set point(s). Abbreviations of the description shall be subject to the Engineer's approval.

IIIIII. Nameplates shall be made of 1/16-inch thick machine engraved laminated phenolic plastic having white numbers and letters not less than 3/16-inch high on a black background. Nameplates attached to instruments may be black laser etched 1/8-inch

high text on stainless steel with sharp edges made smooth. Stamped text shall not be acceptable.

D. Nameplates shall be attached to metal equipment by NEMA rated stainless steel screws and to other surfaces by an epoxy-based adhesive that is resistant to oil and moisture. In cases where the label cannot be attached by the above methods, it shall be drilled and attached to the associated device by means of a braided stainless steel wire affixed with a permanent crimp.

JJJJJJ. Submit sample nameplate of each type.

PART 3 – EXECUTION

3.01 FABRICATION

A. The cabinet itself and all interior and exterior equipment shall be identified with nameplates. The equipment shall be mounted such that service can occur without removal of other equipment. Face mounted equipment shall be flush or semi-flush mounted with flat black escutcheons. All equipment shall be accessible such that adjustments can be made while the equipment is in service and operating. All enclosures shall fit within the allocated space as shown on the Drawings.

B. Enclosures shall provide mounting for power supplies, control equipment, input/output subsystems, panel-mounted equipment and appurtenances. Ample space shall be provided between equipment to facilitate servicing and cooling.

C. Enclosures shall be sized to adequately dissipate heat generated by equipment mounted inside the panel. If required, one or more of the following shall be provided to facilitate cooling:

199. For NEMA 12 cabinets only, louvered openings near the bottom and top or thermostatically controlled, low-noise cooling fans to circulate outside air into the enclosure, exhausting through louvers near the top of the cabinet. Air velocities through the enclosure shall be minimized to assure quiet operation.

200. Thermostatically controlled, low noise internal air blowers to circulate air within the enclosure, maintaining a uniform internal temperature. Initial setpoint shall be 75 degrees F.

201. All intake openings in cabinets and panels shall be fitted with dust filters.

D. Enclosures shall be constructed so that no screws or bolt heads are visible when viewed from the front. Punch cutouts for instruments and other devices shall be cut, punched, or drilled and smoothly finished with rounded edges.

E. Intrusion alarm switches shall be provided on all panels mounted for outside applications containing digital hardware and shall generate an alarm to the nearest PLC when any enclosure door is opened. If panel contains a service light, alarm switch shall also be wired to turn light on when door is opened.

KKKKKK. Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for field incoming conductors. Common connections and jumpers required for internal wiring shall be bridges(no wire jumpers allowed), and not be made on the field side of the terminal. Subject to the approval of the Engineer, a vendor's pre-engineered and prefabricated wiring termination system will be acceptable.

LLLLLL. Wiring within cabinets, panels, and consoles shall be installed neatly and shall comply with accepted standard instrumentation and electrical practices. Power, control, and signal wiring shall comply with Division 26 of the Specifications, except that the minimum wire size for discrete signal wiring may be 16 AWG, and for analog wiring may be 18 AWG. For each pair of parallel terminal blocks, the field wiring shall be between the blocks.

MMMMMM. Separate terminal strips shall be provided for each type of power and signal used within each cabinet. Where applicable, terminal strips for different voltages of discrete signal wiring shall also be separated. Terminal strips shall be labeled as to voltage and function. Sufficient ground terminals for field shielding shall be provided.

NNNNNN. All wiring shall be bundled and run open or enclosed in vented plastic wireway (Panduit) as required. Wireways shall be oversized by a minimum of 10%; overfilled wireways shall not be acceptable. All conductors run open in plastic wireway (Panduit) with no cable ties allowed. Sufficient spacing between wireways and terminals shall be provided to allow maintenance (3-inch minimum). Care shall be taken to separate electronic signal, discrete signal, and power wiring when operating at differing voltages.

OOOOOO. Spare field wiring shall be bundled, tied, and labeled as specified above, and shall be neatly coiled in the bottom of the cabinet.

PPPPPP. All installed spare I/O hardware shall be wired along with live I/O wiring to the field wiring terminal blocks within the cabinet. Where space for spare I/O modules has been provided with the PLC backplane or DIN-rail mounting system, corresponding space for wiring, surge protection, and terminations shall be furnished within the cabinet.

QQQQQQ. A copper ground bus shall be installed in each cabinet and shall be connected to the building power ground.

RRRRRR. Interior panel wiring shall be tagged at all terminations with machine-printed self-laminating labels. Labeling system shall be Brady TLS 2200 Printer with TLS 2200®/TLS PC LinkTM labels, or equivalent system by Seton or Panduit. Where applicable, the wire number shall be the ID number listed in the input/output schedules.

N. Wires shall be color coded as follows:

202. Equipment Ground – GREEN

203. 120 VAC Power – BLACK

204. 120 VAC Power Neutral – WHITE

205. 120 VAC Control (Internally Powered) – RED

206. 120 VAC Control (Externally Powered) – RED

207. 24 VAC Control – RED

208. DC Power (+) – BLUE

209. DC Power (-) – WHITE W/BLUE STRIPE

210. DC Control – BLUE

211. Analog Signal – BLACK/WHITE or BLACK/RED

212. Multi-conductor cable provided by the PLC manufacturer for use in pre-constructed wiring harnesses shall be permitted.

O. Enclosures shall be provided with a main circuit breaker and a circuit breaker on each individual branch circuit distributed from the panel. Main breaker and branch breaker sizes shall be coordinated such that an overload in a circuit will trip only its immediate breaker and not the upstream breaker.

P. Enclosures with any dimension larger than 36 inches shall be provided with 120-volt duplex receptacles for service equipment and LED service lights. Power to these devices shall be independent from the PLC power supply and its associated uninterruptible power system.

Q. Where applicable, enclosures shall be furnished with red laminated plastic warning signs in each section. The sign shall be inscribed "WARNING - This Device Is Connected to Multiple Sources of Power." Letters in the word "WARNING" shall be 0.75 inch high, white.

R. The interconnection between equipment and panel shall be by means of flexible cables provided to permit withdrawal of the equipment from the cabinet without disconnecting the plugs.

S. Panel shall be powered by UL listed cord and plug of appropriate sizing shall be permitted for UPS use.

3.02 PAINTING/FINISHING

SSSSSS. All steel enclosures shall be free from dirt, grease, and burrs and shall be treated with a phosphatizing metal conditioner before painting. All surfaces shall be filled, sanded, and finish coated by spraying a 1-2 mil epoxy prime coat and smooth, level, high grade textured finish between flat and semi-gloss shine. The colors shall be selected by the Owner from a minimum of six color samples provided. Refer to Division 9 for additional requirements. Touch-up paint shall be provided to owner.

TTTTTT. Materials and techniques shall be of types specifically designed to produce a finish of superior quality with respect to adherence, as well as impact and corrosion resistance.

UUUUUU. Panels fabricated from stainless steel shall not be painted.

VVVVVV. Panels fabricated from non-metallic materials (e.g., FRP) shall be gel-coated and shall not be otherwise painted.

END OF SECTION

SECTION 40 67 63

UNINTERRUPTIBLE POWER SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

WWWWWW. The Contractor shall furnish, test, install and place in satisfactory operation all uninterruptible power systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

XXXXXX. One UPS shall be provided for the SCADA Pump Control Panel for the programmable
logic controller (PLC) and its appurtenant equipment provided under this Contract. However, courtesy receptacles in PLC cabinets shall not be powered by the UPS.

YYYYYY. UPS units shall be mounted in or near enclosures containing digital hardware, unless otherwise specified or shown on the Drawings, as follows:

213. UPS units for control panels containing PLCs shall be mounted either within the cabinet or in an adjacent cabinet of suitable environmental rating.

214. Where the UPS is mounted within a dedicated enclosure, that enclosure shall be properly sized for heat dissipation and all other applicable requirements as specified in Section 40 67 00 – Control System Equipment Panels and Racks and its subordinate Sections.

215. Where the UPS is mounted within the PLC cabinet, it shall not interfere with access to other equipment or wiring within the panel (i.e., it shall not be necessary to move or remove the UPS to remove or service other panel-mounted equipment). For floor-mounted PLC cabinets with bottom wiring access (including those cabinets with legs), the UPS shall be placed on a dedicated shelf within the cabinet.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 40 63 43 – Programmable Logic Controllers

1.03 SUBMITTALS

A. The Contractor shall submit UPS sizing calculations for all UPS units furnished under this Contract in accordance with Section 40 61 15 – Process Control System Submittals.

PART 2 – EQUIPMENT

2.01 UNINTERRUPTIBLE POWER SYSTEMS

ZZZZZZ. Each UPS shall consist of a freestanding UPS module and battery modules as required to meet backup run time requirements.

AAAAAAA. UPS units shall be true on-line type. Each UPS shall be sized to match the maximum power requirements of the associated digital equipment, control panel power supplies and accessories. Under normal operation, the AC power shall be converted to DC. The DC power from the battery charger shall supply an inverter and maintain the battery module at full charge. The AC output from the inverter shall be fed to the associated digital equipment power supply unit and/or other equipment power supplies as appropriate. Upon loss of the AC supply, the inverter shall continue to supply normal power to the device, drawing DC from the batteries.

BBBBBBB. Loss of AC power shall be monitored on the line side of the UPS and reported via normally closed (fail safe) unpowered contacts to the associated PLC.

CCCCCCC. Each UPS shall meet the following requirements:

216. Input voltage shall be 120 VAC, single phase, 60 Hz.

217. UPS shall be 24VDC output Voltage, manufactured by WAGO Part No.787-1675, no substitutions permitted.

218. The batteries shall be of the sealed VRLA absorbed glass mat (AGM) type. The battery modules shall be WAGO Part No. 787-873, no substitutions permitted.

219. A status monitoring and control panel shall be provided and shall include the following:

    a. Circuit breaker for the AC input.

220. EMI/RF noise filtering.

221. Surge protection shall be provided on the AC input circuit, which shall have a UL TVSS clamping voltage rating of 400 V with a <5 ns response time

END OF SECTION

SECTION 40 78 00

PANEL MOUNTED INSTRUMENTS

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the panel mounted instruments, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 40 67 00 – Control System Equipment Panels and Racks

1.03 GENERAL INFORMATION AND DESCRIPTION

A. All equipment mounted on the face of a panel shall conform to the same NEMA rating specified for the panel construction.

1.04 TOOLS, SUPPLIES AND SPARE PARTS

A. Tools, supplies and spare parts shall be provided as specified in Section 40 61 22 – Tools, Supplies, and Spare Parts, General. In addition, the following specific spare parts items shall be provided:

222. One of each type of panel mounted equipment (i.e., indicators, signal converters, etc.) provided under this Contract.

223. Five of each type of interposing control relay provided under this Contract.

PART 2 – PRODUCTS

2.01 OPERATORS

DDDDDDD. Control operators shall be 30.5 mm, round, heavy-duty, oil tight NEMA 4X corrosion resistant. For Hazardous areas, control operators shall be rated NEMA 7.

EEEEEEE. Pushbuttons shall be non-illuminated, spring release type. Pushbuttons shall include a full guard. Panic stop/alarm pushbuttons shall be LED illuminated red mushroom type with manual-pull release. Selector switches shall be non-illuminated, maintained contact type, unless otherwise indicated.

C. Pilot lights shall be of the proper control voltage, push-to-test LED type with lens and LED lamp colors as specified below.

224. Red: running, on, or opened

225. Green: off, stopped

226. Amber: fault, alarm, or warning

227. White: generic non-alarm status (Power on)

D. Control operators shall have legend plates as specified herein, indicated on the Drawings, or otherwise directed by the Engineer. Legend plates shall be plastic, black field (background) with white lettering. Engraved nameplates shall be securely fastened above each control operator. If adequate space is not available, the nameplate shall be mounted below the operator.

E. Control operators for all equipment under this Contract shall be of the same type and manufacturer unless otherwise indicated. Control operators such as pushbuttons (PB), selector switches (SS), and pilot lights (PL) shall be Cutler-Hammer/Westinghouse Type E34, Square D Company Type SK, or equal

2.02 ELECTRONIC INDICATORS

FFFFFFF. Electronic indicators shall be 6 digit, as appropriate, with 0.56" high red LED display. Indicators shall be provided with nameplate and scale calibrated to match the calibration of the primary element. The unit shall be designed primarily for use with 4-20 mA current loop signal circuits. Indicator operating voltage shall be 115 VAC 10%, 60 Hz. Indicator controls shall include three (3) front-panel pushbuttons for modifying alarm values and another indicator setup. Two (2) form-C relays shall be provided for each indicator. Relay contact outputs shall be rated 5A, 120/240 VAC, resistive load. Where required, a regulated and isolated 24 V excitation power supply shall be provided. Indicators shall have analog option card Part No. PAXCDL10. Indicators shall be suitable for indoor or outdoor service as required and shall have the same NEMA enclosure rating as the associated enclosure.

GGGGGGG. Indicators shall be Red Lion Model PAXP0000, no substitutions permitted.

2.03 RELAYS

A. Interposing control relays (CR)

1. Where required to interface between motor control centers, equipment controls, and control panels, interposing relays and associated control wiring circuitry shall be furnished and installed to provide the monitoring and/or control functions specified herein.

5. Interposing relays shall be small format type, 4PDT, minimum 10-amp, 120 VAC contact rating, manufactured by Schneider Electric Part No. (RPM42F7)

228. Relay coils shall be 120 VAC as required to interface with equipment.

229. Relays shall have a flag indicator to show relay status, a pushbutton to allow manual operation of the relay, and an internal pilot light to indicate power to the coil.

B. Timing Relays (TR)

230. Timing relays shall be electronic type with 120 VAC coils unless otherwise specified or indicated on the Drawings. Timers shall be provided with a minimum of three function relays timed output contacts and instantaneous contacts where required. Contact ratings shall be the same as for interposing relays.

231. Timing relays shall be the general purpose plug-in type, manufactured by Omron (part No. H3YN-2 AC100-120)

2.04 TOTALIZERS

HHHHHHH. Totalizing counters shall be provided for flush panel, spring-clip mounting. Face dimensions of the totalizing counters shall be no larger than 1-1/8-inches high by 2-inches wide. Totalizing counters shall contain eight digits. Height of the digits shall not be less than 5/32-inch. Numerals shall be white on a black background. The counter shall be non-resettable and shall be totally compatible for operation on the pulses supplied by the associated instrument or integrator. The totalizing counter shall be capable of a maximum count rate of 25 counts/second.

IIIIIII. Legend plates shall be provided for each of the totalizing counters with white letters on a black background with legends as specified below.

JJJJJJJ. Totalizing counters shall be manufactured by Kessler-Ellis, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. Refer to Section 40 67 00 – Control System Equipment Panels and Racks, for additional requirements.

END OF SECTION

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SECTION 40 78 56

INTRINSICALLY SAFE BARRIERS AND SURGE SUPPRESSORS

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, and place in satisfactory operation the isolators and surge protection devices (SPDs) as specified herein and as shown on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 40 67 00 – Control System Equipment Panels and Racks

1.03 TOOLS, SUPPLIES AND SPARE PARTS

The following specific spare parts items shall be provided:

1. One of each type of surge protection device provided under this Contract.

PART 2 – PRODUCTS

2.01 SURGE PROTECTION

A. General

1. All electrical and electronic elements shall be protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical systems.

2. Manufacturer's Requirements: All surge protection devices shall be manufactured by a company that has been engaged in the design, development, and manufacture of such devices for at least 5 years. Acceptable manufacturer shall be Phoenix Contact (Part No.2905228) or equal.

3. Surge protection device installations shall comply with UL 94, the National Electric Code (NEC), and all applicable local codes.

4. Surge protection devices shall be installed as close to the equipment to be protected as practically possible.

5. Device Locations: As a minimum, provide surge protection devices at the following locations:

zzzz. At connections between AC power and electrical/electronic equipment, including, but not limited to, panels, assemblies, and field mounted analog transmitters.

aaaaa. At both ends of analog signal circuits that have any portion of the circuit extending outside of a building.

bbbbb. At both ends of copper-based communication cables which extend outside of a building, including at field instruments and the field side of analog valve position signals.

ccccc. On all external telephone communication lines.

B. AC power protection

1. Surge protection device assemblies for connections to AC power supply circuits shall:

ddddd. Be provided with two 3-terminal barrier terminal strips capable of accepting No. 12 AWG solids or stranded copper wire. One terminal strip shall be located on each end of the unit.

eeeee. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements. The surge protection device shall be provided with provisions for mounting to interior of equipment racks, cabinets, or to the exterior of freestanding equipment.

fffff. Be constructed as multistage devices consisting of gas tube arrestors, high energy metal oxide varistors, or silicon avalanche suppression diodes. Assemblies shall automatically recover from surge events and shall have status indication lights.

ggggg. Comply with all requirements of UL 1449, latest edition.

hhhhh. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

iiiii. Have the following characteristics:

1) Maximum Continuous Operating Voltage: 150VAC

2) Maximum Operating Current: 20 amps

3) Ambient Temperature Range: -20 degrees C to +65 degrees C

4) Response Time: 5 nanoseconds

C. Analog signal circuit protection

1. Surge protection device assemblies for analog signal circuits shall:

jjjjj. Have four lead devices with DIN Rail mounting.

kkkkk. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.

lllll. Be constructed as multistage devices consisting of gas tube arrestors and silicon avalanche suppression diodes. Gas tube arrestors and diodes shall be separated by a series impedance of no more than 20 ohms. Assemblies shall automatically recover from surge events.

mmmmm. Comply with all requirements of UL 497B.

nnnnn. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

ooooo. Limit line-to-line voltage to 40 volts on 24VDC circuits.

ppppp. Have the following characteristics:

5) Maximum Continuous Operating Voltage: 28VDC

6) Ambient Temperature Range: -20 degrees C to +65 degrees C

7) Response Time (Line-to-Line): 5 ns

D. Communication circuit protection

1. Surge protection devices for copper-based data communication circuits shall:

qqqqq. Be designed for the specific data communication media and protocol to be protected (e.g., telephone, serial, parallel, network, data highway, coax, twinaxial, twisted pair, RF).

rrrrr. Provide protection of equipment to within the equipment's surge withstand levels for applicable standard test wave forms of the following standards:

8) IEC 60-1 / DIN VDE 0432 part 2

9) CCITT K17 / DIN VDE 0845 part 2

10) IEEE C62.31

c. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.

sssss. Provide automatic recovery.

2.02 INTRINSICALLY SAFE BARRIERS AND RELAYS

A. Intrinsically safe relays and barriers shall be provided where required to interface with equipment located in Classified (i.e., hazardous) areas.

B. Intrinsically safe relays and barriers shall be FM approved.

C. Manufacturer shall be

232. Pepperl+Fuchs

233. Crouse Hinds

234. Square D

235. Or equal.

ISOLATORS AND CONVERTERS

D. Signal converters shall be provided as required to provide control functions and to interface instrumentation and controls, equipment panels, motor control centers and other instrumentation and controls supplied under other Divisions to the controls provided herein.

E. General Requirements

236. Converters shall be of the miniature type, utilizing all solid-state circuitry suitable for mounting within new or existing cabinetry. Where sufficient cabinet space is not available, sub panels or supplemental enclosures shall be provided.

237. Power supply shall be 120V, 60 hertz where required by the converter, unless otherwise indicated.

238. Repeatability shall be 0.1% of span, deadband shall be 0.1% span, maximum.

239. Where specific converters are not listed but are required to interface with the process control system, they shall comply with the general requirements stated herein.

F. Current to Current (I/I) Isolators

1. Current to current isolators shall be furnished where necessary to provide an isolated current loop, calculations or signal amplification between the plant process

control system and instrumentation and control loops. Isolators shall be sized such that resistance of existing loops shall not exceed maximum rated resistance.

2. Isolators shall be as manufactured by AGM, Moore Industries, Rochester Instrument Systems (RIS), Phoenix Contact, Weidmuller, Acromag, or equal.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. See Section 40 78 00 – Panel Instruments and Accessories, for additional requirements.

END OF SECTION

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Field Instrumentation Equipment

Des crip tion	Part Number		Qty	Vendor	Note
Panel Indicator	PAXP0000/PAXCDL10	EA	1	Red Lion	or approved equal
Transmitter Submersible 10 PSI	FMX21-G FF0/0	A	2	Endress-Hauser	or approved equal
Float Ball	FNM-10	EA	3	Flyght	or approved equal
FM Pressure Transmitter (0-50ps i)	2051T		1	Rosemount	or approved equal
City Water Pres sure Transmitter (0-100ps i)	2051T		1	Rosemount	or approved equal

Alarms, Status Conditions and Monitored Signals

Alarm Pumps Normal	Enable Force Main	Pump 1 Running
Alarm Pump 1 Fault	Enable Generator Fail	Pump 2 Fault
Alarm Pump 2 Fault	Enable Metered Flow	Pump 2 Running
Alarm Any Alarm	Enable Pump 1	Door Authorized Key Switch
Alarm Authorized Key	Enable Pump 2	Bypass Pump Running
Alarm Warning	Enable Power Fail	Door Open Switch
Alarm Bypass Pump	Enable Potable Water	Dry Well Float
Alarm Calculated Flow	Enable Wet Well Level	Ext. Generator Switch
Alarm Door Open	Enable Wet Well Float	Ext. Bypass Pump Switch
Alarm Dry Well High	Setpoint Force Main High	Generator Running
Alarm Force Main Fault	Setpoint Force Main Low	Power Failure
Alarm Force Main High	Setpoint Potable Water High	Spare 1
Alarm Force Main Low	Setpoint Potable Water Low	Wet Well Float
Alarm Force Main Normal	Setpoint Wet Well Lo Lo	Calculated Flow Today
Alarm Generator Fault	Setpoint Wet Well High	Calculated In Flow
Alarm Metered Flow Fault	Setpoint Wet Well Low	Calculated Out Flow
Alarm Metered Flow Normal	Setpoint Wet Well Hi Hi	Calculated Flow Current Month
Alarm Potable Water Fault	Pumps Off Level	Calculated Flow Previous Month
Alarm Potable Water High	Pump Run 1 Level	Calculated Flow Yearly Total
Alarm Potable Water Low	Pump Run 2 Level	Calculated Flow Yesterday
Alarm Potable Water Normal	Elapsed Run Time Pump 1 Today	Scaled Force Main PSI
Alarm Power Fault	Elapsed Run Time Pump 1 Total	Metered Flow Today
Alarm Wet Well Lo Lo	Elapsed Run Time Pump 1 Yesterday	Scaled Metered Flow GPM
Alarm Wet Well Fault	Elapsed Run Time Pump 2 Today	Metered Flow Current Month
Alarm Wet Well High	Elapsed Run Time Pump 2 Total	Metered Flow Previous Month
Alarm Wet Well Low	Elapsed Run Time Pump 2 Yesterday	Metered Flow Yearly Total
Alarm Wet Well Normal	Elapsed Run Time Bypass Pump	Metered Flow Yesterday
Alarm Wet Well Float High	Elapsed Run Time External Generator	Scaled Potable Water PSI
Alarm Wet Well Hi Hi	Elapsed Run Time External Bypass Pump	Scaled Rain Gauge in Inches
Enable Authorized Entry	Elapsed Run Time Generator	Scaled Wet Well Level Ft
Enable Bypass Pump	Pump Station Name	
Enable Dry Well	Pump 1 Fault	