

SPECIFICATIONS - DETAILED PROVISIONS
Section 17005 - General Instrumentation and Control Components

C O N T E N T S

PART 1 - GENERAL	1
1.01 DESCRIPTION	1
1.02 RELATED SECTIONS	1
1.03 REFERENCE STANDARDS AND CODES	1
1.04 INSTRUMENTATION AND CONTROL SUBCONTRACTOR	2
1.05 PERFORMANCE SPECIFICATIONS AND DRAWINGS	4
1.06 INSTRUMENTATION AND CONTROL EQUIPMENT	4
1.07 SUBMITTALS	5
1.08 QUALITY ASSURANCE	10
PART 2 - PRODUCTS	11
2.01 GENERAL	11
2.02 GENERAL REQUIREMENTS FOR COMPONENTS AND APPURTENANCES	12
2.03 FLOAT SWITCHES AND INTRINSICALLY SAFE RELAYS	13
2.04 PRESSURE GAUGES	14
2.05 DIAPHRAGM SEALS	14
2.06 PRESSURE SWITCHES	15
2.07 DIFFERENTIAL PRESSURE SWITCHES	15
2.08 PRESSURE TRANSMITTERS	16
2.09 DIFFERENTIAL PRESSURE TRANSMITTERS	16
2.10 ULTRASONIC LIQUID LEVEL MEASUREMENT SYSTEM	17
2.11 SUBMERSIBLE LIQUID LEVEL MEASUREMENT SYSTEM	19
2.12 CONDUCTANCE LIQUID LEVEL MEASUREMENT SYSTEM	21
2.13 CONDUCTIVITY MEASUREMENT SYSTEM	22
2.14 ANCILLARY MATERIALS AND COMPONENTS	25
PART 3 - EXECUTION	26
3.01 GENERAL	26
3.02 INSTALLATION	26
3.03 FIELD QUALITY CONTROL	28
3.04 FIELD TESTING	30
3.05 INSTRUCTION	31

SECTION 17005
GENERAL INSTRUMENTATION AND CONTROL COMPONENTS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Contractor shall provide all equipment, materials, and labor, and required to place into service a fully configured, integrated, and operational instrumentation and control system as indicated on the Drawings and specified herein.
- B. Design, fabricate, coordinate, install, calibrate, and test the instrumentation and control system to provide proper operation and to interface with related equipment and materials.
- C. Furnish and install auxiliary and accessory devices necessary for system operation or performance and to interface with equipment specified herein and in other Sections of these Specifications.

1.02 RELATED SECTIONS

- A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all Sections and ensure a complete and coordinated project.
- B. Related Specification Sections include, but are not limited to, the following:
 - 1. Division 11 – Equipment
 - 2. Division 13 – Special Construction
 - 3. Division 15 – Mechanical
 - 4. Division 16 – Electrical
 - 5. Division 17 – Instrumentation and Controls

1.03 REFERENCE STANDARDS AND CODES

- A. International Society of Automation (ISA)
 - 1. ISA S5.1 – Instrumentation Symbols and Identification.

General Instrumentation & Control Components

Section 17005 – 2

2. ISA S5.3 – Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems.
 3. ISA S5.4 – Instrument Loop Diagrams.
 4. ISA S20 – Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
 5. ISA TR20.00.01 – Specification Forms for Process Measurement and Control Instruments Part 1: General Considerations.
- B. National Electrical Manufacturers Association (NEMA)
- C. National Fire Protection Agency (NFPA)
1. NFPA 70 - National Electrical Code (NEC).
 2. NFPA 79 – Industrial Control Equipment.

Equipment and materials, including installation of same, shall meet or exceed the applicable requirements of the above standards and codes (latest edition).

1.04 INSTRUMENTATION AND CONTROL SUBCONTRACTOR

Contractor shall designate an Instrumentation and Control Subcontractor (ICS) to be responsible to furnish all services, equipment, and material specified herein.

A. Qualifications

1. As a minimum, the ICS shall have been regularly engaged in the design, selection, purchase, fabrication, installation, calibration, startup, and testing of instrumentation and control equipment on municipal water and wastewater projects.
2. ICS shall have been regularly engaged in performing coordination, design, and selection of equipment and controls to interface between instrumentation and control equipment, and to interface with system control panels, motor control centers, variable frequency drives, packaged systems, programmable logic controllers, etc. for municipal water and wastewater projects of similar or larger magnitude for at least 5 years.
3. Contractor shall submit ICS qualifications and project references (5 minimum) for District review and approval.

4. Personnel employed for system engineering, coordination, supervision, installation, startup, operational testing, and training shall be regularly employed and trained by the ICS.

B. Responsibilities

1. Design, select, fabricate, coordinate, calibrate, and test the instrumentation and control system to provide proper operation and to interface with related equipment and materials furnished by other suppliers under other Sections of these Specifications, with existing facilities (where required), and with District provided Remote Telemetry Unit (RTU) equipment and/or Supervisory Control and Data Acquisition (SCADA) system equipment.
2. Coordinate the design, selection, and fabrication of instrumentation and control systems furnished by others, and confirm that the proposed equipment will provide the required monitoring/control and shall properly interface with other equipment systems (new and existing).
3. Design and prepare control and interconnect diagrams (loop drawings) for all field devices, local control panels, main control panels, motor control centers, etc. showing wiring interconnections for all project equipment, instrumentation, and controls (including existing equipment, instrumentation, and controls).
4. Review and approve shop drawings prepared by the motor control center, variable frequency drive, and other electrical equipment suppliers. ICS shall date and sign said shop drawings prior to submittal to the District for review.
5. Coordinate work so that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling, alarming devices, and all appurtenances are selected, designed, and calibrated to provide the specified accuracy and performance, and are completely compatible and shall function as specified.

6. Provide auxiliary and accessory devices necessary for system operation or performance and to interface with equipment provided by other suppliers under other Sections of these Specifications, with existing facilities (where required), and District provided RTU equipment and/or SCADA system equipment. These devices include, but are not limited to, current isolators, signal conditioners, transducers, and interposing relays. These devices shall be provided whether they are shown on the Drawings or not, and shall be at no additional cost to the District.
7. Installation of instrumentation and control equipment and materials need not be performed by the ICS; however, the ICS shall provide onsite technical supervision of the installation.
8. Prior to installation of any conduit associated with instrumentation and controls, the ICS shall verify conduit size and conduit runs with the Electrical Subcontractor and equipment suppliers for specific equipment to be furnished, and notify the District of any conflicts or deviations.
9. Coordinate services of manufacturer's engineering representatives for instrumentation and control equipment during installation, startup, operation, and instruction of District personnel.

Contactors shall subcontract the work specified herein to a qualified ICS. All work performed is the responsibility of the Contractor even though references are made herein to work requirements and responsibilities of the ICS and Electrical Subcontractor.

1.05 PERFORMANCE SPECIFICATIONS AND DRAWINGS

Instrumentation and control systems shall be furnished and installed to provide equipment performance, operation control, and/or monitoring functions as specified on the Drawings, in specific equipment sections of these Specifications, or in the Special Conditions. Control schematic diagrams, where provided on the Drawings, show control wiring and control functions for specific equipment. ICS shall prepare, or coordinate preparation of all wiring and control diagrams, and computer programs. ICS shall furnish and install all instrumentation and control components required to provide said specified performance and operation.

1.06 INSTRUMENTATION AND CONTROL EQUIPMENT

Instrumentation and control equipment shall be as specified herein, per individual equipment sections of these Specifications, and as shown on the Drawings. Not all products specified herein are necessarily required for this project.

1.07 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11" x 17" for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Detailed Bill of Materials for all instrumentation and control equipment, and appurtenances, listing: manufacturer's name, quantity, description, size, range, and catalog/part number.
2. Summary data sheets for all instrumentation and control equipment in accordance with ISA-20.00.01 format. As a minimum, data sheets shall include the following information: Plant equipment name/number and ISA tag number shown on the Drawings (where provided); item name as specified herein, or separate Specification sections, or indicated on the Drawings; manufacturer's complete model number, item location; input/output characteristics; range, size, and gradation in engineering units; materials of construction for wetted parts and enclosure; and enclosure NEMA classification.
3. Complete documentation for all instrumentation and control equipment, including: manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer's literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.
4. Engineering selection and design parameters and calculations for instrumentation and control components including range, material compatibility for process medium, temperature ratings for project ambient conditions, temperature error and proposed mitigation for same, and other pertinent selection and sizing criteria.
5. Manufacturer's data and drawings showing dimensions, physical configurations, methods of connecting instruments and control equipment together, installation and mounting details, single instrument loop diagrams, and wiring schematics.

General Instrumentation & Control Components

Section 17005 – 6

6. Product data sheets for instrument cables and controller/transmitter cables. Installation requirements for cables and conductors, including shielding, splicing, and grounding requirements.
7. Control program for programmable controllers (if applicable) with complete listing and description of all program functions, all input and output parameters, and factory settings.
8. Interface between instruments, controllers, motor starters, control panels, variable frequency drives, PLCs, etc., District furnished equipment (when supplied), and other equipment related to the instrumentation and control system.
9. Control ladder diagrams for all control, protection and monitoring circuits, including control panel wiring. Ladder diagrams shall show all switches, push buttons, relays, timers, etc. Show all interconnections between power sources and device elements of a particular system or equipment, and all interlocks with other equipment/systems in a manner that fully indicates the circuit function and operation.
10. Loop diagrams for each monitoring and/or control loop. The loop diagrams shall show all components of the loop: analog, digital, and discrete including all relays, switches, signal isolators, etc. which are being provided for proper operation. Loop diagrams shall be provided for all analog and control system components, including those components specified in other Sections of these Specifications and/or shown on the Drawings. Loop diagrams shall be prepared according to ISA-S5.4 format, and shall also include the following:
 - a. All interconnecting wiring between equipment, panels, terminal junction boxes, and field mounted components. Show all panel terminal board identification numbers and all wire numbers. Show all intermediate terminations between field elements and panels.
 - b. The location of all devices.
 - c. The instrument description, including type, manufacturer, model number, range, set points, and operation (e.g. fail open, open on energization, normally closed, etc.) as applicable.
 - d. The instrument loop power requirements back to the termination on the terminal block, fuse block (including fuse size), etc., as applicable.

- e. All grounding points within cabinets and panels and identify the connection point of individual components.
 - f. Each diagram shall include a table summary with output capability of the transmitting instrument, input impedance of each receiving instrument, estimate of loop wiring impedance based on wire size and approximate length, total loop impedance, and reserve output capacity.
11. Interconnection diagrams for all field devices, local control panels, main control panels, motor control centers, etc. showing wiring interconnections for all project equipment, instrumentation, and controls (including existing equipment, instrumentation, and controls). Interconnection diagrams shall be provided for all equipment and appurtenances, including equipment specified in other Sections of these Specifications and/or shown on the Drawings. Interconnection diagrams shall be point-to-point type and shall show all conduit and wiring interconnections with electric panel and circuit numbers for all power sources.
12. Proposed nameplate descriptions for all instrumentation and control equipment.

B. Field Testing and Demonstration Plan

Contractor shall prepare and submit for approval a written plan for field testing and demonstrating that each instrumentation and control system meets the specified operational and performance requirements. Submit a written plan with step by step procedures to be used during pre-startup, startup, and final demonstration testing of system operation and performance.

C. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all instrumentation and control equipment specified herein and incorporated into the Work. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Section 01430, and as specified herein.

General Instrumentation & Control Components
Section 17005 – 8

The O&M Manual shall include, but not be limited to, the following:

1. Equipment Performance Data and Drawings
 - a. Detailed Bill of Materials for all instrumentation and control equipment, and appurtenances, listing: manufacturer's name, quantity, description, size, range, and model/part number.
 - b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, and illustrations.
 - c. Manufacturer's data and drawings showing dimensions, physical configurations, installation and mounting details, single instrument loop diagrams, and wiring schematics.
 - d. Control diagrams, loop diagrams, and interconnect diagrams for all field devices, local control panels, main control panels, motor control centers, etc. for all project equipment, instrumentation, and controls (including existing equipment, instrumentation, and controls).
2. Equipment Installation Requirements
 - a. Complete, detailed installation instructions for all instrumentation and control equipment, and appurtenances.
3. Equipment Operation Data
 - a. Complete and detailed instructions for adjusting all equipment settings, including: input power, output signal, range, span, sensitivity, etc.
 - b. Complete and detailed user manuals and operating instructions, including operator interface menus, programming, and setup parameters for all controllers.
 - c. Printed list of all final setup parameters for each controller, including factory settings and any field modifications to factory settings.

4. Equipment Service and Maintenance Data

- a. Maintenance data shall include all information and instructions required by District's personnel to keep equipment adjusted and calibrated so that it functions properly under the full range of operating conditions.
- b. Explanation with illustrations as necessary for each maintenance task.
- c. Recommended schedule of maintenance tasks.
- d. Troubleshooting instructions.
- e. List of maintenance tools and equipment.
- f. Recommended spare parts list.
- g. Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

5. Manufacturer Warranties

D. Final O&M Manual

Upon successful completion of startup and initial operation, Contractor shall submit a Final O&M Manual in accordance with the requirements of the District's General Conditions, Specification Section 01430, and as specified herein.

1. As-built drawings (including all field changes) for all wiring and interconnection diagrams shall be incorporated into the Final O&M Manuals.
2. In addition, pre-startup and post-startup written certification reports as specified herein shall be included in the Final O&M Manual.

1.08 QUALITY ASSURANCE

A. Manufacturers

To facilitate the District's future operation and maintenance, furnish equipment which is the product of one manufacturer to the maximum extent possible. Where this is not practical, all equipment of a given type shall be the product of one manufacturer.

All equipment shall be of the manufacturer's latest design and shall produce or be activated by signals which are standards for the water and wastewater industry.

B. Model Numbers

Model numbers supplied herein are provided for information purposes only, to assist Contractor in selecting equipment that conforms to the Specification and Drawing requirements. In case of any conflict between model numbers provided and the descriptive requirements specified herein, the descriptive requirements shall govern.

C. Standard of Quality

Only equipment of the types and sizes specified which has been demonstrated to operate successfully shall be furnished. All material and equipment furnished shall be listed by and shall bear the label of Underwriters Laboratories (UL), Edison Testing Labs (ETL), or Factory Mutual (FM).

D. Instrumentation and Control Subcontractor's Certifications

Prior to startup and initial operation of all instrumentation and control equipment (including existing instrumentation and control equipment), the ICS shall submit a written report stating that equipment has been coordinated, calibrated, properly installed, and is ready for startup. After startup and when equipment is ready to be operated, the ICS shall submit a written report for the instrumentation and control equipment certifying that the equipment is ready to be operated, is safe to operate and has been checked, inspected, calibrated, and adjusted as necessary; has been operated under varying service conditions and operated satisfactorily; and is fully covered under the terms of the guarantee.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Where indicated on the Drawings, specified by the individual equipment sections in these Specifications, or by the Special Conditions, the instrumentation and control components shall be as specified herein.
- B. Unless specified otherwise, all equipment shall be suitable for operation over an ambient temperature range of 15°F to 122°F, and at a maximum elevation of 3,300'. Cooling or heating equipment shall be provided if required by the instrumentation and control equipment. Where dissipation of heat cannot be adequately accomplished with natural convection (NEMA 4X enclosures) or forced air ventilation (NEMA 1 gasketed enclosures), additional cooling or heating shall be furnished.
- C. Unless specified otherwise, electrical enclosures for indoor equipment shall be rated NEMA 1 gasketed, or better. Unless specified otherwise, electrical enclosures for outdoor equipment shall be rated NEMA 4X. Outdoor enclosures with sunlight exposure shall be provided with sun shields. In addition, instrumentation located in areas subject to wash down or exposure to chemicals shall be provided with NEMA 4X electrical enclosures.
- D. All instrumentation in hazardous areas shall be intrinsically safe and shall be approved for use in the particular hazardous (classified) location in which it is to be installed.
- E. All panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be of one manufacturer.
- F. Analog measurements and control signals shall be as indicated herein, and shall vary in direct linear proportion to the measured variable, except as noted. Unless specified otherwise, analog output signals shall be 4 to 20 milliamperes (ma) DC.
- G. Unless specified otherwise, power for the instrument and control equipment shall be 120VAC, single phase, 60 Hz.
- H. Where DC power supplies are not furnished integral with any one instrument system loop, Contractor shall provide a separate solid-state power supply and fuses (primary and secondary).

2.02 GENERAL REQUIREMENTS FOR COMPONENTS AND APPURTENANCES

A. Materials and Components

Electrical materials and components shall be as specified in Section 16050, as indicated on the Drawings, and as specified herein.

B. Signal Isolators, Converters, and Power Supplies

Signal isolators shall be furnished and installed in each measurement and control loop, wherever required to ensure adjacent component impedance match, or where feedback paths may be generated. Signal converters shall be included where required to resolve any signal level incompatibilities. Signal power supplies shall be included, as required by the manufacturer's instrument load characteristics, to ensure sufficient power to each loop component.

C. Tags and Nameplates

1. Each field instrument shall be provided with a rectangular Type 316 stainless steel tag. The tag shall be engraved with the project instrument tag number. The instrument tag shall be attached directly to the instrument with stainless steel screws or with a stainless steel chain.
2. Each panel mounted instrument, controller, or control component shall be provided with a nameplate. The nameplate shall be engraved with the project description of the device. Nameplates shall conform to the requirements of Section 16050.

D. Wiring and Cables

1. Wire Type and Sizes

All power and control wiring shall be provided in accordance with Section 16050. Instrument supply power conductors shall be minimum #12 AWG. Control signal conductors shall be minimum #14 AWG. Wire insulation colors shall be in accordance with Section 16050.

2. Cables

Shielded cables shall be minimum #16 AWG and shall be in accordance with Section 16050. Instrument transducers or sensors requiring special cable shall be provided by the instrument manufacturer and shall be factory connected to the device. Cable between the transducer or sensor and corresponding controller shall be provided with the device. ICS shall verify the length of cable required for each specific installation location. Cable shall be installed in a single run with no splices.

3. Wire Termination

Conductors from field instruments or components shall terminate in control panels, MCC sections, etc. at terminal blocks.

4. Wire Marking

All conductors and cables shall be marked at termination points with a marking system as specified in Section 16050.

2.03 FLOAT SWITCHES AND INTRINSICALLY SAFE RELAYS

- A. Float switches shall be designed for operation in water and raw sewage and shall be hermetically sealed in high impact corrosion resistant polypropylene or polyurethane. Cable shall be minimum 16 gauge multi-strand polyvinylchloride (PVC) jacketed cable (oil and water resistant) suitable for underwater use and heavy flexing service. Float switches shall be rated minimum 4 A at 120 VAC. Each float switch shall be utilized for one operation. A single float switch shall not be used as example for pump start and stop.
- B. Float switches shall be as manufactured by Flygt Corporation, Warrick Controls, Anchor Scientific Inc., Consolidated Electric Co., or equal.
- C. Unless specified otherwise, each float switch shall be provided with an intrinsically safe relay complete with reduced voltage transformer and contacts. Intrinsically safe relays shall be specified for use in NEC, Class I, Division 1 (hazardous) locations, and shall be Factory Mutual or UL listed for explosion proof service. Intrinsically safe relays shall be as manufactured by Warrick (no substitutes).

2.04 PRESSURE GAUGES

- A. Unless otherwise shown or specified, pressure gauges shall be weatherproof and provided with 4-1/2" dials, 1/4" or 1/2" threaded connections, and black phenolic resin, black Pocan, or epoxy coated aluminum cases with safety glass windows. Gauge socket and internal component materials shall be compatible with the process medium. As a minimum, gauge sockets and internal components (including bourdon tubes and tips, bellows, or diaphragms) shall be constructed of Type 316L stainless steel. Gauges shall be suitable for dry or liquid filled operation. Gauge accuracy shall be $\pm 0.5\%$ of span per ASTM B40.1, Grade 2A. Gauge range shall be selected for 150% of the working pressure or vacuum of the monitored medium. Gauge dials shall be provided with white backgrounds and black markings. Gauge units shall be applicable to the medium and pressure and/or vacuum range.
- B. Pressure gauges shall be as manufactured by Ashcroft, Wika, Marsh Instruments, or equal.

2.05 DIAPHRAGM SEALS

A. General

Where shown on the Drawings or specified elsewhere, diaphragm seals shall be provided between the process medium and the pressure or vacuum sensing element (e.g. gauge, transmitter, or switch). Diaphragm seals shall be provided with upper and lower housings and diaphragms that are welded or clamped between the housings. Upper and lower housings shall be connected with bolts (4 minimum). Diaphragm seals shall be provided with 1/2" threaded female NPT process connections, 1/4" or 1/2" threaded instrument connections, and lower housings with 1/4" flushing connections. Unless otherwise shown on the Drawings, one (1) diaphragm seal shall be provided for each instrument for direct mounting.

Manufacturer shall be responsible for selecting the diaphragm seal based on each specific instrument assembly, including the diaphragm size, diaphragm material, diaphragm spring constant, assembly fill fluid medium, assembly fill fluid volume, and connection piping size (if not direct mounted) to maintain a minimum accuracy of $\pm 1\%$ of full instrument range based on an ambient temperature range of 20°F to 120°F and exposure to direct sunlight. In addition, manufacturer shall be responsible for selecting diaphragm, bottom housing, and

gasket materials to be compatible with the process medium. As a minimum, diaphragm, lower housing, upper housing, and bolts shall be constructed of Type 316L stainless steel.

Diaphragm seals shall be as manufactured by Ashcroft, Wika, or equal.

B. Water Service (Potable and Non-Potable)

Diaphragms seals for water service shall be of all Type 316L stainless steel construction, including diaphragm, lower housing, upper housing, and hardware.

C. Chlorine Service (Solution)

Diaphragms seals for chlorine service shall be of all Hastelloy C-276 construction, including diaphragm, lower housing, upper housing, and hardware.

2.06 PRESSURE SWITCHES

- A. Pressure switches shall utilize bourdon tubes, diaphragms, or bellows as the sensing/actuating element. Unless otherwise specified, the sensing/actuating element material shall be Type 316 stainless steel. The set point shall be readily field adjustable over the range specified. Switches shall have deadband adjustable up to a maximum of 100% of switch range. Pressure range shall be as indicated on the Drawings. Switches shall be SPDT, rated for 5 A at 240 VAC. Unless specified otherwise, switch enclosures shall be rated NEMA 4X. Switch pressure connection shall be 1/4" FNPT.
- B. Pressure switches shall be Model 836 as manufactured by Allen Bradley (no substitutes).

2.07 DIFFERENTIAL PRESSURE SWITCHES

- A. Differential pressure switches shall utilize bourdon tubes, diaphragms, or bellows as the sensing/actuating element. Unless otherwise specified, the sensing/actuating element material shall be stainless steel. The set point shall be readily field adjustable over the range specified. Switches shall have deadband adjustable up to a minimum of 50% of switch range. Repeatability shall be $\pm 1\%$ of range. Switch pressure range shall be as indicated on the Drawings. Switches shall be SPDT, rated for 10 A (minimum) at 240 VAC. Unless specified otherwise, switch enclosures shall be rated NEMA 4X. Switch pressure connections shall be 1/4" FNPT.
- B. Differential pressure switches shall be as manufactured by Winters, Ashcroft, or equal.

2.08 PRESSURE TRANSMITTERS

- A. Pressure transmitters shall be electronic two wire devices with the following features: adjustable span, zero and damping adjustments, integral indicator scaled in engineering units, solid state circuitry and 4-20 mA output. Accuracy shall be $\pm 0.25\%$ of span. Overrange capacity, without affecting calibration, shall not be less than 150% of maximum range. Process wetted materials shall be compatible with the process fluid, unless specified for installation with a diaphragm seal. Unless specified otherwise, process wetted materials shall be Type 316 stainless steel. Body material shall be Type 316 stainless steel. Transmitter process connection shall be 1/2" NPT. Fill fluid, unless otherwise specified, shall be silicone oil. Transmitter housing shall be epoxy coated low copper aluminum alloy and rated NEMA 4X, unless specified otherwise.
- B. Unless specified for direct mounting, pressure transmitters shall be provided with mounting brackets and installation kits. Bracket shall be suitable for surface mounting, pipe mounting, or block and bleed valve manifold mounting. Mounting bracket wetted materials shall be compatible with the process fluid, unless specified for installation with a diaphragm seal. Unless specified otherwise, mounting bracket wetted materials shall be constructed of Type 316 stainless steel. Mounting brackets, installation kits, and accessories shall be provided by the pressure transmitter manufacturer.
- C. Pressure transmitters shall be as manufactured by Foxboro (no substitutes).

2.09 DIFFERENTIAL PRESSURE TRANSMITTERS

- A. Differential pressure transmitters shall be electronic two wire devices with the following features: adjustable span, zero and damping adjustments, integral indicator scaled in engineering units, solid state circuitry and 4-20 mA output. Accuracy shall be $\pm 0.25\%$ of span. Over-range capacity, without affecting calibration, shall not be less than 150% of maximum range. Span shall be field adjustable over at least a 4 to 1 range. Process wetted materials shall be Type 316 stainless steel. Body material shall be Type 316 stainless steel. Process connections shall be 1/2" NPT. Fill fluid, unless otherwise specified, shall be silicone oil. Transmitter housing shall be epoxy coated low copper aluminum alloy and rated NEMA 4X, unless specified otherwise. A three (3) valve manifold shall be provided with the transmitter, unless indicated otherwise on the Drawings. Manifold wetted materials shall be Type 316 stainless steel.

- B. Differential pressure transmitters shall be provided with mounting brackets and installation kits. Bracket shall be suitable for surface mounting, pipe mounting, or block and bleed valve manifold mounting. Mounting bracket wetted materials shall be compatible with the process fluid, unless specified for installation with a diaphragm seal. Unless specified otherwise, mounting bracket wetted materials shall be constructed of Type 316 stainless steel. Mounting brackets, installation kits, and accessories shall be provided by the differential pressure transmitter manufacturer.
- C. Pressure transmitters shall be as manufactured by Foxboro (no substitutes).

2.10 ULTRASONIC LIQUID LEVEL MEASUREMENT SYSTEM

A. General

Ultrasonic liquid level measurement systems shall consist of a microprocessor based electronic controller, a non-contacting transducer, and cable from transducer to controller. The electronic controller shall be capable of receiving, processing, and transmitting ultrasonic signals. All operating parameters shall be entered via the controller keypad. For liquid level, the controller shall, upon demand, display current head, temperature, and distance from transducer to liquid level.

The ultrasonic liquid level measurement system shall be Miltronics Multi Ranger Plus as manufactured by Siemens (no substitutes).

B. Service

The transducer shall be capable of submergence without degradation. Transducer shall function over an ambient temperature range of -40°F to 200°F, and shall be rated by FM and CSA for Class I and II hazardous environments. Controller shall function over an ambient temperature range of 15°F to 122°F.

C. Performance

The transducer shall transmit and receive an acoustic signal to accurately measure liquid level over a range of 0' to 30', unless specified otherwise. Point of zero reference shall be operator adjustable. The output signal shall be proportional to level from 0 to 100% with a resolution of $\pm 0.1\%$. The transducer shall be provided with integral temperature sensor for speed-of-sound compensation. Unless specified otherwise, the transducer shall be the Echomax XPS Series with a 6° beam angle.

D. Level Measurement Features

1. Controller shall be provided with output indicating meter with four character LCD display programmable in engineering units of: feet, inches, or percent of span.
2. Interconnecting Cable: Cable between transducer and controller shall be supplied with unit, and shall be suitable for a maximum system length of 1,000'. Contractor shall verify length of cable required for each specific installation. Cable shall be installed in a single run with no splices.
3. Discrete Outputs: Controller shall provide up to five discrete outputs, each adjustable over entire scale range.
4. Alarms: Alarms shall be programmable for level, rate of change of level, differential level, or loss of echo.
5. Alarm Messages: Loss of echo and cable circuit open or shorted.

E. Controller Interface

1. Controller Output: 4-20 mA DC output, current isolated, into a maximum of 600 ohms (return to ground).
2. Power Supply: Unit shall operate on 120-Volt, 60 Hz power, unless specified otherwise.
3. Discrete Outputs: Form "C" SPDT relays, 5 amps (continuous), non-inductive, 250 VAC.
4. Controller shall be provided with necessary output functions and communication interfaces to enable implementation of control and monitoring operations as specified in other equipment sections of these Specifications, and/or shown on the Drawings.

F. Controller Enclosure

1. Controller enclosure shall be rated NEMA 4.
2. Indoor controllers shall be wall mounted or panel mounted. Where controller is specified to be panel mounted, it shall be flush mounted in the panel door. ICS shall provide all brackets, supports, bezels, etc. necessary for flush panel mounting.

3. Outdoor controllers shall be provided with stainless steel, sheet metal sun shields (20 gauge, minimum). Sun shields shall be open at the front and bottom, and shall be of sufficient size to allow access to controller for operation and maintenance. Free edges shall be rolled. Sun shields shall be constructed without sharp edges and corners.

2.11 SUBMERSIBLE LIQUID LEVEL MEASUREMENT SYSTEM

A. General

The submersible liquid level measurement system shall continuously monitor the liquid level in a groundwater well, tank, or wet well. The measurement system shall be of the submersible level pressure type. As a minimum, the measurement system shall consist of a submersible pressure sensor, cable, and accessories, as specified herein. Unless indicated otherwise on the Drawings, the system power supply and display unit shall be the RTU or MCP identified to receive the analog level signal. The power supply shall be 24 VDC normal (9 to 28 VDC operation range).

The submersible liquid level measurement system shall be Model PTX 1830 as manufactured by Druck, Inc. (GE Sensing).

B. Sensor and Cable

1. The sensor shall be an all-titanium device that accurately measures depth or level in a well, tank, or body of fluid. A micro-machined silicon measuring element shall be sealed within a titanium pressure module assembly and shall be fully isolated from the pressure media. The pressure module assembly shall be contained in a slimline, welded titanium body and terminated with an injection molded cable assembly.
2. The molded cable shall be a two-conductor cable with aluminum-mylar shield, Kevlar strain cord, nylon vent tube, and polyurethane jacket. The integral cable vent tube shall reference the sensor to atmospheric pressure. The molded polyurethane cable along with the internal potting in the sensor transmitter shall be constructed to prevent the ingress of water into the cable and back of the sensor transmitter for indefinite immersion in a pressure of 1,000 psi.
3. The cable jacket material shall be impervious to water and chemicals normally found in groundwater, surface water, and wastewater.

General Instrumentation & Control Components

Section 17005 – 20

4. Cable lengths shall be available in 1 ft. increments up to a maximum of 1,600 ft. ICS shall determine the required cable length for each specific installation location.
5. The sensor transmitter shall be a 4-20 mA, two-wire, loop powered device. The sensor accuracy shall be $\pm 0.1\%$ of full scale. Long term stability shall be $\pm 0.1\%$ of full scale per year. The sensor shall be suitable for operating temperatures ranging from -4 to 140°F, and sensor output shall be temperature compensated from 30 to 86°F.
6. The sensor operating pressure range shall be as indicated on the Drawings, or specified in the Special Conditions. The sensor shall be capable of being over-pressurized to 400% of the operating full scale pressure (to a maximum of 2,000 psig) with negligible effect on calibration.
7. The sensor shall be rated by FM for use in NEC Class I, Division 1, Groups A through D hazardous environments.

C. Accessories

Unless specified otherwise, each submersible liquid level measurement system shall be provided with the following accessories:

1. A sensor termination enclosure with the following components:
 - a. DIN rail mounted terminal blocks for termination of sensor cable conductors and conductors from 4-20 ma shielded cable to signal termination point.
 - b. Gore-Tex micro-filter designed to prevent the ingress of water into the enclosure.
 - c. Desiccant module with sight gage for determining desiccant change intervals.
 - d. PVC base and clear polycarbonate cover. Enclosure shall be rated NEMA 4X.
 - e. 2-inch pipe mounting kit.
2. A cable clamp designed to hold cable by distributing the clamping force over an 8-inch long section of cable jacket.

3. A sensor slimline sink weight.
4. A direct calibration adaptor.
5. Spare desiccant modules (5 total) in sealed containers.

D. Lightning Surge Arrestor

Where Drawings show installation of a submersible sensor in a surface water location, the sensor shall be provided with an integral lightning surge arrestor assembly certified to IEC Standard 61000-4-5 (Level 4). Contractor shall provide a separate ground rod assembly for the surge arrestor. The resistance of the ground rod assembly shall be less than 100 ohms. A minimum #12 AWG ground conductor shall be provided from the lightning arrestor to the ground rod and shall interconnect with the drain-wire on the sensor cable.

E. Intrinsically Safe Barriers

Where Drawings show installation of a submersible sensor in a wastewater location classified as hazardous by the NEC, the sensor shall be provided with the appropriate intrinsically safe barriers.

2.12 CONDUCTANCE LIQUID LEVEL MEASUREMENT SYSTEM

A. General

Each conductance liquid level measurement system shall consist of level sensors, connection fitting, and relays as shown on the Drawings and specified herein. Contractor shall furnish and install all material and appurtenances as necessary to provide a complete liquid level measurement system.

Conductance liquid level measurement system shall be as manufactured by Warrick Controls Inc., Gems Sensors Inc., or equal.

B. Level Sensors

Level sensors shall be conductance type, utilizing electrodes and the conductivity of the process fluid itself to measure level. The system shall be equipped with multiple level sensing electrodes and one ground electrode. The number and lengths of level sensing electrodes shall be as shown on the Drawings. Unless specified otherwise, the electrodes shall be constructed of Type 316 stainless steel and shall be provided with PVC heat shrink sheathings.

C. Connection Fitting

Each connection fitting shall be pressure-tight, and suitable for connection to the flanged top outlet of a pressure vessel. Connection fitting shall be provided with an integral epoxy coated aluminum terminal housing and Type 316 stainless steel electrode couplings. The number of electrode couplings shall accommodate the number of level-sensing electrodes shown on the Drawings and required grounding electrode. Connection fitting flange shall be rated for a pressure that is equal to or greater than the pressure vessel rating. As a minimum, the connection fitting flange shall be rated for a working pressure of 230 psig at 100°F. The connection fitting flange shall be constructed of Type 316 stainless steel or 1018 carbon steel. Contractor shall coordinate the size of the pressure vessel top outlet flange with the connection fitting flange provided by the level measurement system manufacturer.

D. Relays

Liquid level measurement system relays shall be solid-state, plug-in modules suitable for 11-pin octal sockets. Relays shall be general purpose, single level or differential service, with DPDT dry contacts rated for 5A (minimum) at 120 VAC. Relays shall be suitable for operation on 120 VAC primary voltage with 12 VAC secondary voltage.

2.13 CONDUCTIVITY MEASUREMENT SYSTEM

A. General

The conductivity measurement system shall continuously measure conductivity in aqueous solutions. The measurement system shall sense, transmit and display/control liquid conductance, expressed in microSiemens/centimeter (mS/cm). Conductivity measurement system shall include: sensor, sensor mounting assembly, controller, junction box, interconnecting cables, cable plugs, and all appurtenances necessary to provide a complete and operable measurement system. Sensor material and mounting assembly material shall be compatible with measured liquid. The ICS shall confirm material compatibility with the measured liquid and shall confirm the pressure and temperature ratings of all components with the maximum operating conditions.

Conductivity measurement system shall be the Hach 3700-SC Electrodeless Conductivity System as manufactured by Hach Company (no substitutes).

B. Conductivity Sensor

Conductivity sensor shall be inductive electrodeless type. The conductivity sensor shall have a built-in Pt 1000 RTD temperature compensator. The sensor shall be water resistant. Sensor wetted materials shall be available in polypropylene, PVDF, PEEK, or PFA Teflon. Unless specified otherwise, sensor wetted materials shall be PFA Teflon. The sensor shall be rated for a maximum pressure of 200 psi and a maximum temperature of 200°C. The sensor shall be equipped with an integral 5 conductor cable. Unless specified otherwise, the cable shall be provided with a Teflon coated jacket rated for 200°C.

C. Sensor Mounting Assembly

Sensor shall be convertible style with 3/4-inch NPT end connection suitable for immersion mounting, union mounting, or insertion mounting, as indicated on the Drawings and as specified below:

1. Immersion mounting – sensor shall be directly fastened on the end of a CPVC pipe (1/2-inch diameter by 4-foot long) with 1/2 x 3/4-inch NPT coupling and plastic pipe-mount junction box with terminal strip.
2. Union mounting – sensor shall be fastened to a union adapter for mounting into a standard 2-inch NPT pipe tee. Unless specified otherwise, union and pipe tee shall be construction of Type 316 stainless steel and shall be rated for a maximum pressure of 200 psi and a maximum temperature of 60°C.
3. Insertion mounting – sensor shall be fastened into a 2-inch ball valve assembly for mounting into a standard 2-inch NPT pipe tee. Unless specified otherwise, ball valve assembly and pipe tee shall be construction of Type 316 stainless steel and shall be rated for a maximum pressure of 80 psi and a maximum temperature of 95°C.

Mounting assembly hardware shall be provided by the sensor manufacturer.

D. Controller

1. The conductivity controller shall be a programmable microprocessor based electronic device with full input/output signal isolation. The controller shall be correctly matched to the conductivity sensor. Unless specified otherwise, controller shall be configured to operate two (2) digital sensor inputs.
2. Controller display shall be graphic dot matrix LCD with LED backlighting.

General Instrumentation & Control Components

Section 17005 – 24

3. The controller shall be provided with the following features: two (2) conductivity analog output signals (4-20 mA) capable of transmission into a maximum impedance of 500 ohms; four (4) user configurable SPDT relays (Form C) rated 5A to 230 VAC and 30 VDC resistive maximum; and 25W sensor/network card with Modbus RS232/RS485 network connection.
4. Conductivity measurement range shall be 0.5 to 10,000 mS/cm, 0 to 99.99 % concentration, and 0 to 9999 ppm total dissolved solids. Repeatability shall be $\pm 2\%$ of full span. Operating temperature range shall be -20 to 60°C.
5. Unless specified otherwise, power supply to controller shall be 120 VAC, 60 Hz.
6. Controller enclosure shall be rated NEMA 4X, and shall be suitable for panel or surface mounting as indicated on the Drawings.
7. Unless specified otherwise, controller shall be Hach SC200 Model LXV404.99.00552 as manufactured by Hach Company (no substitutes).

E. Accessories

Each conductivity measurement system shall be provided with all accessories and components necessary for a complete and operational system. As a minimum, each conductivity measurement system shall be provided with the following accessories:

1. Digital gateway designed to provide a digital interface between the conductivity sensor and controller. Unless specified otherwise, each digital gateway shall be provided with a mounting clip, NEMA 4X FRP junction box with back panel (sized for housing digital gateway), and cord fittings for sensor cable and digital extension cable.
2. Digital extension cable with end connectors for connection to digital gateway and controller. The ICS shall determine the required cable length for each specific installation location.

A digital termination box shall be provided when the distance between the digital gateway and controller exceeds 100 meters.

2.14 ANCILLARY MATERIALS AND COMPONENTS

A. Pipe and Fittings

Unless indicated otherwise on the Drawings, all pressure gauges, pressure switches, and pressure transmitters shall be connected to process piping with Class 150 threaded fittings, Schedule 40 pipe nipples, and isolation ball valve. Unless specified otherwise, all fittings, pipe nipples, and ball valves shall be constructed of Type 316 stainless steel.

B. Block and Bleed Valve Manifolds

Where indicated on the Drawings, pressure transmitters and differential pressure transmitters shall be provided with block and bleed valve manifolds capable of isolating process sensing lines, venting to atmosphere, and connection of test equipment for instrument calibration. Block and bleed valve manifolds shall be 3-valve or 5-valve, as indicated on the Drawings. All wetted materials shall be compatible with the process fluid. Unless specified otherwise, valves shall be constructed of Type 316 stainless steel. Block and bleed valve manifolds shall be as manufactured by Foxboro, Anderson Greenwood, or equal.

Unless indicated otherwise on the Drawings, block and bleed valve manifolds shall be provided with mounting kits for mounting the manifold and pressure transmitter assembly to a 2" diameter Schedule 40 hot dipped galvanized pipe stanchion.

C. Protective Coatings

All metallic enclosures, except stainless steel, shall be provided with a corrosion resistant factory coating, fusion bonded epoxy or equivalent coating system.

D. Fasteners

Unless indicated otherwise on the Drawings, equipment and appurtenances shall be securely mounted to walls and floors using Type 316 stainless steel wedge anchors or epoxy anchors for masonry and concrete structures, and Type 316 stainless steel machine bolts and lag screws for metal and wood structures (respectively).

PART 3 - EXECUTION

3.01 GENERAL

- A. It is the general intent of these Specifications that installation of all instrumentation and control equipment; and supply and installation of all field wiring, conduit, and wiring external to the motor control centers, control panels and electrical equipment shall be performed by the Electrical Subcontractor. The ICS shall furnish all instrumentation and control equipment specified herein and supervise installation by the Electrical Subcontractor. In addition, the ICS shall coordinate design of controls within motor control center(s), control panels and electrical equipment, and ensure compatibility of design with equipment and equipment systems.
- B. The ICS's attention is directed to the electrical and mechanical details of this project. Referral to these portions of the Contract Documents shall be required in order to understand the full intent and scope of work required.

3.02 INSTALLATION

A. General

- 1. All instrumentation and control equipment shall be installed in accordance with the manufacturer's written instructions, NEC standards, requirements and standards specified herein, and as shown on the Drawings.
- 2. Wiring between process instruments and remote mounted signal converters/controllers shall conform to the manufacturer's recommended cable type and procedures.
- 3. All instrumentation and control equipment shall be grounded per manufacturer's requirements. Contractor shall coordinate grounding between process instruments and remote mounted signal converters/controllers, and electrical ground system to ensure compliance with the manufacturer's recommended grounding procedures.
- 4. Minimum process connection size for pressure gauges, switches, and transmitters shall be 1/2" NPT. Provide threaded reducers and 1/4" diameter nipples to transition from 1/2" diameter process connection appurtenances to 1/4" device pressure connections.

5. Unless indicated otherwise on the Drawings, all pressure gauges, pressure switches, and pressure transmitters shall be connected to process piping with Class 150 threaded fittings, Schedule 40 pipe nipples, and isolation ball valve. Unless specified otherwise, all fittings, pipe nipples, and ball valves shall be constructed of Type 316 stainless steel.

B. Pressure Gauges

1. Pressure gauges shall be liquid filled (fill fluid as selected by manufacturer), except where diaphragm seals are specified.
2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and isolation ball valves shall be constructed of the same material as the diaphragm seal lower housing.

C. Pressure Switches

1. Pressure switches shall be provided with Type 316 stainless steel pulsation dampeners, except where diaphragm seals are specified.
2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and isolation ball valves shall be constructed of the same material as the diaphragm seal lower housing.

D. Pressure Transmitters

1. Direct connected pressure transmitters shall be provided with Type 316 stainless steel pulsation dampeners, except where diaphragm seals or block and bleed valve manifolds are specified.
2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and isolation ball valves shall be constructed of the same material as the diaphragm seal lower housing.
3. Bracket mounted pressure transmitters and bracket mounted pressure transmitters with block and bleed valve manifolds shall be mounted to 2" diameter Schedule 40 hot dipped galvanized pipe stanchions with stainless steel U-bolts. Each stanchion shall be provided with 3/8" thick steel base plate and four 3/8" diameter anchor bolts for floor mounting.

E. Differential Pressure Transmitters

1. Where indicated on the Drawings, differential pressure transmitters shall be provided with block and bleed valve manifolds. Block and bleed valve manifolds shall be in furnished accordance with the requirements specified herein.
2. For diaphragm seal installations with lower housing constructed of materials other than Type 316 stainless steel, all pipe fittings, pipe nipples, and appurtenances shall be constructed of the same material as the diaphragm seal lower housing.
3. Unless indicated otherwise on the Drawings, differential pressure transmitter brackets or manifolds shall be mounted to 2" diameter Schedule 40 hot dipped galvanized pipe stanchions with stainless steel U-bolts. Each stanchion shall be provided with 3/8" thick steel base plate and four 3/8" diameter anchor bolts for floor mounting.
4. Connections from process piping to differential pressure transmitter brackets or block and bleed valve manifolds shall be Schedule 40 piping as specified herein, or Type 316 stainless steel tubing (0.035" wall thickness) with compression (Swagelok) fittings.

F. Float Switches

1. Unless indicated otherwise on the Drawings, float switches shall be provided with stainless steel clamps and appurtenances suitable for mounting switches to a vertical 3/4-inch pipe.
2. Vertical pipe shall be accessible by District personnel without entering the structure and shall be capable of being easily removed for float cleaning and adjustment.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Engineering Representative

The services of manufacturer's engineering representative especially trained and experienced in the installation of the equipment shall be provided to supervise the installation, be present when the instruments and equipment are first put into operation, and inspect, check, adjust as necessary, and calibrate the instruments. All costs for representative's services shall be included in the Contract Price.

B. Calibration

1. Unless specified otherwise, each field instrument shall be calibrated after installation, in conformance with the requirements specified herein and the instrument manufacturer's instructions. Those components having adjustable features shall be set for the specific conditions and applications of the project, and shall be within the specified limits of accuracy.
2. Each field instrument shall be calibrated at 0%, 25%, 50%, 75%, and 100% of span using test instruments to simulate inputs and read outputs that are rated to an accuracy of at least 5 times greater than the specified accuracy of the instrument being calibrated. Test instruments shall have accuracies traceable to the National Institute of Standards and Technology (NIST).
3. A calibration sheet shall be prepared for each instrument recording all calibration readings, including the readings as finally adjusted within the specified tolerances. Contractor shall submit a written report to the District on each instrument. The report shall include the field calibration sheet for each instrument, and associated manufacturer's standard calibration sheet (if applicable).
4. Elements and equipment which cannot achieve proper calibration or accuracy, either individually or within a system, shall be replaced.

C. Certify Proper Installation

After all installation and connection work has been completed, the ICS and manufacturer's representative shall check it all for correctness, verifying polarity of electric power and signal connections, making sure all process connections are free of leaks, and all other similar details. The ICS and manufacturer's representative shall certify in writing that for each loop or system checked out, that equipment is properly installed, setup, calibrated, and is ready for operation. Refer to Part 1.08C herein for ICS Certification.

3.04 FIELD TESTING

A. Operational Demonstration Testing

Contractor shall demonstrate that the performance of installed instrumentation and control equipment and materials complies with specified requirements. Equipment shall be operated through its full range for not less than 2 hours unless a longer period is specified elsewhere. Immediately correct defects and malfunctions with approved methods and materials in each case, and repeat the demonstration. Operational demonstration testing shall conform to the approved startup, initial operation and demonstration testing plan.

B. Field Operation Tests

Unless specified otherwise, test all instrumentation and control systems for not less than 24 hours, with no interruptions except for normal maintenance. Field operation tests shall conform to the approved test plan.

1. Testing Materials and Equipment

Contractor shall furnish all labor, equipment, and materials for required tests, including all test instruments, recorders, gauges, chemicals, power, etc.

2. Testing Methods

Contractor shall perform field tests on equipment as specified in the Special Conditions and/or Detailed Provisions for the specific equipment. Unless specified otherwise, operate systems continuously for a minimum of 24 hours. Cause equipment to cycle through the applicable range of operation at a steady rate of change. Induce simulated alarm and distressed operating conditions, and test controls and protective devices for correct operation in adjusting system functions or causing system shutdown.

3. Defects

Contractor shall immediately correct all defects and malfunctions disclosed by tests. Contractor shall use new parts and materials as required to perform corrective work, as approved by the District. The specified total test period shall be extended by the interruption time for corrective work.

4. Test Records

Contractor shall continuously record all function and operation parameters during the entire test period. Contractor shall submit complete, well organized, and clearly labeled test data to the District for review and approval.

3.05 INSTRUCTION

District's personnel shall be instructed in the functions and operation of each system and shall be shown the various adjustable and set point features which may require re-adjustment, resetting or checking, re-calibration, or maintenance by them from time to time. Instruction shall include interactions of the systems, operations, shutdowns, alarms, failure, and controls. This instruction shall be scheduled at a time arranged with the District at least two (2) weeks in advance. Instruction shall be classroom type for a minimum of four (4) hours, or as specified by the Special Conditions. Instruction shall be given by the ICS and other qualified persons who have been made familiar in advance with the systems in this Facility.

END OF SECTION 17005

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