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USACE / NAVFAC / AFCESA / NASA **UFGS-40 95 00 (October 2007)**

Preparing Activity: USACE **Superseding UFGS-40 95 00 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2011
****

SECTION TABLE OF CONTENTS

DIVISION 40 - PROCESS INTEGRATION

SECTION 40 95 00

PROCESS CONTROL

10/07

2.3.4.12 Ultrasonic Flowmeter
2.3.4.13 Variable Area Flowmeter
2.3.4.14 Venturi Tube
2.3.4.15 Vortex Shedding Flowmeter
2.3.5 Level Instrumentation
2.3.5.1 Bubble Type Level Sensor
2.3.5.2 Capacitance Type Level Sensor
2.3.5.3 Conductivity Switch
2.3.5.4 Displacement Type Level Switch
2.3.5.5 Mercury Float Switch
2.3.5.6 Reed Sensor
2.3.5.7 Ultrasonic Sensor
2.3.5.8 Leak Detection
2.3.6 Pressure Instrumentation
2.3.6.1 Pressure Sensor
2.3.6.2 Pressure Switch
2.3.6.3 Differential Pressure
2.3.6.4 Differential Pressure Switch
2.3.6.5 Pneumatic to Electric (PE) Switch
2.3.7 Temperature Instrumentation
2.3.7.1 Fluid Temperature Range
2.3.7.2 Resistance Temperature Detector (RTD)
2.3.7.3 Continuous Averaging RTD
2.3.7.4 Infrared Temperature Sensor
2.3.7.5 Temperature Switch
2.3.7.6 Thermocouple
2.3.7.7 Thermowell
2.3.8 Process Analytical Instrumentation
2.3.8.1 Ammonia Gas
2.3.8.2 Calorimeter (Heat Capacity/Fuel Value)
2.3.8.3 Carbon Dioxide
2.3.8.4 Carbon Monoxide
2.3.8.5 Chlorine Gas
2.3.8.6 Chlorine in Liquid
2.3.8.7 Combustible Gas
2.3.8.8 Calorimetric Analyzer
2.3.8.9 Flame Ionization Detector (FID)
2.3.8.10 Hydrogen Sulfide Gas
2.3.8.11 Oxides of Nitrogen (NOx) Gas
2.3.8.12 Oxygen Gas
2.3.8.13 Oxygen Dissolved
2.3.8.14 Oxygen Reduction Potential (ORP)
2.3.8.15 Ozone (O3) Gas
2.3.8.16 Ozone (O3) in Water
2.3.8.17 pH Monitoring
2.3.8.18 Photoionization Detector
2.3.8.19 Total Dissolved Solids (TDS)
2.3.8.20 Water Turbidity
2.3.9 Electrical Instrumentation
2.3.9.1 Hour Meter
2.3.9.2 Watt-Hour Meter
2.3.10 Miscellaneous Measurements
2.4 COMPRESSED AIR STATIONS
2.4.1 Air Compressor Assembly
2.4.2 Compressed Air Station Specialties
2.4.2.1 Refrigerated Dryer, Filters and Pressure Regulator
2.4.2.2 Coalescing Filter
2.4.2.3 Flexible Pipe Connections
2.4.2.4 Vibration Isolation Units

2.7.4 Power Line Conditioner
2.7.4.1 85 Percent Load
2.7.4.2 Load Changes
2.7.5 Grounding
2.7.6 Convenience Outlet
2.7.7 Panel Interior Light
2.7.8 Ventilation System
2.7.9 Heating System
2.7.10 Air Conditioning System
2.8 CENTRAL STATION AND OPERATORS WORKSTATION EQUIPMENT
2.8.1 Workstation Computer
2.8.1.1 Minimum Processor Operating Speed
2.8.1.2 RAM Memory
2.8.1.3 Power Supply
2.8.1.4 Real Time Clock (RTC)
2.8.1.5 Input/Output (I/O) Ports
2.8.1.6 SVGA Color Monitor
2.8.1.7 Hard Disk
2.8.1.8 Floppy Disk Drives
2.8.1.9 Zip Drive
2.8.1.10 Modem
2.8.1.11 CD Drive
2.8.1.12 Network Interface Card
2.8.2 Operator's Workstation Computer
2.8.3 Printer
2.8.4 LAN System
2.8.5 LAN Hubs
2.8.6 Uninterruptible Power Supply (UPS)
2.8.7 Portable Tester/Workstation
2.8.8 Communication and Programming Device
2.9 CENTRAL STATION SOFTWARE
2.9.1 Graphical Operations
2.9.1.1 Graphical User Interface
2.9.1.2 Display Information
2.9.1.3 System Graphics Implementation
2.9.1.4 Display Editor
2.9.1.5 Graphical Object Oriented Programming
2.9.1.6 Charting
2.9.1.7 System Menus and Displays
2.9.1.8 Hard-Copy Screen Request
2.9.2 Command Software
2.9.2.1 Command Input
2.9.2.2 Command Input Errors
2.9.2.3 Special Functions
2.9.2.4 Operator's Commands
2.9.2.5 Level of Addressing
2.9.2.6 System Access Control
2.9.3 Alarms
2.9.3.1 Digital Alarms
2.9.3.2 Analog Alarms
2.9.3.3 Alarm Messages
2.9.3.4 Alarm Classes
2.9.4 Pop-up Note Function
2.9.5 Real Time Clock Synchronization
2.9.6 System Reaction
2.9.6.1 Occurrence
2.9.6.2 Location
2.9.7 Report Generator
2.9.7.1 Periodic Automatic Report

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCESA / NASA | **UFGS-40 95 00 (October 2007)**

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SECTION 40 95 00

PROCESS CONTROL
10/07

****
NOTE: This guide specification covers the requirements for process instrumentation and control systems.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****
PART 1 GENERAL

****
NOTE: Use Section 43 21 29 FLOW MEASURING EQUIPMENT [POTABLE WATER] [SEWAGE TREATMENT PLANT] for simple liquid flow applications.
****

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature

when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI INCITS 154	(1988; R 2004) Office Machines and Supplies - Alphanumeric Machines - Keyboard Arrangement

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE FUN IP	(2009; Errata 2010) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2009; Errata 2010) Fundamentals Handbook, SI Edition

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2006) Grooved and Shouldered Joints

ASME INTERNATIONAL (ASME)

ASME B31.8	(2010; Supplement 2010) Gas Transmission and Distribution Piping Systems
ASME BPVC SEC VIII D1	(2007; Addenda 2008; Addenda 2009) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A536	(1984; R 2009) Standard Specification for Ductile Iron Castings
ASTM B88	(2009) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2005) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D 1238	(2010) Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D 1693	(2008) Standard Test Method for

	Environmental Stress-Cracking of Ethylene Plastics
ASTM D 2000	(2008) Standard Classification System for Rubber Products in Automotive Applications
ASTM D 635	(2010) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
ASTM D 638	(2010) Standard Test Method for Tensile Properties of Plastics
ASTM D 792	(2008) Density and Specific Gravity (Relative Density) of Plastics by Displacement

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE 802.3	(2008; AT 2009; AV 2009; BC 2009; Corr 1 2009; INT 1 2010; BA 2010; AZ 2010; BG 2011; BD 2011) Standard Information Technology--Telecommunications and Information Exchange Between Systems--Specific Requirements Part 3: CSMA/CD Access Method and Physical Layer Specifications
IEEE C37.90	(2005) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C37.90.1	(2002; Errata 2003; Errata 2004) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61131-3	(2003) Programmable Controllers - Part 3: Programming Languages; Ed 2.0

INTERNATIONAL TELECOMMUNICATION UNION (ITU)

ITU V.34	(1998) Data Communication Over the Telephone Network: A Modem Operating at Data Signaling Rates of up to 33,600 Bit/S for Use on the General Switched Telephone Network and on Leased Point-To-Point 2-Wire Telephone-Type Circuits
ITU V.42 bis	(1990) Data Communication over the Telephone Network: Data Compression Procedures for Data Circuit Terminating Equipment (DCE) Using Error Correction Procedures

ISA - INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air
ISA MC96.1	(1982) Temperature Measurement Thermocouples

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2005; R 2008) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 4	(2010) Terminal Blocks

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011) National Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 250	(1991) Calibration Services Users Guide

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-232	(1997f; R 2002) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 60	Standards of Performance for New Stationary Sources
47 CFR 15	Radio Frequency Devices
47 CFR 68	Connection of Terminal Equipment to the Telephone Network

UNDERWRITERS LABORATORIES (UL)

UL 1059	(2001; Reprint Jul 2010) Standard for Terminal Blocks
UL 508	(1999; Reprint Apr 2010) Industrial Control Equipment
UL 94	(1996; Reprint Oct 2010) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 DEFINITIONS

Definitions, Symbols, and engineering unit abbreviations shall conform to IEEE Stds Dictionary, as applicable.

1.3 SYSTEM DESCRIPTION

****
NOTE: Add site specific requirements. Supplement this specification with drawings which include a piping and instrumentation diagram (P&ID) and a comprehensive control (ladder) diagram.
****

The process instrumentation and control system shall be used to monitor and control the operation of process equipment as specified and in accordance with the sequence of control and control schematics shown on the drawings. The control system shall provide for operator interaction, overall control system supervision, and process equipment control and monitoring. Provide hardware configured and sized to support expansion as specified and shown on the drawings.

1.3.1 General Requirements

****
NOTE: Provide a brief and concise description of the control system. Include major pieces of equipment to be monitored or controlled and a brief description of how the control system will operate or monitor the equipment, the type of data to be logged and/or available for reports, trending, etc. The information shall be site specific.
****

The control system shall consist of [_____].

1.3.2 Operation

****
NOTE: Show the minimum number of control panels to be provided on the drawings. Provide setpoint ranges, alarm settings and other parameters not addressed in the sequence of control in a data base/setting table on the drawings.
****

The control system provided under this specification shall operate using direct digital control (DDC) algorithms or ladder logic type and supervisory control to provide the required sequences of operation. Input data to the controller shall be obtained by using instruments and controls interfaced to mechanical, electrical, utility systems and other systems as shown and specified. All required setpoints, settings, alarm limits, and sequences of operation shall be as identified [in the database/ settings tables] [and] [or] [sequences of operation shown on the drawings]. The number and location of control panels shown on drawings shall be provided as a minimum.

1.3.3 Points

****
NOTE: Provide an input/output (I/O) summary table on the drawings. List all inputs to and outputs from the control system. Identify each point type, analog, digital, pulse accumulator; input, output, control, monitoring, etc. Identify alarms, software and failure mode setting associated with each point in the table. Label each point so that it can be easily referenced to the control system schematic drawings or process and instrumentation drawings.
****

Inputs to and outputs from the control system shall be in accordance with the Input/Output (I/O) Summary Table shown on the drawings. Each connected analog output (AO), analog input (AI), digital output (DO), digital input (DI), pulse accumulator (PA) input and other input or output device connected to the control system shall represent a "point" where referred to in this specification.

1.3.4 Data Transmission Systems (DTS)

****
NOTE: Include in the project specification any of the following UFGS for the appropriate DTS: Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM, Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).
****

Data transmission systems for communication [between PLCs] [and] [between PLCs and the central station] shall be provided in [Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM][Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP)] and as shown on the drawings.

1.3.5 Operation and Maintenance Data Requirements

Outline the step-by-step procedures required for system startup, operation and shutdown. Include in the instructions layout, wiring and control diagrams of the system as installed, the manufacturer's name, model number, service manual, parts list and a brief description of all equipment and their basic operating features.

List routine maintenance procedures, possible breakdowns and repairs and trouble shooting guides.

1.4 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.][information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation
Wiring

SD-03 Product Data

****
NOTE: Delete the requirement for compressed air station on systems that do not utilize pneumatic devices.
****

Compressed Air Stations
Control Drawings

Submit in booklet form, indexed to the unique identifiers, consisting of data sheets that document compliance with the specification. Where multiple components are shown on a catalog cut, mark the application specific component.

Sensors and Meters
Performance Verification Test (PVT)
Factory Test Procedure

SD-06 Test Reports

Factory Test Report
Testing, Adjusting and Commissioning
Performance Verification Test(PVT)
Endurance Test
Insertion Turbine Flowmeter

SD-07 Certificates

Control and Sensor Wiring
Ground Rods

SD-10 Operation and Maintenance Data

Training Manual
Instrumentation and Control System

1.5 SITE ENVIRONMENTAL CONDITIONS

****
NOTE: Provide the following site specific environmental conditions. Enter the appropriate seismic parameters from UFC 3-310-04, AWWA D100 or AWWA D103.
****

Capacity and design of the air moving equipment and accessories shall be suitable for 24-hour full load service and shall meet the following criteria.

a. Location

1. Latitude [_____].
2. Longitude [_____].
3. Altitude (above MSL) [_____] m ft
4. Seismic parameters [_____].

b. Heating Degree Days [_____].

c. Winter Design Temperatures

1. Outside Air (Ventilation) [_____] (99%).
2. Outside Air (Heat Loss) [_____] (97.5%).
3. Inside Air Temperature [_____] degrees C degrees F

d. Cooling Degree Days [_____].

e. Summer Design Temperatures

1. Outside Air (Ventilation) [_____] DB (1%).
2. Outside Air (Ventilation) [_____] MCWB (1%).
3. Outside Air (Heat Minimum) [_____] DB (2.5%).
4. Outside Air (Heat Minimum) [_____] (2.5%).
5. Inside Air Temperature [_____] degrees C degrees F

f. Contaminants [_____] [dust] [dirt] [corrosive environment] [hazardous environment].

1.6 SEQUENCING

****
NOTE: Edit to include specific and unique requirements for components or elements of the project. Describe those items which must be installed, commissioned and available for beneficial use prior to other, interconnected elements being available for demolition, decommissioning, or other construction activity which may affect their ability to perform their intended function.
****

Construction shall be sequenced as follows: [_____].

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Materials and equipment shall be standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products. Units of the same type of equipment shall be products of a single manufacturer. Items of the same type and purpose shall be identical and supplied by the same manufacturer, unless replaced by a new version approved by the Government.

2.1.2 Nameplates

Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Laminated plastic nameplates shall be provided for equipment devices and panels furnished. Each nameplate shall identify the device, such as pump "P-1" or valve "VLV-402". Labels shall be coordinate with the schedules and the process and instrumentation drawings. Laminated plastic shall be 3 mm 1/8 inch thick, white with black center core. Nameplates shall be a minimum of 25 by 75 mm 1 by 3 inches with minimum 6 mm 1/4 inch high engraved block lettering. Nameplates for devices smaller than 25 by 75 mm 1 by 3 inches

shall be attached by a nonferrous metal chain. All other nameplates shall be attached to the device.

2.2 GENERAL REQUIREMENTS

****
Show hazardous area classification on the drawings.
****

Equipment located outdoors, not provided with climate controlled enclosure, shall be capable of operating in the ambient temperature range indicated in paragraph ENVIRONMENTAL CONDITIONS, unless otherwise specified. Electrical equipment will conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Equipment and wiring must be in accordance with NFPA 70, with proper consideration given to environmental conditions such as moisture, dirt, corrosive agents, and hazardous area classification.

2.3 MONITORING AND CONTROL PARAMETERS

****
NOTE: Provide a schedule on the drawings that includes all required instrumentation. Provide device information such as: Alpha-Numeric designator, the operating range (pressure, temperature, flow) of construction material, media to be monitored or controlled, control signal, valve type (2-way, 3-way, normally open, normally closed, etc.). Include automatic control valves and manually operated control valves.

It may be appropriate to defer the enclosure requirements to the electrical section or to provide different enclosures for different areas: indoor, outdoor, areas with hazard classification indicated on the drawings, etc. Within an area, the requirements should be consistent.
****

The control system shall be complete including sensors, field preamplifiers, signal conditioners, offset and span adjustments, amplifiers, transducers, transmitters, control devices, engineering units conversions and algorithms for the applications; and shall maintain the specified end-to-end process control loop accuracy from sensor to display and final control element. Control equipment shall be powered by a 120 vAc, single phase, 60 Hz power source, with local transformers included as needed for signal transmission and subsystem operation. Connecting conductors shall be suitable for installed service. Enclosures shall be rated for NEMA [1] [4] [4X] [7] [9] [12] [_____].

2.3.1 Transmitter

****
NOTE: Show all panels on the drawings. Distance between transmitter and sensor is critical.
****

Unless indicated otherwise, each sensor shall be provided with a transmitter, selected to match the sensor. Except where specifically indicated otherwise on the drawings, the transmitter shall be provided with

a [four] [_____] digit or analog visual display of the measured parameter and shall provide a [4 to 20 mAdc] [_____] output signal proportional to the level of the measured parameter. Accuracy shall be plus or minus [0.5] [1] [2] [5] [_____] percent of full scale reading with output error not exceeding plus or minus [0.25] [0.5] [_____] percent of [the calibrated measurement] [full scale]. Transmitter shall be located where indicated, mounted integrally with the sensor, pipe mounted, wall mounted or installed in the control panel. The distance between the sensor and transmitter shall not exceed the manufacturer's recommendation. Field preamplifiers and signal conditioners shall be included when necessary to maintain the accuracy from sensor to the programmable logic controller or recorder.

2.3.2 Off-Gas or Vapor Service

****
NOTE: If there are substantial temperature or pressure changes across a blower or unit process, it may be cost effective to specify differing requirements upstream and downstream of the process.
****

Sensors and meters in [off-gas] [or] [vapor] service shall be rated for continuous duty service at fluid approach velocities from 2.5 to 25 m/s 500 to 5000 fpm with correspondingly higher constriction velocities over a fluid temperature range from minus [18] [25] [_____] degrees C to [40] [50] [66] [_____] degrees C minus [0] [15] [_____] degrees F to [105] [120] [150] [_____] degrees F at pressures from minus [50] [_____] kPa gage up to [100] [700] [_____] kPa gage minus [7.2] [_____] psi gage up to [15] [100] [_____] psi gage.

2.3.3 Liquid Service

****
NOTE: If there are substantial temperature or pressure changes across a pump or unit process, it may be cost effective to specify differing requirements upstream and downstream of the process.
****

Sensors and meters in liquid service shall be rated for continuous duty service at fluid approach velocities from [0.1] [0.75] [_____] m/s to [2] [3] [_____] m/s [0.327] [2.5] [_____] ft/s to [7] [10] [_____] ft/s with correspondingly higher constriction velocities over a fluid temperature range from [0] [_____] degrees C to [40] [50] [_____] degrees C [32] [_____] degrees F to [105] [120] [_____] degrees F at pressures up to [70] [350] [700] [1000] [_____] kPa [10] [50] [100] [150][_____] psi gage.

2.3.4 Flow Sensor

****
NOTE: Most flow meters need straight unobstructed piping of 10 pipe diameters upstream and 5 pipe diameters downstream. Verify that the location will allow installation meeting the criteria or that the accuracy of type of flow meter selected is not affected by the location. Design includes attendant elements such as mounting devices, differential pressure transmitter and interpretive ancillary components in this and other sections and on the

drawings to complete the system.
****

Liquid flow indication shall be provided in L/s gpm. [Off-gas] [or] [Vapor] flow indication shall be provided in cubic m/second cubic feet per minute. Pressure taps shall incorporate appropriate snubbers. Unless indicated otherwise, the flow transmitter shall produce a signal that is proportional to the volumetric flow rate, compensated for fluid temperature, and shall have an accuracy of plus or minus [1] [3] [_____] percent of [full flow] [the actual flow]. Flow transmitter shall be located within 5 m 15 feet of the flow element. The flow transmitter shall include a [digital] [_____] readout of the volumetric flow rate to [3] [_____] significant figures. [The controller shall be provided with a minimum of three alarm lights. The first alarm light shall indicate when the lower (warning) detection level has been exceeded. The second alarm light shall indicate when the upper (alarm) detection level has been exceeded. The third alarm light shall indicate a controller malfunction, including loss of power or loss of sensor input.] [The controller shall be provided with a minimum of three sets of dry contacts rated in accordance with NEMA ICS 1. The first set of contacts shall close when the lower (warning) detection level has been exceeded. The second set of contacts shall close when the upper (alarm) detection level has been exceeded. The third set of contacts shall close when a controller malfunction has occurred, including loss of power or loss of sensor input.] The alarm levels shall be individually adjustable. The controller shall be provided with an audible warning horn that sounds when the upper detection level has been exceeded, and a warning horn silence button. The controller shall provide a [4-20 mAdc] [_____] output signal to the programmable logic controller, proportional to the measured parameter. The controller shall be provided with an internal battery to maintain operation for a minimum of 12 hours if power is lost. Flow rate shall be controlled to within plus or minus [5] [_____] percent of the design flow.

2.3.4.1 Flow Nozzle

Flow nozzle shall be made of austenitic stainless steel. The inlet nozzle form shall be elliptical and the nozzle throat shall be the quadrant of an ellipse. The thickness of the nozzle wall and flange shall be such that the accuracy will not be degraded by distortion of the nozzle throat from strains caused by the pipeline temperature and pressure, flange bolting, or other methods of installing the nozzle in the pipeline. The outside diameter of the nozzle flange or the design of the flange facing shall be such that the nozzle throat shall be centered accurately in the pipe.

2.3.4.2 Flow Switch

Flow switch shall have a repetitive accuracy of plus or minus [10] [_____] percent of actual flow setting. Switch actuation shall be adjustable over the operating flow range. Flow switch for use in [water] [contaminated groundwater] [sewage] [air] [vapor] [gas] [hot gas] [corrosive vapor] [_____] system shall be rated for use and constructed of suitable materials for installation in the environment encountered. The flow switch shall have non flexible paddle with Form C snap action contacts, rated in accordance with NEMA ICS 1.

2.3.4.3 Magnetic Flowmeter

Magnetic flowmeter shall be non-intrusive and shall measure fluid flow through the use of a self generated magnetic field. The magnetic flow

element shall be encapsulated in [type 300 stainless steel] [or] [anodized aluminum]. Flowmeter shall be capable of measuring clean or dirty flow up to a maximum flow velocity of [3] [_____] m/s [10] [_____] fps. The metering tube shall be constructed of [316 stainless steel] [anodized aluminum] [material compatible with the fluid being measured]. The maximum pressure drop across the meter and appurtenances shall be 34 kPa 5 psi at the maximum flow rate.

2.3.4.4 Natural Gas or Propane Flow Meter

Flowmeter for natural gas or propane flows, corrected to standard conditions, of up to 0.02 cu. m/sec 2500 cfh shall be of the positive displacement diaphragm or bellows type and for flows above 0.02 cu. m/sec 2500 cfh, shall be of the axial flow turbine type. Meters shall be designed specifically for natural gas or propane supply metering and rated for the pressure, temperature and flow rates of the installation. Permanent meters shall be suitable for operation in conjunction with an energy monitoring and control system. Meter body shall be constructed of [316 stainless steel] [_____]. Meter shall have a minimum turndown ratio of [10] [_____] to [1] [_____] with an accuracy of plus or minus [1] [_____] percent of actual flow rate. The meter index shall include a direct reading mechanical totalizing register and electrical impulse dry contact output for remote monitoring. The electrical impulse dry contact output shall provide not less than 1 pulse per 2.8 cubic meters 100 cubic feet of gas and shall require no field adjustment or calibration. The highest electrical impulse rate available from the manufacturer, not exceeding 10 pulses per second, for the installed application shall be provided.

2.3.4.5 Orifice Plate

****
NOTE: Show the operating ranges and ratings on the drawings for operating pressures and flow. Differential pressure output ranges for flow conditions are to be coordinated. Accuracy of computed flow will be improved with inclusion of temperature and pressure of upstream conditions.
****

Orifice plate shall be made of [304] [316] series stainless steel sheet. The outlet side of the bore shall be beveled at a 45 degree angle. The thickness of the cylindrical face of the orifice shall [not exceed one-fiftieth of the pipe inside diameter or one-eighth of the orifice bore, whichever is smaller] [be 3.3 mm 0.125 inch nominal]. The orifice plate shall be flat within 0.10 mm 20 mils. The orifice surface roughness shall not exceed 0.5 micron 0.02 mils. Orifice plates shall be concentric plates with a square and sharp upstream edge of the orifice. Orifice bore shall be designed to match the operating parameters stated in the drawings. Plate shall be permanently identified with line size, flange rating, orifice bore diameter, plate thickness and material.

2.3.4.6 Paddle Type Flowmeter

Sensor accuracy shall be plus or minus [2] [_____] percent of rate of flow, minimum operating flow velocity shall be [0.3] [_____] m/s [1.0] [_____] fps. Sensor repeatability and linearity shall be plus or minus [1] [_____] percent. Sensor shall be non-magnetic, with forward curved impeller blades designed for water containing debris. Wetted materials shall be made from

non-corrosive materials and shall not contaminate water. The sensor shall be provided with isolation valves.

2.3.4.7 Pitot Tube

The velocity sensing element shall be of the pitot tube type. Each transmitter shall have a low range differential pressure sensing element and a square root extractor. Sensing element accuracy shall be plus or minus 1 percent of full scale. Transmitter accuracy shall be plus or minus 0.25 percent of the calibrated measurement. Overall accuracy shall be plus or minus [3] [_____] percent over a range of 2.5 to 13 m/s 500 to 2500 fpm scaled to air volume. The resistance to air flow shall not exceed 20 Pa 0.08 inch water at an air flow of 10 m/s 2000 fpm.

2.3.4.8 Annular Pitot Tube

****
NOTE: Annular pitot tubes should not be used where the flow is pulsating or where pipe vibration is allowed. Pulse flow is characteristic of positive displacement pumps and blowers.
****

Sensor shall have an accuracy of plus or minus [2] [_____] percent of full flow and a repeatability of plus or minus [0.5] [_____] percent of measured value. Annular pitot tube shall be averaging type differential pressure sensors with four total head pressure ports and one static port made of austenitic stainless steel. The total head pressure ports shall extend diametrically across the entire pipe.

2.3.4.9 Positive Displacement Flowmeter

Output accuracy shall be plus or minus 2 percent of the flow range. The flow meter shall be a direct reading, gerotor, nutating disc or vane type displacement device rated for liquid service. A counter shall be mounted on top of the meter, and shall consist of a non-resettable mechanical totalizer for local reading, and a pulse transmitter for remote reading. The totalizer shall have a six digit register to indicate the volume passed through the meter in L gallons. A sweep-hand dial will indicate down to 5 L 1 gallon. The pulse transmitter shall have a hermetically sealed reed switch which is activated by magnets fixed on gears of the counter. The meter shall have a bronze body with threaded or flanged connections as required for the application. The maximum pressure drop at full flow shall be 35 kPa 5 psi gage.

2.3.4.10 Turbine Meters

****
NOTE: Verify that the location will allow installation with the minimum straight unobstructed piping of 10 pipe diameters upstream and 5 pipe diameters downstream.
****

Turbine meters shall be [series 300 stainless steel] [bronze] with an accuracy of plus or minus [1] [_____] percent from [30] [_____] percent to 100 percent of actual flow.

2.3.4.11 Insertion Turbine Flowmeter

****

NOTE: Verify that the location will allow installation with the minimum straight unobstructed piping of 10 pipe diameters upstream and 5 pipe diameters downstream. Placement downstream of the blower or pump is preferable for head loss considerations.

****

Design of the flowmeter probe assembly shall incorporate integral flow, temperature, and pressure monitoring. The meter flow sensing element shall operate over the temperature range with a pressure loss limited to [1] [_____] percent of operating pressure at maximum flow rate. The internal temperature transmitter shall monitor the full temperature range of the fluid. The integral pressure transmitter shall monitor the pressure range with end limits of [0] [_____] MPa [0] [_____] psi to 2 MPa 300 psi gage. The flowmeter electronics shall be scaled and rescaled in the field when application data changes. The flowmeter shall be designed for installation in pipe sizes of 75 mm 3 inches and larger to accommodate maximum probe insertion depths up to 1.1 m 44 inches. The retractor assembly shall have a rotor depth gage having graduations of 2.5 mm 0.1 inches to determine exact position of turbine rotor in the pipe. The meter retractor assembly and the turbine rotor assembly shall be constructed of [Series 300 stainless steel] [_____] with [polytetrafluoroethylene (PTFE)] [_____] seals. The meter retractor assembly shall be designed to protect the turbine rotor during insertion into the pipeline. Retraction of the turbine rotor shall be accomplished by using a hand wheel. The retractor assembly shall include an isolation valve providing a means of removal of the meter from service to allow for field maintenance and field replacement of the rotor assembly or parts. The turbine rotor shall be designed to allow compensation for bearing wear without affecting rotor calibration. The turbine rotor shall have an over range operating capacity of 150 percent of maximum flow for up to 5 seconds. The rotor shall be calibrated at the factory in an actual flow of similar fluid over the flow range performed on test equipment with accuracy traceable to the National Institute of Standards and Technology (NIST). A copy of the calibration test data, including all of the physical parameters under which the calibration tests were performed, shall be submitted with each turbine rotor. Calibration test data shall be analyzed to determine the rotor's arithmetic average "K" factor, the best line fit and the plus or minus deviation from these figures. Turbine flowmeter accuracy shall be plus or minus 1 percent of reading for a minimum turndown ratio of 1:1 through a maximum turndown ratio of 50:1. Repeatability shall be plus or minus 0.25 percent of reading. Accuracy of the transmitter shall be plus or minus 0.25 percent over the calibrated span. The turbine rotor response time from minimum to maximum flow shall be less than 10 milliseconds.

2.3.4.12 Ultrasonic Flowmeter

****

NOTE: Doppler meters rely on reflectors in the flowing liquid. To obtain reliable measurements attention must be given to the lower limits for concentrations and sizes of solids or bubbles. The flow must also be rapid enough to keep these materials in suspension. One manufacturer gives values of 1.8 m/s (6 ft/s) for solids and 0.75 m/s

(2.5 ft/s) for small bubbles. To perform within their stated specifications, some Doppler meters require a minimum Reynolds number of 4,000.

Transit-time meters rely on an ultrasonic signal's completely traversing the pipe, so the path must be relatively free of solids and air or gas bubbles. To perform within stated specifications, one type of transit-time meter requires a minimum Reynolds number of 10,000.

****

Ultrasonic flowmeter shall utilize high frequency [Doppler shift] [transit-time] transducer. Flowmeter shall be capable of measuring flow up to a maximum flow rate of [5] [_____] m/s [15] [_____] fps.

2.3.4.13 Variable Area Flowmeter

Meters shall have an accuracy of plus or minus [5] [_____] percent of full scale. The flowmeter body shall be clear acrylic plastic with [brass] [stainless steel] end fittings. The float shall be [glass] [or] [stainless steel]. The metering tube shall be tapered and shall be provided with a direct reading flow scale engraved on the meter body.

2.3.4.14 Venturi Tube

Venturi tube shall be made of cast iron or cast steel. The throat section shall be lined with austenitic stainless steel. Thermal expansion characteristics of the lining shall be the same as that of the throat casting material. The surface of the throat lining shall be machined to a plus or minus 1.2 micron 50 mils finish, including the short curvature leading from the converging entrance section into the throat. The metering tube shall be rated for continuous duty service at minimum pressure of [700] [_____] kPa [100] [_____] psi gage.

2.3.4.15 Vortex Shedding Flowmeter

The accuracy shall be within plus or minus [0.8] [_____] percent of the actual volumetric flow. The flow meter body shall be made of austenitic stainless steel. Flowmeter shall be rated for continuous duty service at minimum pressure of [700] [_____] kPa [100] [_____] psi gage. The vortex shedding flowmeter body shall not require removal from the piping in order to replace the shedding sensor.

2.3.5 Level Instrumentation

****

NOTE: Indicate the location and the NFPA hazard classification on the drawings. Hazard classification of sumps and tank interiors frequently differ from the general area hazard classification. Include a schedule of level sensing elements with operating range requirements. Tabulation of devices is to be included on the drawings. Component identifiers are to be coordinated with the drawings. Use the Instrument Society of America (ISA) suggested alphanumeric system for development of discrete device numbering.

****

Pressure taps shall incorporate appropriate snubbers. Relays and housing shall be intrinsically safe or explosion proof as required by the NFPA hazard rating for compatibility with the contents of the tank or sump. [The controller shall be provided with a minimum of three alarm lights. The first alarm light shall indicate when the lower (warning) detection level has been exceeded. The second alarm light shall indicate when the upper (alarm) detection level has been exceeded. The third alarm light shall indicate a controller malfunction, including loss of power or loss of sensor input.] [The controller shall be provided with a minimum of three sets of dry contacts rated in accordance with NEMA ICS 1. The first set of contacts shall close when the lower (warning) detection level has been exceeded. The second set of contacts shall close when the upper (alarm) detection level has been exceeded. The third set of contacts shall close when a controller malfunction has occurred, including loss of power or loss of sensor input.] The alarm levels shall be individually adjustable. The controller shall be provided with an audible warning horn that sounds when the upper detection level has been exceeded, and a warning horn silence button. The controller shall provide a [4-20 mAdc] [_____] output signal to the programmable logic controller, proportional to the measured parameter. The controller shall be provided with an internal battery to maintain operation for a minimum of 12 hours if power is lost.

2.3.5.1 Bubble Type Level Sensor

Bubbler type liquid level sensor shall be of the hydrostatic balance type, operating from compressed air. Each gauging system shall contain the following: an air set including [compressor] [or] [connection to plant air], compressed air pressure regulating valve, air filter and moisture trap; a sight feed bubbler with built-in adjusting needle valve; a tank entry gland with air supply and equalized pilot signal connections; a 13 mm 1/2 inch [standard weight 316 stainless steel] [schedule 80 carbon steel] dip tube; a direct reading circular gauge 300 mm 12 inch in diameter calibrated for the connected tank and tank liquid; connections to the circular gauge and to the pressure transducer for zero setting and calibration check; a connecting bubbler supply and equalized pilot signal [copper] [aluminum] [stainless] tubing with minimum field made joints; and a pressure transmitter, selected to correspond to the range required to gauge the connected tank.

2.3.5.2 Capacitance Type Level Sensor

Liquid level sensor shall produce a signal that is proportional to the measured level. Sensor shall be capacitance type. The transmitter shall have non-interacting zero and span adjustments, and shall have an accuracy of plus or minus [0.1] [_____] percent of calibrated span. Assemblies shall include wall bracket or mounting plate, austenitic stainless steel rods, stainless steel bolts and corrosion resistant housing.

2.3.5.3 Conductivity Switch

The switch shall detect the presence of a fluid by measuring the electrical resistance between a sensor and a ground electrode. Electrodes shall be constructed of [316 stainless steel] [Hastelloy] [titanium]. Electrodes shall be fully clad using [polyolefin] [polytetrafluoroethylene (PTFE)]. The conductivity switch shall be capable of [1] [2] [3] [4] separate level set points. The switch shall [be provided with] [use the container as] a ground electrode. Electrode lengths shall be as necessary, based on the application and to meet the requirements of the control sequence. A relay

switching point shall be provided for each sensor. Contacts shall be rated for a maximum of 240 vAc, 5 A. Switch shall have a maximum response time of 2 seconds. Assembly shall be [flange mounted] [NPT thread (male)] [including surface mounting bracket] and suitable for the indicated environment.

2.3.5.4 Displacement Type Level Switch

Liquid level switch shall be displacement type, having a minimum of two tandem floats with each float independently activating a set of Form C contacts at two different level settings. Each switch shall have a narrow differential band. The mounting connections shall be threaded, flanged or surface mounted to suit the application. All surfaces in contact with the tank contents shall be austenitic stainless steel. The switch enclosure shall be explosion proof for use in a hazardous environment, complete with a sealed water tight junction box, terminal block, and mounting plate. Each set of contacts shall be snap action, dry contact type with one normally open and one normally closed, contact rated in accordance with NEMA ICS 1. The switch shall be actuated by a magnetically equipped stainless steel displacer. Repetitive accuracy shall be plus or minus 6 mm 1/4 inch of actual displacer setting.

2.3.5.5 Mercury Float Switch

Float switch assemblies for use in liquid systems shall consist of wall bracket or mounting plate, galvanized steel rods, stainless steel bolts, explosion proof and corrosion resistant housing, and intrinsically safe relays. Each switch shall consist of two normally open mercury switches, encapsulated in epoxy resin. The float casing shall be polypropylene. The switch cable shall be oil resistant thermoplastic cable with 4 No. 18 gauge stranded copper conductors, rated for 600 Volt application.

2.3.5.6 Reed Sensor

Sensor shall consist of a transmitter tube with a reed strip located inside. The tube length shall [be of sufficient length to permit adjustment of switch actuation within process parameters] [extend the full height of the tank]. A float containing a permanent magnet shall fit over the transmitter tube and shall move up and down with the liquid level. The transmitter tube and sliding float assembly shall be as required for the application as shown on the drawings. Wetted parts shall be [_____], [316 stainless steel,] [PVC,] [polypropylene,] or [polytetrafluoroethylene (PTFE)] suitable for the installed service indicated. Assembly shall be [flange mounted] [NPT thread (male)] [include surface mounting bracket].

2.3.5.7 Ultrasonic Sensor

The sensor shall be microprocessor based and shall provide continuous, non-contact level measurement of liquids and solids utilizing microwave pulsed time of flight measurement method. The sensor shall operate in a frequency band approved for industrial use. The sensor shall be capable of measuring in a range of 0 to [7] [1] [_____] m 0 to [20] [3] [_____] feet with an accuracy of plus or minus [1] [_____] percent of full scale. The sensor shall be capable of distinguishing between real echoes, reflections and background noise. The sensor shall automatically compensate for temperature changes. The sensor shall be capable of operating in a temperature range from minus [25] [_____] degrees C to [40] [50] [_____] degrees C minus [15] [_____] degrees F to [105] [120] [_____] degrees F. Assembly shall be [flange mounted] [NPT thread (male)] [include surface

mounting bracket] of sufficient size to eliminate echoing and suitable for the installed environment indicated. Mounting assembly shall be suitable for service without requiring entry or drainage of the [vessel] [sump] where level is being measured.

2.3.5.8 Leak Detection

Double walled containment system leak detectors shall use electrodes mounted in the interstices of double walled containment systems with a minimum time delay of [0.5] [_____] seconds. Leak detectors for open systems shall be mounted at slab or floor level with either a minimum time delay of [0.5] [_____] seconds or a minimum built-in-vertical adjustment of [3] [_____] mm [1/8] [_____] inch to prevent activation due to high humidity. Detector shall have a contact rating of 1.0 amps resistive or 200 mA inductive at 28 vDc. Leak detector panel shall indicate the location and detector causing the alarmed state. The indicator shall be manual reset type. A framed, non-fading half-size as-built location map in laminated plastic shall be provided for the cable leak detection system in double containment piping systems indicating the as installed system configuration; sensing string layout shall be furnished. Marks in meters feet along the length of pipeline interstitial cable shall be provided as references to locate leaks.

2.3.6 Pressure Instrumentation

****
NOTE: Indicate on the drawings where visual indication of the measured pressure is required. Include a schedule of pressure sensing elements with operating range requirements. Include a tabulation of devices drawings. Component identifiers are to be coordinated with the drawings using the Instrument Society of America (ISA) suggested alphanumeric system for development of discrete device numbering.
****

Pressure taps shall incorporate appropriate snubbers. The controller shall be provided with a minimum of three [alarm lights. The first alarm light shall indicate when the lower (warning) detection level has been exceeded. The second alarm light shall indicate when the upper (alarm) detection level has been exceeded. The third alarm light shall indicate a controller malfunction, including loss of power or loss of sensor input] [sets of dry contacts rated in accordance with NEMA ICS 1. The first set of contacts shall close when the lower (warning) detection level has been exceeded. The second set of contacts shall close when the upper (alarm) detection level has been exceeded. The third set of contacts shall close when a controller malfunction has occurred, including loss of power or loss of sensor input]. The alarm levels shall be individually adjustable. The controller shall be provided with an audible warning horn that sounds when the upper detection level has been exceeded, and a warning horn silence button. The controller shall provide a [4-20 mAdc] [_____] output signal to the programmable logic controller, proportional to the measured parameter. The controller shall be provided with an internal battery to maintain operation for a minimum of 12 hours if power is lost. Pressures shall be controlled to within plus or minus [5] [_____] percent of design pressures.

2.3.6.1 Pressure Sensor

The sensing element shall be either capsule, diaphragm, bellows, Bourdon tube, or solid state as applicable for the installation. The pressure transducer shall withstand up to 300 percent of rated pressure, with an accuracy of plus or minus [1.0] [_____] percent of full scale selected to put the design range of the measured pressure in the middle third of the transducer's range. Pressure shall be measured in kPa psi gage with a range, plus or minus [10] [_____] percent of design range and shall be furnished with [display] [display and printout] to the nearest [1.0] [_____] kPa [0.145] [_____] psi. The transmitter output error shall not exceed [0.1] [_____] percent of calibrated span.

2.3.6.2 Pressure Switch

Sensors shall be diaphragm or Bourdon tube and shall be constructed of [brass] [316 stainless steel] [_____]. Pressure switch shall have a repetitive accuracy of plus or minus [5.0] [_____] percent of the operating range and shall withstand up to [150] [_____] percent of rated pressure. Switch actuation set point shall be adjustable over the operating pressure range with a differential adjustment span of [20] [_____] to [40] [_____] percent of the range of the switch. The switch shall have Form C snap-action contacts rated in accordance with NEMA ICS 1.

2.3.6.3 Differential Pressure

The sensor/transmitter assembly accuracy shall be plus or minus [2] [_____] percent of full scale. The over pressure rating shall be a minimum of [300] [_____] percent of the operating pressure. Transmitter shall be suitable for installation with the low pressure connection removed.

2.3.6.4 Differential Pressure Switch

Each switch shall be an adjustable diaphragm, or bellows operated device, with taps for sensing lines for connection of pressure fittings designed to sense fluid pressure. [For measuring air, gas or vapor stream differential pressure, these fittings shall be of the angled-tip type with tips pointing into the air stream.] The adjustable differential range shall be a maximum of [0.037] [0.125] [_____] kPa [0.15] [0.5] [_____] inches water at the low end to a minimum of [0.087] [1.49] [_____] kPa [0.35] [6.0] [_____] inches water at the high end. Two Form C contacts rated in accordance with NEMA ICS 1 shall be provided.

2.3.6.5 Pneumatic to Electric (PE) Switch

Each switch shall have an adjustable set point range of [20] [_____] to [137] [_____] kPa [3.0] [_____] to [20] [_____] psi gage and an adjustable differential from [13] [_____] to [41] [_____] kPa [2.0] [_____] to [6.0] [_____] psi. Contacts shall be Form C rated in accordance with NEMA ICS 1.

2.3.7 Temperature Instrumentation

****
NOTE: Component identifiers are to be coordinated with the drawings using the Instrument Society of America (ISA) suggested alphanumeric system for development of discrete devise numbering.
****

The controller shall be provided with a minimum of three [alarm lights. The first alarm light shall indicate when the lower (warning) detection level has been exceeded. The second alarm light shall indicate when the upper (alarm) detection level has been exceeded. The third alarm light shall indicate a controller malfunction, including loss of power or loss of sensor input] [sets of dry contacts rated in accordance with NEMA ICS 1. The first set of contacts shall close when the lower (warning) detection level has been exceeded. The second set of contacts shall close when the upper (alarm) detection level has been exceeded. The third set of contacts shall close when a controller malfunction has occurred, including loss of power or loss of sensor input]. The alarm levels shall be individually adjustable. The controller shall be provided with an audible warning horn that sounds when the upper detection level has been exceeded, and a warning horn silence button. The controller shall provide a [4-20 mAdc] [_____] output signal to the programmable logic controller, proportional to the measured parameter. The controller shall be provided with an internal battery to maintain operation for a minimum of 12 hours if power is lost.

2.3.7.1 Fluid Temperature Range

****

NOTE: Include a schedule of temperature sensing elements with operating range requirements. The following includes sample tables to assist in defining the exposure and service requirements. Alternatively, tabulation of devices may be included on the drawings. Include a table on the drawings with the following headings:

ID No. Description Minimum, C Maximum, C Type

****

All devices shall be suitable for process temperatures, which define the exposure of the element, and are described in the table on the drawings. Mercury shall not be used in thermometers.

a. Type A shall be bimetal thermometer: Direct reading, hermetically sealed, suitable for external adjustment. Accurate within 1 percent of full range. Stainless steel construction. Complete with thermowell.

b. Type B shall be remote reading gas/vapor thermometer: Direct reading, [stainless steel] [aluminum] [phenolic] case designed for panel mounting, complete with armor cable, bulb and ancillary components for complete system. Movementless design, resistant to shock and vibration and free from error created by elevation. Provided with gas operated molecular sieve. Accurate within 1 percent over full range.

c. Type C shall be: [_____].

2.3.7.2 Resistance Temperature Detector (RTD)

RTD shall be platinum, with an accuracy of plus or minus [0.1] [_____] percent at 0 degrees C 32 degrees F. RTD shall be encapsulated in [epoxy,] [stainless steel Series 300,] [anodized aluminum] [or copper].

2.3.7.3 Continuous Averaging RTD

****
NOTE: Indicate on the drawings where averaging temperature probes are required.
****

Continuous averaging RTD shall have an accuracy of plus or minus [0.5] [2] [_____] degrees C [0.9] [3.6] [_____] degrees F at the reference temperature, and shall be of sufficient length to ensure that the resistance represents an average over the cross-section in which it is installed. The sensor shall have a bendable copper sheath.

2.3.7.4 Infrared Temperature Sensor

Infrared temperature sensor shall be encapsulated in series 300 stainless steel or anodized aluminum. Sensor shall have an accuracy of plus or minus 1 percent of temperature measured or 1.4 degrees C 2.5 degrees F, whichever is less.

2.3.7.5 Temperature Switch

****
NOTE: Include a table on the drawings with the following headings:

ID No. Description Minimum, C Maximum, C
****

All devices shall be suitable for process temperatures, which define the exposure of the element, and as described in the table shown on the drawings. Temperature switch shall have a repetitive accuracy of plus or minus [1] [_____] percent of the operating ranges shown. Switch actuation shall be adjustable over the operating temperature range. The switch shall have Form C snap action contacts, rated in accordance with NEMA ICS 1.

2.3.7.6 Thermocouple

****
NOTE: Thermocouples should not be used for measuring temperatures below 260 degrees C (500 degrees F).
****

Thermocouple shall be factory assembled with Series 300 stainless steel sheathing. Wiring insulation shall be magnesium oxide. Minimum insulation resistance wire to wire or wire to sheath shall be 1.5 megohm at 500 V dc. Thermocouple shall be [Type E,] [Type K,] [Type J,] [or] [Type R]. Thermocouple error shall not exceed that specified in ISA MC96.1. All wire/cable from thermocouple to transmitter shall be of the type necessary to match the thermocouple used. Transmitter selected shall match the type of thermocouple provided. The transmitter shall include automatic cold junction reference compensation with span and offset adjustments, and upscale open thermocouple detection.

2.3.7.7 Thermowell

Thermowell shall be monel, brass, or copper for use in water lines; wrought iron for measuring flue gases; and austenitic stainless steel for other

applications. Calibrated thermowells shall be provided with threaded plug and chain, 50 mm 2 inch lagging neck and inside diameter insertion neck as required for the application. The thermowell shall include a connection box, sized to accommodate the temperature sensing devise.

2.3.8 Process Analytical Instrumentation

****
NOTE: Add requirements for additional site specific measurements, including span and accuracy for any application not included in this specification.
****

Probes shall be easily removable without interrupting service. Sampling pumps shall be included where necessary or applicable to the sensing device. For sensors integral to the electronic controller the sample may be drawn directly into the sensor or may be drawn through a sample tube. For sensors remotely located the sample may be drawn through a sample tube. Outdoor sample tubes shall be heat traced. Sensor and controller construction shall be suitable for operation in the monitored medium. Systems requiring automated zero and calibration gas or reagents shall be provided with [_____] days supply of calibration gas or reagent. The controller shall be provided with a minimum of three [alarm lights. The first alarm light shall indicate when the lower (warning) detection level has been exceeded. The second alarm light hall indicate when the upper (alarm) detection level has been exceeded. The third alarm light shall indicate a controller malfunction, including loss of power or loss of sensor input] [sets of dry contacts rated in accordance with NEMA ICS 1. The first set of contacts shall close when the lower (warning) detection level has been exceeded. The second set of contacts shall close when the upper (alarm) detection level has been exceeded. The third set of contacts shall close when a controller malfunction has occurred, including loss of power or loss of sensor input]. The alarm levels shall be individually adjustable. The controller shall be provided with an audible warning horn that sounds when the upper detection level has been exceeded, and a warning horn silence button. The controller shall provide a [4-20 mAdc] [_____] output signal to the programmable logic controller, proportional to the measured parameter. The controller shall be provided with an internal battery to maintain operation for a minimum of 12 hours if power is lost.

2.3.8.1 Ammonia Gas

The sensor shall be capable of monitoring ammonia in the range of [0] [_____] to [10] [_____] mg/L with an accuracy of plus or minus [1] [_____] percent of full scale reading. The sensor response time shall be [90] [_____] percent in a maximum of [20] [_____] seconds.

2.3.8.2 Calorimeter (Heat Capacity/Fuel Value)

Calorimeter shall be a self-contained device capable of measuring the heat capacity of a sample. The colorimeter shall measure the heat released from the sample by igniting the sample reading use of multiple temperature sensors. The sensor shall be capable of detecting methane in the range of [0] [_____] to [100] [_____] ppmv with an accuracy of plus or minus [1] [_____] percent of full scale reading.

2.3.8.3 Carbon Dioxide

Continuous emissions monitoring systems (CEMS) for measuring CO2 shall be

provided with installed back-up devices. The CEMS shall comply with 40 CFR 60, Appendix B, Performance Specification 2 and the QA/QC requirements of 40 CFR 60, Appendix F. Calculation of emission rates shall be in conformance with 40 CFR 60, Appendix A, Reference Method 19. The sensor shall be capable of detecting carbon dioxide in the range of [0] [_____] to [100] [_____] ppmv with an accuracy of plus or minus [1] [_____] percent of full scale reading. The sensor response time shall be [90] [_____] percent in a maximum of [60] [_____] seconds. The controller shall monitor [a single point] [multiple points].

2.3.8.4 Carbon Monoxide

Continuous emissions monitoring systems (CEMS) for measuring CO shall be provided with installed back-up devices. The CEMS shall comply with 40 CFR 60, Appendix B, Performance Specification 4 and the QA/QC requirements of 40 CFR 60, Appendix F. Calculation of emission rates shall be in conformance with 40 CFR 60, Appendix A, Reference Method 19. The sensor shall be capable of detecting carbon monoxide in the range of [0] [_____] to [50] [100] [500] mg/L with an accuracy of plus or minus [1] [_____] percent of full scale reading. The sensor response time shall be [90] [_____] percent in a maximum of [60] [_____] seconds.

2.3.8.5 Chlorine Gas

****
NOTE: Follow Chlorine Institute Recommendations.
****

All parts of the chlorine measurement system, including the sensors, transmitters, controllers and peripheral devices, that may come in contact with chlorine or a chlorine-filled environment shall be constructed of materials suitable for this application. The chlorine sensor shall provide continuous monitoring of the chlorine level in the range from [0] [_____] to [10] [_____] mg/L with an accuracy of plus or minus [1] [_____] percent of the full scale reading. The sensor response time shall be [90] [_____] percent in a maximum of [20] [_____] seconds.

2.3.8.6 Chlorine in Liquid

****
NOTE: Follow Chlorine Institute recommendations.
****

All parts of the chlorine measurement system, including the sensors, transmitters, controllers and peripheral devices, that may come in contact with chlorine or a chlorine-filled environment shall be constructed of materials suitable for this application. Residual chlorine sensor shall continuously monitor the chlorine residual. The sensor shall be capable of detecting chlorine in the range of [0] [_____] to [1] [5] [10] [20] [_____] mg/L with an accuracy of plus or minus [1] [_____] percent of full scale reading. The sensor response time shall be [90] [_____] percent in a maximum of [60] [_____] seconds.

2.3.8.7 Combustible Gas

Combustible gas sensor shall be provided with a means to collect representative continuous samples and measure for the presence of explosive vapors. Combustible gas sensor shall be poison resistant. Measuring range shall be from [0] [_____] percent of the lower explosive limit (LEL) to 100

[_____] percent of the [lower explosive limit (LEL)] [upper explosive limit (UEL)]. Response time shall be less than [10] [_____] seconds to indicate [50] [_____] percent LEL when exposed to [100] [_____] percent LEL. Zero drift shall be less than [3] [_____] percent per year. The sensor shall have a minimum operational life of [1] [_____] year. The system shall be provided with [_____] days of zero and calibration gas.

2.3.8.8 Calorimetric Analyzer

****

NOTE: Limit the range to improve the sensitivity. Substitute the appropriate analyzer name and range in the first sentence. The remainder of the paragraph applies to any of the following:

Phenolphthalein Alkalinity Analyzer 0 to [50] [100] mg/L.
Total Alkalinity Analyzer 0 to [50] [100] [500] mg/L.
Free Chlorine Analyzer 0 to [0.5] [1.0] [2.0] [5.0] mg/L.
Total Chlorine Analyzer 0 to [0.5] [1.0] [2.0] mg/L.
Hexavalent Chromium Analyzer 0 to [0.2] [1.0] mg/L.
Copper Analyzer 0 to [5.0] [10.0] mg/L.
Hardness Analyzer 0 to [0.5] [1.0] [2.0] [5.0] [10] [20] [50] [100] mg/L.
Silica Analyzer 0 to [25] [50] mg/L.

****

[Hardness] [_____] analyzer shall be suitable for range of [0] [_____] to [0.5] [1.0] [2.0] [5.0] [10] [20] [50] [100] mg/L as [Calcium Carbonate ($CaCO_3$) equivalent] [_____]. Calorimetric analyzer shall be an on-line continuous reading process instrument using a colorimeter that compensates for moderate changes in the light source, the sample cell condition, sample turbidity and background color. Analyzer shall include sampling pumps, reagent storage and dispenser as well as colorimeter and colorimeter cell. System shall be self-cleaning. Analyzer shall require no more than weekly instrument standardization. Repeatability and reproducibility shall be plus or minus [10] percent of the alarm trip value on 1 and 2 mg/L range and plus or minus 4 percent of alarm trip value on the remaining ranges. Reagent requirements shall be no greater than 1 L each of indicator and buffer every two months for continuous operation.

2.3.8.9 Flame Ionization Detector (FID)

****

NOTE: A version with non-methane (NMOC) measurement capability is available when regulations require it.

****

A continuous flame ionization detector (FID) shall be installed on a pumped sampling line to measure the total hydrocarbon (THC) content. The analyzer must had been configured at the factory for either H_2 or H_2/He fuel and calibrated for propane or methane equivalence. Accuracy shall be not less than [_____] [4 ppmv] [10 percent of full scale] as methane. Range and span shall b e continuously variable. Precision shall be not less than [_____] [1] percent of full scale. Twenty four hour drift of both zero and span shall be no greater than plus or minus [1] [_____] percent of full scale.

2.3.8.10 Hydrogen Sulfide Gas

The hydrogen sulfide sensor shall be rated for continuous monitoring of the hydrogen sulfide level in the range from [0] [_____] to [10] [25] [50] [100] [_____] ppmv with an accuracy of plus or minus [1] [_____] percent of full scale reading. The sensor response time shall be [90] [_____] percent in a maximum of [60] [_____] seconds.

2.3.8.11 Oxides of Nitrogen (NOx) Gas

Continuous emissions monitoring systems (CEMS) for measuring NOx shall be provided with installed back-up devices. The CEMS shall comply with 40 CFR 60, Appendix B, Performance Specification 3 and the QA/QC requirements of 40 CFR 60, Appendix F. Calculation of emission rates shall be in conformance with 40 CFR 60, Appendix A, Reference Method 19. Monitor shall be designed to verify compliance with standards for NOx normalized to a 3 percent oxygen basis and shall have a range of from [0] [_____] to [100] [_____] ppmv. Sensor shall be accurate to plus or minus [5] [_____] ppmv. Sensor shall be complete with automatic zero and span calibration using a timed calibration gas system, and shall require no periodic calibration.

2.3.8.12 Oxygen Gas

Continuous emissions monitoring systems (CEMS) for measuring O2 shall be provided with installed back-up devices. The CEMS shall comply with 40 CFR 60, Appendix B, Performance Specification 2 and the QA/QC requirements of 40 CFR 60, Appendix F. Calculation of emission rates shall be in conformance with 40 CFR 60, Appendix A, Reference Method 19. Oxygen in air shall be monitored by an oxygen sensor and electronic controller. The oxygen sensor shall be rated for continuous monitoring of the oxygen level in air in the range of [0] [_____] to [20] [25] [30] [_____] percent with an accuracy of plus or minus [1] [_____] percent of full scale reading. The sensor response time shall be [90] [_____] percent in a maximum of [60] [_____] seconds. The controller shall have automatic zeroing and shall require no normal maintenance or periodic recalibration.

2.3.8.13 Oxygen Dissolved

The dissolved oxygen sensor shall provide continuous measure of dissolved oxygen. Wetted materials shall be [stainless steel,] [PVC] or glass. Sensor shall be rated for continuous use to a depth of [15] [_____] m [50] [_____] feet and shall be automatically temperature compensating over the temperature range. Sensor shall be capable of measuring dissolved oxygen level of from [0] [_____] to [15] [_____] ppmv. The sensor shall have an accuracy of plus or minus [1] [_____] percent of full scale reading.

2.3.8.14 Oxygen Reduction Potential (ORP)

The sensor shall be [submersible] [flow-through] type. Sensor shall have a range of plus or minus [500] [_____] mV and shall have an accuracy of plus or minus [0.1] [_____] percent of sensor span. The sensor shall automatically compensate for temperature over the temperature range. The sensor body shall be PVC, CPVC or epoxy and suitable for installation in the environment.

2.3.8.15 Ozone (O3) Gas

****

NOTE: The standard instrument provides the range 0-1,000 ppmv (parts per million by volume) an alternate display of ozone concentration is in millipascals.

****

Ozone in air shall be monitored by a ozone gas sensor and electronic controller. The sensor shall be capable of detecting ozone in the range of [0] [_____] to [1,000] [_____] ppmv with an accuracy of plus or minus [1] [_____] percent of the full scale reading. The sensor response time shall be [90] [_____] percent in a maximum of [60] [_____] seconds.

2.3.8.16 Ozone (O3) in Water

The dissolved ozone sensor shall provide continuous measurement of dissolved ozone level from [0] [_____] to [20] [_____] mg/L. The sensor shall automatically compensate for temperature over the temperature range. The sensor shall have an accuracy of plus or minus [1] [_____] percent of the full scale reading. [System shall include variable area flow meter and needle valve to regulate rate of sample flow through sensor unit.] [Sensor shall be suitable for direct submersion.]

2.3.8.17 pH Monitoring

****

NOTE: Limit the range to improve the sensitivity.

****

The sensor shall be [submersible] [or] [flow-through] type. Sensor shall have a range of [1] [4] [5] [5.5] [_____] pH units to [8.5] [9] [11] [14] [_____] pH units and shall have an accuracy of plus or minus [0.1] [0.01] [_____] pH unit. The sensor shall automatically compensate for temperature over the temperature range. The sensor body shall be PVC, CPVC or epoxy.

2.3.8.18 Photoionization Detector

****

NOTE: Refer to other Section where concentration data is given. Show sampling points on the drawings.

****

Contaminant and background concentrations are [as follows:] [_____]. Photoionization detector shall be provided with a means to collect representative continuous samples and measure for the presence of volatile organic compounds (VOCs). Sampling points are as indicated on the drawings. The system shall be provided with automated zero and calibration gas system.

2.3.8.19 Total Dissolved Solids (TDS)

The TDS sensor shall measure the specific conductance using a conductivity sensor, displaying the total dissolved solids value in [milligrams per liter (mg/L) of dissolved NaCl equivalent] [microohms (microSiemens) per centimeter (uS/cm)] and transmitting an analog signal for remote processing. System shall be industrial grade and suitable for measurement of conductivity in a solution [by insertion of the sensing element into the pipeline, using a hot tap assembly] [including a variable area flow meter and needle valve to regulate rate of sample flow through sensor unit]. Sensor assembly shall be suitable for periodic removal for adjustment and

cleaning without requiring shut down of the process. Sensor shall be suitable for range of [0] [_____] to [10,000] [_____] [milligrams per liter (mg/L) of dissolved NaCl equivalent] [microohms per centimeter (uS/cm)]. Range shall be field verified for the application and adjusted as required. Sensing element shall be constructed of [316 stainless steel] [_____] and glass, including temperature element, and be capable of continuous operation. Sensing element shall be unaffected by color in the fluid, pressure, and rate of flow. Sensor shall have automatic temperature compensation and shall require no normal maintenance or periodic recalibration.

2.3.8.20 Water Turbidity

System shall be complete and include indicating meter, sensing element and a transmitter. System shall be industrial grade and suitable for measurement of turbidity by [insertion of the sensing element into the pipeline, using a hot tap assembly] [direct submersion of the sensing element into the vessel or flow channel]. Sensor assembly shall be suitable for periodic removal for adjustment and cleaning without requiring shutdown of the process. Sensor shall be suitable for range from [0] [_____] to [2] [20] [200] Nephelometric turbidity units (NTU). The accuracy shall be plus or minus [2] [_____] percent of full scale reading. Range shall be field verified for the application and adjusted as required. Sensing element shall be constructed of [316 stainless steel] [_____] and glass. Sensing element shall be unaffected by color in the fluid, pressure, temperature and rate of flow. Sensor shall have automatic zeroing and shall require no normal maintenance or periodic recalibration.

2.3.9 Electrical Instrumentation

Electrical power measurements with a range for the specific application, plus or minus [1.0] [_____] percent of range (display and print to nearest kWh and kW). Electrical measurements with a range for the specific application plus or minus [1.0] [_____] percent of range (display and print to nearest [0.1] [_____] for volts and amperes, and to the nearest [0.01] [_____] for VAR and PF).

2.3.9.1 Hour Meter

Hour meter shall provide a totalized readout of the number of hours of operation for the equipment monitored. Meter shall provide readout with a minimum of [5] [6] [7] digits including [1] [_____] decimal places. The display shall be non-resettable. The meter shall be driven by a [24] [120] [240] vAc synchronous motor.

2.3.9.2 Watt-Hour Meter

Watt-hour meters shall be in accordance with ANSI C12.1 and shall have pulse initiators for remote monitoring of watt-hour consumption. Meter sockets shall be in accordance with ANSI C12.1. Pulse initiator shall consist of Form C contacts with a current rating not to exceed 2 amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 10 VA, and a life rating of one billion operations.

2.3.10 Miscellaneous Measurements

Miscellaneous measurements with a range for the specific application plus or minus [1.0] [_____] percent of range (display and print to nearest [0.1] [_____] of the specified units.

2.4 COMPRESSED AIR STATIONS

****
NOTE: If the control system does not utilize pneumatic devices, the air compressor and accessories should be deleted.
****

Submit instrumentation compressed-air station schematic diagram showing equipment utilized, including compressor with motor output and voltage; starter; isolators; manual bypasses; tubing sizes; drain piping and drain traps; reducing valves; air-dryer; and data on manufacturer's names and model numbers, mounting, access, and clearance requirements. Include in the air-compressor and air-dryer data calculations of the air consumption of current-to-pneumatic transducers (IPs), pneumatic control valves and of other control system devices to be connected to the compressed-air station; the number of starts per hour, the running time for the unit selected; and the compressed air-supply dewpoint temperature at 552 kPa 80 psig.

2.4.1 Air Compressor Assembly

The air compressor shall be a high-pressure compressing unit with electric motor. The compressor shall be equipped with a motor with totally enclosed belt guard, an operating-pressure switch, safety relief valves, gauges, intake filter and intake silencer and combination type magnetic starter with under voltage protection and thermal overload protection for each phase, and shall be supported by a steel base mounted on an air storage tank. The air compressor shall provide the compressed air required for control operation while operating not more than one-third of the time. The tank shall be of sufficient volume so that no more than six compressor starts per hour are required with the starting pressure switch differential set at 140 kPa 20 psi gage. The air storage tank shall be fabricated for a working pressure of not less than 1380 kPa 200 psi gage and constructed and certified in accordance with ASME BPVC SEC VIII D1. The tank shall be provided with an automatic condensate drain trap with manual override feature. [A second (duplex arrangement) compressor of capacity equal to the primary compressor shall be provided, with interlocked control to provide automatic changeover upon malfunction or failure of either compressor. A manual selector switch shall be provided to index the lead compressor including the automatic changeover.]

2.4.2 Compressed Air Station Specialties

2.4.2.1 Refrigerated Dryer, Filters and Pressure Regulator

A refrigerated dryer shall be provided in the air outlet line of the air storage tank. The dryer shall be of the size required for the full [delivery capacity of the compressor] [air requirement of the control system]. The air shall be dried at a pressure of not less than 483 kPa 70 psi gage to a temperature not greater than 2 degrees C 35 degrees F. The dryer shall be provided with an automatic condensate drain trap with manual override feature. The refrigerant used in the dryer shall be one of the fluorocarbon gases and have an ozone depletion potential of not more than 0.05. A 5 micron prefilter and coalescing-type oil removal filter with shut-off valves shall be provided in the dryer discharge. Each filter bowl shall be rated for 1034 kPa 150 psi gage maximum working pressure. A pressure regulator with high side and low side pressure gauges and a safety valve shall be provided downstream of the filter. Pressure regulators of

the relieving type shall not be used.

2.4.2.2 Coalescing Filter

A coalescing prefilter, together with an automatic drain valve, shall be provided for removal of liquids. The flow through the prefilter shall be from inside to outside and reduce an entrained quantity of 50 ppmv oil to 0.0013 ppmv effluent liquid oil and water and remove all particulates greater than 0.6 micron absolute. The prefilter housing (bowl) shall be fitted with a drain port to eliminate collected liquids and provide sufficient sump volume to prevent liquid re-entrainment, and an automatic drain valve with adjustable cycle and drain times. Prefilter pressure drop shall be less than 21 kPa 3 psi saturated. A particulate after filter, outside to inside flow, designed to remove desiccant fines shall be provided. The after filter cartridge shall have a particulate removal rating of 0.5 micron absolute. Both prefilter and after filter housings shall allow for service of elements without removing the entire assembly from the system. Filter life shall be stated and guaranteed by the vendor.

2.4.2.3 Flexible Pipe Connections

The flexible pipe connectors shall be designed for 1034 kPa 150 psi gage and 121 degrees C 250 degrees F service and shall be constructed of rubber, polytetrafluoroethylene (PTFE) resin or braided corrosion-resistant steel, bronze, monel or galvanized steel. The connectors shall be suitable for the service intended and may have threaded or soldered ends. The length of the connectors shall be as recommended by the manufacturer for the service intended.

2.4.2.4 Vibration Isolation Units

The vibration isolation units shall be standard products with published loading ratings and shall be single rubber-in-shear, double rubber-in-shear or spring type.

2.4.2.5 Compressed Air Piping

Control air delivered to the system shall conform to ISA 7.0.01. Air lines for pneumatic controls shall be seamless copper tubing or nonmetallic tubing. Nonmetallic tubing shall be compounded from polyethylene. Air lines concealed in walls shall be hard-drawn copper tubing or nonmetallic tubing in rigid conduit. Terminal single lines shall be hard-drawn copper tubing except when the run is less than 300 mm 12 inches in length, flexible polyethylene may be used. Nonmetallic tubing will not be used for applications where the tubing could be subjected to a temperature exceeding 55 degrees C 130 degrees F. Fittings for nonmetallic tubing shall be for instrument service and may be brass or acetyl resin of the compression or barbed push-on type. Tubing shall be as follows:

a. Copper tubing shall conform to ASTM B88M ASTM B88 and shall have sweat fittings and valves. Exposed tubing shall be hard drawn in exposed areas and hard-drawn or annealed in concealed areas. Only tool made bends shall be used. Fittings for copper tubing shall be brass or copper solder joint type except at connections to the apparatus, where fittings shall be brass compression type. Grooved mechanical joints and fittings shall be designed for not less than 862 kPa 125 psig service and shall be the product of the same manufacturer. Grooved fittings and mechanical coupling housing shall be ductile conforming to ASTM A536. Gaskets for use in grooved joints

shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D 2000 for circulating medium up to 110 degrees C 230 degrees F. Grooved joints shall conform to AWWA C606. Tubing shall be rack mounted where multiple tubes run in parallel. Multiple tubes may be bundled when concealed.

b. Tubing shall be flame resistant, multiple polyethylene tubing in an extruded PVC protective sheath, or unsheathed polyethylene tubing in rigid metal, intermediate metal, or electrical metallic tubing conduit for areas where tubing is exposed. Tubing shall have barbed fittings and valves, and shall conform to the following: Burst pressure shall be 3.8 MPa 550 psi gage at 24 degrees C 75 degrees F to 1.2 MPa 175 psi gage at 66 degrees C 150 degrees F, minimum. Stress crack resistance in accordance with ASTM D 1693 shall be 200 hours, minimum. Tensile strength in accordance with ASTM D 638 shall be 14 MPa 2000 psi, minimum. Average density in accordance with ASTM D 792 shall be 920 kg/m3. Average flow rate in accordance with ASTM D 1238 shall be 0.30 decigram per minute.

c. Plastic tubing shall have the burning characteristics of linear low density polyethylene tubing, shall be self extinguishing when tested in accordance with ASTM D 635, shall have UL 94 V-2 flammability classification, and shall withstand stress cracking when tested in accordance with ASTM D 1693. Polyethylene tubing shall not be used for smoke removal systems.

2.4.3 Barrier Jacket

Plastic tubing bundles shall be provided with mylar barrier and flame retardant polyethylene jacket. Each tube shall be numbered.

2.5 PROGRAMMABLE LOGIC CONTROLLER (PLC)

****
NOTE: Typically, either modular or loop type PLCs will be used throughout the control system. The designer must determine which is best suited for the application and delete the paragraph pertaining to the type that will not be used. If it is determined that the use of both types is necessary, the drawings will indicate where each type will be used and both types will be included in the edited specification.
****

2.5.1 PLC General Requirements

PLCs shall be micro-processor based, capable of receiving discrete and analog inputs and, through programming, shall be able to control discrete and analog output functions, perform data handling operations and communicate with external devices. PLCs shall meet the requirements of Class A computing devices, and shall be labeled as set forth in 47 CFR 15 and shall be able to withstand conducted susceptibility test as outlined in NEMA ICS 1, NEMA ICS 2, NEMA ICS 3, [and] [or] IEEE C37.90.1. PLCs shall function properly at temperatures between 0 and 50 degrees C 32 and 122 degrees F at 5 to 95 percent relative humidity non-condensing and shall tolerate storage temperatures between minus 40 and plus 60 degrees C 40 and plus 140 degrees F at 5 to 95 percent relative humidity non-condensing.

2.5.2 Modular PLC

PLCs shall be based on a modular, field expandable design allowing the system to be tailored to the process control application. The system shall be expandable through the use of additional hardware and/or user software. As a minimum, the PLC shall include a mounting backplane, power supply module, central processing unit (CPU) module, communications module, and input/output (I/O) module. The modules shall be grouped together in a mounting rack or cabinet. The mounting rack backplane shall provide the communications mechanism to fully integrate the individual modules located within the rack. Modules shall plug directly into the backplane. The use of wire connectors between modules will not be allowed. The rack size shall be as needed to hold the equipment necessary while performing the required control functions. The system configuration shall allow for the removal and/or installation of modules under power.

2.5.2.1 Central Processing Unit (CPU) Module

The CPU module shall be a self contained, microprocessor based unit that provides time of day, scanning, application (ladder rung logic) program execution, storage of application programs, storage of numerical values related to the application process and logic, I/O bus traffic control, peripheral and external device communications and self diagnostics.

2.5.2.2 Communications Module

The communications module shall allow peer-to-peer communication with other PLCs and shall allow the PLC to communicate with the central station, or workstation. The communication module shall utilize the manufacturer's standard communication architecture and protocol, ethernet architecture and protocol or a combination of these. The communication module shall allow programming of the PLC to be done locally through the use of a laptop computer or from the central station or remote workstation.

2.5.2.3 Power Supply Module

One or more power supply modules shall be provided as necessary to power other modules installed in the same cabinet. Power supply modules shall plug directly into the backplane. Auxiliary power supplies may be used to supply power to remote cabinets or modules.

a. Power supply modules shall use [AC] [DC] power with a nominal voltage of [120 vAc] [220 vAc] [24 vDc] plus or minus 5 percent. The power supply module shall monitor the incoming line voltage level and shall provide over current and over voltage protection. If the voltage level is detected as being out of range the power supply module shall continue to provide power for an adequate amount of time to allow for a safe and orderly shutdown. Power supply modules shall be capable of withstanding a power loss for a minimum of 20 milliseconds while still remaining in operation and providing adequate power to all connected modules.

b. Each power supply module shall be provided with an on-off switch integral to the module. If the manufacturer's standard power supply module is not provided with an on-off switch, a miniature toggle type switch shall be installed near the PLC and shall be clearly labeled as to its function.

c. Power supply modules shall be provided with an indicating light

which shall be lit when the module is operating properly.

2.5.2.4 Input/Output (I/O) Modules

Modules shall be self contained, microprocessor based units that provide an interface to field devices. The module shall be located in the same mounting rack as the other PLC components. The unit shall plug directly into the backplane of the mounting rack. Each module shall contain visual indication to display the on-off status of individual inputs or outputs.

2.5.3 Loop PLC

PLCs shall be single or multiple loop controllers depending on the control system requirements. Controllers shall be self contained and shall include a central processing unit (CPU), program memory, power supply, input/output capability, network communications capability and display/keyboard. The controller shall have a scaleable process variable for each loop. Analog input signals shall be based on the use of proportional, integral and derivative (PID) control logic. Analog outputs shall be configured as direct acting or reverse acting. The controller shall have keyboard, display, auto/manual selection for control of each loop output, remote setpoint, adjustment/local setpoint adjustment selection with adjustable high-end and low-end limits, ratio and bias adjustment on remote setpoint input, operator-initiated self-tune/manual-tune selection and anti-reset wind-up feature. Controller shall power analog output loops to 20 mAdc when connected to a load of 600 ohms.

2.5.3.1 Central Processing Unit (CPU)

The central processing unit shall be microprocessor based and shall provide time of day, scanning, application program (ladder rung logic) execution, storage of application programs, storage of numerical values related to the applications process and logic, I/O bus traffic control, peripheral and external device communications and self diagnostics.

2.5.3.2 Power Requirements

Each controller shall be powered by 120 vAc. Power consumption shall not exceed 25 watts. Controller shall provide electrical noise isolation between the AC power line and the process variable inputs, remote setpoint inputs and output signals of not less than 100 dB at 60 Hertz common mode rejection ration and not less than 60 dB at 60 hertz normal-mode rejection ration.

2.5.3.3 On-Off Switch

Each controller shall be provided with an integral on-off switch. If the controller is not provided with a manufacturers standard on-off switch, a miniature toggle type switch shall be installed near the controller and shall be clearly labeled as to its function.

2.5.3.4 Parameter Input and Display

Control parameters shall be entered and displayed directly, in the correct engineering units, through a series of keystrokes on a front panel display with decimal point and polarity indication. Display shall be [in metric English units] [in metric or English units as selected by the operator].

2.5.3.5 Self Tuning

Controllers shall be provided with self-tuning operation which shall apply to proportional, integral and derivative modes of control and shall modify the mode constants as required. Self-tuning shall only be in operation when selected from the front panel.

2.5.3.6 Manual Tuning

Controllers shall be provided with manual tuning operation which shall apply to proportional, integral and derivative modes of control, by means of individually adjustable mode constants. These adjustments shall be set for the appropriate value if a particular control mode action is required or to zero if that particular mode is not desired. The proportional mode constant shall be adjustable from 0 to 200 percent of the input signal range. The integral mode constant shall be adjustable from 0 to 20 repeats per minute. The derivative mode constant shall be adjustable from 0 to 5 minutes.

2.5.4 Program Storage/Memory Requirements

The CPU shall utilize the manufacturer's standard non-volatile memory for the operating system. The controller shall have electronically erasable, programmable, read only memory (EEPROM) for storage of user programs and battery backed RAM for application memory. The EEPROM shall be loaded through the controller keypad, central station or through the use of a laptop computer. The CPU memory capacity shall be based on the system's control requirements. The memory capacity shall be sized such that, when the system is completely programmed and functional, no more than 50 percent of the memory allocated for these purposes is used.

2.5.5 Input/Output Characteristics

Each controller shall allow for analog input, analog output, discrete input and discrete output. The number and type of inputs and outputs for the system shall be as shown on the drawings and shall comply with the sequence of control. The system capacity shall include a minimum of 20 percent spare input and output points (no less than two points) for each point type provided. During normal operation, a malfunction in any input/output channel shall affect the operation of that channel only and shall not affect the operation of the CPU or any other channel. Analog input circuits shall be available in [+/-10V] [+/-5V] [0-10V] [0-5V] [4-20 mA]. Discrete input circuits shall be available in [5 volt TTL] [10-30 vDc] [18-26 vDc] [79-132 vAc]. All input circuits shall have a minimum optical isolation of 1500 VRMS and shall be filtered to guard against high voltage transients from the externally connected devices. Analog output circuits shall be available in [+/-10V] [4-20 mA]. Discrete output circuits shall be available in [5 volt TTL] [10-30 vDc] [18-26 vDc] [79-132 vAc]. All output circuits shall have a minimum optical isolation of 1500 VRMS and shall be filtered to guard against high voltage transients from the externally connected devices.

2.5.6 Wiring Connections

Wiring connections shall be heavy duty, self lifting, pressure type screw terminals to provide easy wire insertion and secure connections. The terminals shall accept two #14 AWG wires. A hinged protective cover shall be provided over the wiring connections. The cover shall have write-on areas for identification of the external circuits.

2.5.7 On-Off Switch

Each controller shall be provided with an integral on-off power switch. If the controller is not provided with a manufacturer's standard on-off switch, a miniature toggle type switch shall be installed in the control panel near the controller and shall be clearly labeled as to its function.

2.5.8 Diagnostics

Each PLC shall have diagnostic routines implemented in firmware. The CPU shall continuously perform self-diagnostic routines that will provide information on the configuration and status of the CPU, memory, communications and input/output. The diagnostic routines shall be regularly performed during normal system operation. A portion of the scan time of the controller shall be dedicated to performing these housekeeping functions. In addition, a more extensive diagnostic routine shall be performed at power up and during normal system shutdown. The CPU shall log input/output and system faults in fault tables which shall be accessible for display. When a fault affects input/output or communications modules the CPU shall shut down only the hardware affected and continue operation by utilizing the healthy system components. All faults shall be annunciated at [the PLC] [and] [the central station]. Diagnostic software shall be useable in conjunction with the portable tester.

2.5.9 Accuracy

Controllers shall have an accuracy of plus or minus 0.25 percent of input span.

2.6 PLC SOFTWARE

All PLC software described in this specification shall be furnished as part of the complete control system.

2.6.1 Operating System

Each PLC shall be provided with the manufacturer's standard operating system software package. The PLC shall maintain a point database in its memory that includes all parameters, constraints and the latest value or status of all points connected to the PLC. Execution of the PLC application programs shall use the data in memory resident files. The operating system shall support a full compliment of process control functions. It shall be possible to define these functions using a mix of function blocks, ladder logic diagrams, sequential function charts and text programming. Programming methods and interactions shall be based on IEC 61131-3. A combination of the programming methods shall be possible within a single controller. The operating system shall allow loading of software locally or from the central station and data files from the portable tester. It shall also support data entry and diagnostics using an operator interface panel attached directly to the PLC. Each PLC shall be capable of operating in stand alone mode.

2.6.1.1 Startup

The PLC shall have startup software that causes automatic commencement of operation without human intervention, including startup of all connected I/O functions. A PLC restart program based on detection of power failure at the PLC shall be included in the PLC software. The restart program

shall include start time delays between successive commands to prevent demand surges or overload trips.

2.6.1.2 Failure Mode

Upon failure for any reason, each PLC shall perform an orderly shutdown and force all PLC outputs to a predetermined (failure mode) state, consistent with the failure modes shown and the associated control device.

2.6.2 Functions

The controller operating system shall be able to scan inputs, control outputs, and read and write to its internal memory in order to perform the required control as indicated in the sequence of control on the drawings. The controller shall periodically perform self diagnostics to verify that it is functioning properly.

2.6.2.1 Analog Monitoring

The system shall measure and transmit all analog values including calculated analog points.

2.6.2.2 Logic (Virtual)

Logic (virtual) points shall be software points entered in the point database which are not directly associated with a physical I/O function. Logic (virtual) points shall be analog or digital points created by calculation from any combination of digital and analog points, or other data having all the properties of real points, including alarms, without the associated hardware. Logic (virtual) points shall be defined or calculated and entered into the database. The calculated analog point shall have point identification in the same format as any other analog point.

2.6.2.3 State Variables

If an analog point represents more than two (up to 8) specific states, each state shall be nameable. For example, a level sensor shall be displayed at its measured engineering units plus a state variable with named states usable in programs or for display such as low alarm/low/normal/high/high alarm.

2.6.2.4 Analog Totalization

Any analog point shall be operator assignable to the totalization program. Up to eight analog values shall be totalized within a selectable time period.

2.6.2.5 Trending

****
NOTE: If the trending function is to be performed at the central station and is not required to be done at the PLC, this requirement will be deleted.
****

Any analog or calculated point shall be operator assignable to the trend program. Up to eight points shall be sampled at individually assigned intervals, selectable between 1 minute and 2 hours. A minimum of the most

recent 128 samples of each trended point shall be stored. The sample intervals shall be able to be defined, modified, or deleted online.

2.6.3 Alarm Processing

****
NOTE: If the alarm processing function is to be performed at the central station and is not to be done at the PLC, this requirement will be deleted.
****

Each PLC shall have alarm processing software for AI, DI, and PA alarms for all real and virtual points connected to that PLC.

2.6.3.1 Digital Alarms

Digital alarms are those abnormal conditions indicated by DIs as specified and shown. The system shall automatically suppress analog alarm reporting associated with a digital point when that point is turned off.

2.6.3.2 Analog Alarms

Analog alarms are those conditions higher or lower than a defined value, as measured by an AI. Analog readings shall be compared to predefined high and low limits, and alarmed each time a value enters or returns from a limit condition. Unique high and low limits shall be assigned to each analog point in the system. In control point adjustment (CPA) applications, key the limit to a finite deviation traveling with the setpoint. The system shall automatically suppress analog alarm reporting associated with an analog point when that analog point is turned off.

2.6.3.3 Pulse Accumulator (PA) Alarms

Pulse accumulator alarms are those conditions calculated from totalized values of accumulator inputs or PA input rates that are outside defined limits as specified and shown. PA totalized values shall be compared to predefined limits and alarmed each time a value enters a limit condition. Unique limits shall be assigned to each PA point in the system.

2.6.4 Constraints

2.6.4.1 Equipment Constraints Definitions

Each control point in the database shall have PLC resident constraints defined and entered by the Contractor, including as applicable: maximum starts (cycles) per hour; minimum off time; minimum on time; high limit (value in engineering units); and low limit (value in engineering units).

2.6.4.2 Constraints Checks

All control devices connected to the system shall have the PLC constraints checked and passed before each command is issued. Each command point shall have unique constraints assigned. High and low "reasonableness" values or one differential "rate-of-change" value shall be assigned to each AI. Each individual point shall be capable of being selectively disabled by the operator from the central station.

2.6.5 Control Sequences and Control Loops

****
NOTE: Sequences to be implemented will be developed by the designer to meet site requirements. The designer will define allowable process control loop accuracies as a part of the sequences. Control sequences and database tables will be shown on the drawings.
****

Specific functions to be implemented are defined in individual system control sequences and database tables shown on the drawings, and shall include, as applicable, the following functions: PI control shall provide proportional control and proportional plus integral control; two position control shall provide control for a two state device by comparing a set point against a process variable and an established dead band; floating point control shall exercise control when an error signal exceeds a selected dead band, and shall maintain control until the error is within the dead band limits; signal selection shall allow the selection of the highest or lowest analog value from a group of analog values as the basis of control and shall include the ability to cascade analog values so that large numbers of inputs can be reduced to one or two outputs; signal averaging shall allow the mathematical calculation of the average analog value from a group of analog values as the basis of control and shall include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control; reset function shall develop an AO based on up to two AIs and one operator specified reset schedule.

2.6.6 Command Priorities

A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. Override commands entered by the operator shall have higher priority than those emanating from applications programs.

2.6.7 Resident Application Software

****
NOTE: The data base and settings tables will be incorporated into the contract package. Specify only those applications programs to be implemented at time of acceptance. Do not specify a program unless sensors and controls required to implement it are included in the design package.
****

Provide resident applications programs developed in accordance with paragraph Graphical Object Oriented Programming to achieve the sequences of operation, parameters, constraints, and interlocks necessary to provide control of the process systems connected to the control system. All application programs shall be resident in the PLC and shall execute in the PLC, and shall coordinate with each other, to insure that no conflicts or contentions remain unresolved.

2.6.7.1 Program Inputs and Outputs

Use program inputs listed for each application program to calculate the

required program outputs. Where specific program inputs are not available, a "default" value or virtual point appropriate for the equipment being controlled and the proposed sequence of operation shall be provided to replace the missing input, thus allowing the application program to operate.

2.6.7.2 Failure Mode

****
NOTE: Assure that the appropriate failure modes are identified on the drawings.
****

In the event of a PLC failure, the controlled equipment shall continue to function in the failure mode shown on the drawings.

2.7 CONTROL PANELS

****
NOTE: For locations or equipment that will be powered by an uninterruptible power supply (UPS) during a commercial power outage, the control panel shall be included on the UPS.

Include in the design package requirements for sufficient ventilation, heating or air conditioning to ensure that the control panel internal temperature and humidity will be maintained within the PLCs operational parameters when exposed to the temperature and humidity indicated in paragraph SITE ENVIRONMENTAL CONDITIONS. Include allowance for any solar gain. If the requirements for ventilation, heating and air conditioning are not necessary, they will be deleted.
****

2.7.1 Components

2.7.1.1 Enclosures

The enclosure for each control panel shall conform to the requirements of NEMA 250 for the types specified. Finish color shall be the manufacturer's standard, unless otherwise indicated. Damaged surfaces shall be repaired and refinished using original type finish. Enclosures for installation in mechanical equipment rooms shall be Type [1] [4] [12]; those for installation in clean, dry indoor occupied space may be Type 1; other locations shall be as otherwise specified or shown. Enclosures for equipment installed outdoors shall be Type 4 or as shown. Enclosures for installation in a corrosive environment shall be Type 4X and shall be constructed of [stainless steel] [fiberglass] [polymer plastic]. Painted steel shall not be allowed for use in a corrosive environment. Enclosure shall be provided with a single, continuously hinged exterior door with print pocket, 3-point latching mechanism and key lock and a single, continuously hinged interior door.

2.7.1.2 Controllers

Controllers shall be in accordance with paragraph Programmable Logic Controller (PLC).

2.7.1.3 Standard Indicator Light

Indicator lights shall comply with NEMA ICS 1, NEMA ICS 2 and UL 508. Lights shall be heavy duty, round and shall mount in a 22.5 mm 0.875 inch mounting hole. Indicator lights shall be LED type and shall operate at 120 vAc or 24 vDc. Long life bulbs shall be used. Indicator light shall be provided with a legend plate labeled as shown on the drawings. Lens color shall be as indicated on the drawings. Lights shall be push to test (lamp) type.

2.7.1.4 Selector Switches

****
NOTE: Indicate on the drawings where key operated switches are required.
****

Selector switches shall comply with NEMA ICS 1, NEMA ICS 2 and UL 508. Selector switches shall be heavy duty, round and shall mount in a 22.5 mm 0.875 inch mounting hole. The number of positions shall be as indicated on the drawings. Switches shall be [illuminated] [non-illuminated] [as indicted of the drawings]. Switches shall be rated for 600 volts, 10 amperes continuous. Selector switches shall be provided with a legend plate labeled as shown on the drawings. Where indicated or required, dual auxiliary contacts shall be provided for the automatic position to provide position sensing at the central station or workstation. Auxiliary contacts shall be rated for 120 vAc, 1A as a minimum. Where indicated on the drawings, switches shall be key operated. All keys shall be identical.

2.7.1.5 Push Buttons

Push buttons shall comply with NEMA ICS 1, NEMA ICS 2 and UL 508. Push buttons shall be heavy duty, round and shall mount in a 22.5 mm 0.875 inch mounting hole. The number and type of contacts shall be as indicated on the drawings or required by the Sequence of Control. Push buttons shall be rated for 600 volts, 10 amperes continuous. Push buttons shall be provided with a legend plate labeled as shown on the drawings.

2.7.1.6 Relays

Relays shall comply with IEEE C37.90 and derated for altitude above 1,500 m. Relays shall be [single-pole, single-throw (SPST)] [single-pole, double-throw (SPDT)] [double-pole, single throw (DPST)] [double-pole, double-throw (DPDT)] [as required by the Sequence of Control]. Relay coil shall be [120 vAc] [24 vDc] and shall be provided with matching mounting socket. Power consumption shall not be greater than 3 watts.

2.7.1.7 Terminal Blocks

Terminal blocks shall comply with NEMA ICS 4 and UL 1059. Terminal blocks for conductors exiting control panels shall be two-way type with double terminals, one for internal wiring connections and the other for external wiring connections. Terminal blocks shall be made of bakelite or other suitable insulating material with full deep barriers between each pair of terminals. A terminal identification strip shall form part of the terminal block and each terminal shall be identified by a number in accordance with the numbering scheme on the approved wiring diagrams.

2.7.1.8 Chart Recorder

****
NOTE: Delete this paragraph if no chart recorders are required as part of control panels. If multiple control panels are provided, indicate on the drawings which are to be provided with chart recorders.
****

Chart recorders shall be microprocessor based circular recorder capable of recording up to [1] [2] [4] [_____] inputs simultaneously. Input applications shall include temperature, pressure, flow and level. The recorder shall receive inputs in the form of [4-20 mA] [or] [0-5 vDc] signals and shall record the data in the proper engineering units. Each chart shall record [24 hours] [7 days] [the time frame indicated on the drawings]. Pens shall be replaceable, felt tip type. Recorder shall have an accuracy of plus or minus [1] [_____] percent of full scale. Charts shall be paper, 250 mm 10 inches in diameter. Recorder shall operate using [120] [240] vAc electrical power and shall operate in a temperature range of 0 to 45 degrees C 32 to 115 degrees F.

2.7.1.9 Event Recorders

****
NOTE: Delete this paragraph if an event recorder is not required as part of the control panel. If multiple control panels are provided, indicate on the drawings which are to be provided with an event recorder.
****

Recorder shall be provided with [8] [16] [32] [_____] channels for input of data [and [_____] assignable alarm relay contacts]. Engineering units, scaling factor and alarm limits shall be assignable to each channel. The recorder shall have a slow chart speed for normal operation and a faster speed for alarm conditions. The recorder will automatically operate at the faster speed when one or more channels exceed their high or low alarm setting. The date and time shall be printed when the alarm condition begins and when the alarm condition has cleared. The recorder shall automatically return to the normal speed when the alarm has cleared. The recorder normal speed shall be selectable from 0.2 to 300 cm/hour 0.01 to 120 inches/hour in increments of 0.02 cm/hour 0.01 inch/hour. The recorder shall have an accuracy of plus or minus 1 percent of full scale input for each channel. Recorder shall operate using [120] [240] vAc electrical power and shall operate in a temperature range of 0 to 45 degrees C 32 to 115 degrees F.

2.7.1.10 Autodialer

Autodialer shall be a self contained, programmable device capable of automatic operation. The unit shall automatically dial preprogrammed number(s) to report alarm(s) or other specified conditions. The autodialer shall automatically redial upon receipt of a busy signal. The number of redials shall be an operator definable parameter. The unit shall be capable of dialing a minimum of three phone numbers. The unit shall communicate over voice grade phone lines.

2.7.1.11 Alarm Horns

Alarm horns shall be provided where indicated on the drawings. Horns shall be vibrating type and shall comply with UL 508. Horns shall provide 100 dB at 10 feet. Exterior mounted horns shall be weather proof by design or shall be mounted in a weather proof enclosure that does not reduce the effectiveness of the horn.

2.7.2 Panel Assembly

Control panels shall be factory assembled and shipped to the jobsite as a single unit. Panels shall be fabricated as indicated and devices shall be mounted as shown or required. Each panel shall be fabricated as a bottom-entry connection point for control system electrical power, [control system main air source,] control system wiring, [control air pneumatic tubing,] [communications system wiring to [other control panels] [operators workstation]].

2.7.3 Electrical Requirements

Each panel shall be powered by a dedicated [120 volts ac] [220 volts ac] circuit, with a fuse, [10 amp] [_____] [sized as recommended by the equipment manufacturer], and a disconnect switch located inside the panel. Wiring shall terminate inside the panel on terminal blocks. Electrical work shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as shown on the drawings.

2.7.4 Power Line Conditioner

Each control panel shall be provided with a power line conditioner to provide both voltage regulation and noise rejection. The power line conditioner shall be of the ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power line side. The power line conditioner shall be sized for 125 percent of the actual connected kva load. Characteristics of the power line conditioner shall be as follows:

2.7.4.1 85 Percent Load

At 85 percent load, the output voltage shall not deviate by more than plus or minus 1 percent of nominal voltage when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal voltage.

2.7.4.2 Load Changes

During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus 3 percent of nominal voltage. Full correction of load switching disturbances shall be accomplished within 5 cycles, and 95 percent correction shall be accomplished within 2 cycles of the onset of the disturbance.

2.7.5 Grounding

Control panel enclosures shall be equipped with a solid copper ground bus or equivalent. The ground bus shall be securely anchored to the enclosure so as to effectively ground the entire structure. Clamp-type terminals sized large enough to carry the maximum expected current shall be provided on the ground bus for grounding cables. Where a definite circuit ground is required, a single wire not less than #10 AWG shall run independently to

the panel ground bus and shall be fastened to the ground bus with a bolted terminal lug. Cases of instruments, relays and other devices shall be effectively grounded through the enclosures steel structure unless otherwise indicated. Insulated wiring having a continuous rated current of not less than the circuit fuse rating shall be used for grounding. Grounding terminals of power receptacles shall be solidly grounded to the panel enclosure.

2.7.6 Convenience Outlet

****
NOTE: Coordinate with electrical drawings to provide power for control panel convenience outlet and other required accessories.
****

A 120 volt ac, 20 amp, ground fault interruption (GFI) type duplex convenience outlet shall be provided inside the panel. The outlet circuit shall be separate from the panel power circuit.

2.7.7 Panel Interior Light

[Where indicated,] [Each] control panel[s] shall be provided with a [60 watt incandescent] [40 watt fluorescent] light. The light shall be operated by a manual on-off switch mounted on the interior door of the enclosure. The light shall be powered by the same circuit as the convenience outlet.

2.7.8 Ventilation System

[Where indicated,] [Each] control panel[s] shall be provided with two single phase, 120 volt ac ventilation fans. Each fan shall supply a minimum of 50 L/s 100 cfm of ventilation air through the enclosure. Each fan shall be provided with a line voltage thermostat. Thermostat setpoints shall be adjustable in a range of 21 to 60 degrees C 70 to 140 degrees F as a minimum. Each supply and exhaust grille shall contain a filter that is easily removed for cleaning or replacement.

2.7.9 Heating System

[Where indicated,] [Each] control panel(s) shall be provided with a thermostatically controlled electric heater capable of maintaining an enclosure temperature of [2] [_____] degrees C [35] [_____] degrees F when continuously exposed to an ambient temperature of [_____] degrees C degrees F.

2.7.10 Air Conditioning System

[Where indicated,] [Each] control panel[s] shall be provided with a mechanical refrigeration air conditioning system. The system shall be capable of maintaining a temperature of [38] [_____] degrees C [100] [_____] degrees F inside the enclosure with all equipment in the panel operating and while continuously exposed to [full sunlight and] an ambient air temperature of [_____] degrees C degrees F. The compressor and condenser shall be located outside the control panel enclosure. Provisions shall be made to remove condensate from the control panel and to protect all devices within the enclosure from condensate.

2.8 CENTRAL STATION AND OPERATORS WORKSTATION EQUIPMENT

2.8.1 Workstation Computer

****
NOTE: The designer must edit the following paragraph to require only the computer equipment that is necessary based on the requirements and complexity of the control system. If an operator's workstation is not required or if its requirements differ from those for the central station computer, reference to it shall be deleted from this section. If the requirements for the operator's workstation computer are the same as those for the central station computer, this section will be used for both. Indicate on the drawings where the central station is to be located. Verify that the location for the equipment will be provided with climate controls to provide a suitable environment for the equipment. Indicate the central station and the required DTS on the control system block diagram.
****

Computer shall be a standard [desk top] [tower] configuration, unmodified digital computer of modular design. Computing devices, as defined in 47 CFR 15, supplied as part of the control system shall be certified to comply with the requirements of Class B computing devices and shall be labeled as set forth in 47 CFR 15.

2.8.1.1 Minimum Processor Operating Speed

[Dual micro processors] [A single microprocessor] with Processors with minimum processor operating speed of [3.06GHz] [2.80GHz] [2.66GHz] [2.53GHz] [2.40GHz] [2.20GHz] [2.0GHz] [1.8GHz] [1.7GHz] [233MHz] [166MHz] [_____].

2.8.1.2 RAM Memory

Ram memory shall be [2GB] [128MB] [32MB] [_____], expandable to a minimum of [_____] GB.

2.8.1.3 Power Supply

Minimum power supply shall have a capacity of [250] [180] [160][_____] watts. Suspend to RAM (S3) sleep support with wakeup capabilities.

2.8.1.4 Real Time Clock (RTC)

Real time clock accurate to within plus or minus [one] [_____] minute per month. Battery backed for a minimum of 3 months.

2.8.1.5 Input/Output (I/O) Ports

1 PS/2 keyboard 101 key, 64 character standard ASCII character set based on ANSI INCITS 154 with 8 programmable hotkeys.

1 PS/2 [2 button] [touch pad] mouse: minimum resolution of 16 dots per mm 400 dots per inch.

1 NIC

2 serial [_____] TIA-232 ports. Data transmission rate shall be software adjustable between 9600 and 57,600 bps.

1 enhanced parallel port.

1 Ethernet

1 [1000 G network connection] [1180 wireless network adapter] [RJ-45 network port]

[8] [_____] USB [2] [_____] in front and [6] [_____] in rear

1 graphic

1 microphone

1 audio in

1 audio out

1 headphone

1 IEEE 1394 controller card

2.8.1.6 SVGA Color Monitor

SVGA color monitor shall be no less than [432] [_____] mm [17] [_____] inches, with a minimum resolution of [1280 by 1024] [_____] pixels, noninterlaced, and a maximum dot pitch of [0.28] [_____] millimeters. The video output card shall support at least [256] [_____] colors at a resolution of [1280 by 1024] [_____] at a minimum refresh rate of [70] [_____] Hz.

2.8.1.7 Hard Disk

Hard disk with a minimum of [3.2] [_____] gigabytes of formatted storage.

2.8.1.8 Floppy Disk Drives

[One] [Two] high density floppy disk drive[s] and controller[s] in 90 mm 3-1/2 inch diameter size shall be provided.

2.8.1.9 Zip Drive

One zip drive and controller with [250 MB] [100 megabyte] of formatted storage shall be provided.

2.8.1.10 Modem

****

NOTE: The designer will show the required telephone circuits to support the telephone modem specified.

****

Modem shall operate [on integrated services digital network (ISDN) circuits] [on analog telephone lines] at [128K] [56K] [28.8] [_____] kbps,

full duplex using asynchronous communications. It shall have an error detection, auto answer/autodial, and call progress detection. The modem shall meet the requirements of [ITU V.34, ITU V.42 bis] [_____] for error correction and [ITU V.42 bis] [_____] for data compression standards. Model shall be suitable for operating on [ISDN circuits] [unconditioned voice grade telephone lines] in conformance with 47 CFR 68.

2.8.1.11 CD Drive

CD drive: [ROM] [CD-read/write [RW]] [DVD-ROM/CD-RW] combination drives with formatted storage capacity of [650] [_____] megabytes, [24X] [_____] speed.

2.8.1.12 Network Interface Card

Network interface card shall be provided for LAN equipment functions and for serving devices as shown on the drawings. The network interface card shall use a 16 bit interface to the data bus; it shall be supplied with an on-board [RJ45] [_____] connector and transceiver for direct connection to the LAN. It shall also have an auxiliary unit input port for performing diagnostics. On-board buffer of at least 16K bytes shall be included to prevent the loss of data packages.

2.8.2 Operator's Workstation Computer

****
NOTE: If an operator's workstation is required, indicate its location on the drawings. Indicate the operator's workstation and required DTS on the control system block diagram. If an operator's workstation is not required, reference to it will be deleted. If the requirements for the operator's workstation computer are different than those for the central station computer, list those items that are different.
****

The operator's workstation computer shall be the same as the central station computer, except for the following items: [_____].

2.8.3 Printer

A laser printer shall installed at each of the following connections [the central station computer] [and] [the operator workstation]. The printer shall meet the following requirements: The input interface shall be a parallel port connection. Resolution shall be a minimum of [23 by 23 dots/mm 600 by 600 dots/inch] [_____]. Printing speed shall be a minimum of [4] [_____] pages per minute. The data buffer size shall be a minimum of [10] [_____] megabytes. The size for paper and other media shall be [216 by 28 mm 8.5 X 11 inches] [_____]. The paper cassette shall have a [250] [_____] sheet minimum capacity.

2.8.4 LAN System

The local area network (LAN) shall be used to allow communication between PLCs located in the control panel[s], the central station computer [and the operator's workstation computer] [and the printer]. The LAN system configuration and requirements shall comply with the control system schematics and block diagram shown on the drawings and [Section 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM] [Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP)]. All LAN equipment shall fully comply with IEEE 802.3 (10 BASE 2 or 10 BASE T) Ethernet networks. Cables and connecting hardware shall conform to the requirements of [Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM] [Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP)].

2.8.5 LAN Hubs

Network hubs shall provide communication between network devices using network cables. Network hubs shall support protocol utilized in the LAN. Network hubs shall be modular and expandable from a minimum of [_____] [16] ports up to [_____] [48] ports. Each port shall have LED indicator for network monitoring status. Network hubs shall permit online network changes without disturbing network devices. Malfunctioning network devices shall be automatically removed from service without shutting down the network.

2.8.6 Uninterruptible Power Supply (UPS)

A self contained UPS suitable for installation and operation at the central station [and operator's workstation] shall be provided. The unit[s] shall be sized to provide a minimum of 10 minutes of operation of the central station [and operator's workstation] computer. The UPS shall incorporate surge suppression, noise filtering (normal and common mode) short circuit protection and voltage regulation (brownout and overvoltage protection). UPS shall be complete with all necessary power supplies, transformers, batteries, and accessories and shall include visual indication of normal power operation, UPS operation, abnormal operation and visual and audible indication of low battery power. The UPS shall comply with the Federal Communications Commission Standard 15J part A for radio noise emissions.

2.8.7 Portable Tester/Workstation

A portable tester/workstation shall be provided and shall be connectable to any PLC. The portable tester/workstation shall consist of a portable computer with a nominal 250 mm 10 inch active color matrix liquid crystal display, capable of displaying up to 256 colors at a minimum resolution of [640 x 480] [_____] pixels, 64 bit microprocessor operating at a minimum of [133] [_____] MHz. The portable tester/workstation shall have, as a minimum, [1.2] [_____] GB hard drive, [16] [_____] megabytes of memory, integral pointing device, serial and parallel ports, color VGA video port for an external color monitor, 88 mm 3.5 inch floppy disk drive, modem, PCMCIA type 3 slot, rechargeable battery, battery charger and a compatible network adapter. The portable tester/workstation shall be provided with the proper cables, connectors, adapters and software required to connect to and be compatible with the PLCs. Connection may be made directly to the PLCs or to the communications network. The tester/work station shall be capable of performing all workstation functions contingent on proper password level.

2.8.8 Communication and Programming Device

A hand-held communication and programming device shall be provided. The communication and programming device shall connect to the PLC directly for readout of variables, override, control, servicing, troubleshooting and adjustment of control parameters. The device shall be provided with all necessary cables, connectors and adapters to allow connection to the PLC. The device shall communicate in English language for inquiry, reporting and

programming purposes.

2.9 CENTRAL STATION SOFTWARE

****
NOTE: The designer should edit this paragraph, as needed, to require only the central station software that is necessary based on the requirements and complexity of the control system. Where no information is available on future expansion, require a minimum expansion capability of 50 percent. Where specific expansion requirement information is available, it shall be used to determine the expansion capability requirements.
****

The central station software shall provide the communication, programming and control capabilities necessary to support all specified points and functions, plus a minimum expansion of [50] [_____] percent of the current number of points, complete with their point database. The central station shall be online at all times and shall perform all required functions as specified. The central station software shall be one or more standard software modules. Where multiple modules are used the modules shall be capable of sharing data and operating together seamlessly. Software shall be windowing type using icons and pull down menus. The system shall support multiple user operation with multiple tasks for each user and shall support operation and management of all peripheral devices.

2.9.1 Graphical Operations

2.9.1.1 Graphical User Interface

The central station shall be provided with an object-oriented, mouse driven, graphical user interface. The graphical user interface shall include a set of desktop utilities including the following: file management; shell tool; calculator; text editor; and icon editor.

2.9.1.2 Display Information

The central station shall display information necessary to support all requirements specified, including: operator commands; alarm notification; reports; system graphics as specified and as shown, incorporating dynamic data; and curve plotting.

2.9.1.3 System Graphics Implementation

System graphics displays shall be hierarchical displays which integrate dynamic data into the display. System graphics shall reflect actual system configuration. Each system schematic shall be included as a separate display. Different colors, textures, and use of inverted video shall be used for various components and dynamic data. The displays shall include standard and/or custom symbols. A library of callable display symbols containing symbols for all necessary equipment and control devices shall be furnished. Symbols shall conform to ASHRAE FUN SI ASHRAE FUN IP where applicable. Data associated with a display shall be updated within 5 seconds of the digital status change or the analog change in excess of the analog change differential. Any dynamic data which is not current, due to PLC communications failure, PLC failure, or point out of service, shall be highlighted or flagged.

2.9.1.4 Display Editor

The display editor shall enable the user to create, modify, save and delete displays and symbols. Within the display shall be dynamic fields. The function of linking the dynamic fields with the database shall be handled by a separate software module which shall be executed automatically as the last step of the database generation and modification procedure.

2.9.1.5 Graphical Object Oriented Programming

The system shall include a graphical object oriented programming function which shall be used to create all control sequences utilized in the control panels. This function shall reside in the central station to create, modify, and test software for control panel resident programs. The graphical object oriented programming function shall provide programming elements to be connected together to create a logic diagram. The diagram shall be compilable to produce executable code for the control panel. The graphical object oriented programming function shall include elements necessary to create logic diagrams that represent sequences of operation. Program elements shall be able to be combined into a custom template which can then be used as a standard function. Program checkout and debug facilities shall include display of dynamic and/or simulated system variables and points on the programming screens. The user shall be able to fix or force values of variables to enable program checkout during debugging. The programming shall allow for the use of the portable tester for loading files directly into the control panel, uploading of existing control panel programming and database information and downloading of control panel programming and database information.

2.9.1.6 Charting

The user shall be able to display data in chart formats, and the system shall support the presentation of data: 1) with time on the X-axis (horizontal) and amplitude on the Y-axis (vertical) for trend charts; and 2) in bar chart form with a minimum of 360 15-minute divisions and 31 1-day divisions to be displayed on the X-axis.

2.9.1.7 System Menus and Displays

The user shall be able to call up the following displays by dedicated function key, pull down menu or by icon and shall be able to page forward and backward on linked multiple page displays. The system menu and index displays shall also contain icons which can be used to call up subsequent displays.

a. System Menu (list of all graphics and menus).

b. Index (list of all PLCs).

c. Alarm Summary (list of all uncleared alarms).

d. Abnormal Summary (list of all devices not in normal state; keeps track of alarm conditions which have been cleared).

e. Data Communications Summary (listing of availability for each communication channel, by statistically processing the number of transmission errors, outages, and other abnormal conditions for each channel).

2.9.1.8 Hard-Copy Screen Request

The central station shall be able to obtain a hard copy of the monitor display being viewed. This shall be an exact "snapshot" of the data and device symbols shown on the selected monitor.

2.9.2 Command Software

The software shall provide for defining and selecting points, parameters, graphics, report generation, and all other functions associated with operation. The operator commands shall be usable from central station computer and workstation keyboards with individual operator passwords as specified.

2.9.2.1 Command Input

Command menus shall utilize full words and acronyms selected to allow operators to use the system without extensive training or data processing backgrounds. The system shall prompt the operator.

2.9.2.2 Command Input Errors

The system shall supervise operator inputs to ensure they are correct for proper execution. Operator input assistance shall be provided whenever a command cannot be executed because of operator input errors.

2.9.2.3 Special Functions

The system shall support the following special functions by using a mouse, in addition to all other commands specified:

a. Help shall produce a display of all commands available to the operator. The help command, followed by a specific command, shall produce context sensitive listing with a short explanation of the purpose, use, and system reaction to that command.

b. Start/Enable shall manually start equipment and enable monitoring and control of points.

c. Stop/Disable shall manually stop equipment and disable monitoring and control components.

d. Display Diagram shall display diagrams of specific utility systems or other systems.

e. Diagram Development shall facilitate development of diagrams of specific utility systems or other systems.

f. Auto/Override shall override automatic operation of a point or return a point to automatic operation.

g. Print Report shall allow the operator to print reports.

h. Confirm Action shall allow the operator to confirm that the desired command sequence has been correctly entered and is to be executed.

i. Cancel Action shall perform the opposite function of the confirm action, at any time prior to executing confirm action.

j. Memo Pad shall allow the operator to create, store and retrieve pop-up notes.

2.9.2.4 Operator's Commands

The operator's commands shall provide the means for entry of control and monitoring commands, and for retrieval of information. The operator's commands shall perform such tasks as requesting a display of any digital, analog, or accumulator point, or any group of related points, startup and shutdown selected systems or devices, modifying, adjusting, enabling or defining a point or point parameters.

2.9.2.5 Level of Addressing

****
NOTE: When specifying level of addressing for identification, delete Area or Facility where not required.
****

Four levels of addressing for identification shall be provided as follows:

a. Point. The individual sensor or control device within a unit.

b. Unit. The unit that a point is associated with, such as a blower.

c. Sub-system. The sub-system that a point is located in or near.

d. System. The system that a sub-system is located in or near.

2.9.2.6 System Access Control

A minimum of [_____] passwords shall be usable with the control system software. The system shall maintain an ASCII disk file logging all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications for each password. Each password shall be definable as to the functions that the operator can perform.

2.9.3 Alarms

The software shall notify an operator of the occurrence of an alarm condition. The control system alarm history shall be stored in an ASCII file and shall be recallable by the operator using the report generator. Alarm messages shall take precedence over other functions. A minimum of the most recent [25] [_____] system alarms shall be directly available at the central station computer. Operator acknowledgment of one alarm shall not be considered as acknowledgment of any other alarm nor shall it inhibit reporting of subsequent alarms. Alarm data to be displayed and stored shall include: identification of the alarm; date and time to the nearest second of occurrence; device or sensor type; limit exceeded (if analog); engineering units; current value or status; alarm class; and alarm messages.

2.9.3.1 Digital Alarms

Digital alarms shall be subject to immediate reporting, within the alarm response time, at the central station.

2.9.3.2 Analog Alarms

These alarms shall be subject to immediate reporting, within the alarm response time, at the central station. The control panel analog readings shall be compared to predefined high and low limits, and alarmed to the central station each time a value enters or returns from a limit condition. The program shall automatically change the high or low limits, or both, of any analog point, based on time scheduled operations as specified, allowing for a time interval before the new alarm limit becomes effective. For those applications where setpoint adjustments are made, the alarm limit shall be keyed to a finite deviation traveling with the setpoint.

2.9.3.3 Alarm Messages

A unique message with a field of 60 characters shall be provided for each alarm. Assignment of messages to a point shall be an operator editable function. Secondary messages shall be assignable by the operator for printing to provide further information, such as telephone lists or maintenance functions, and shall be editable by the operator.

2.9.3.4 Alarm Classes

Classes of alarms, which will be identified for each item, include class 1 and class 2 alarm conditions. Class 1 (Critical) shall include display, print, and audible alarm at occurrence and at return-to-normal. Acknowledgment of class 1 alarms by the operator shall be required at occurrence and at return-to-normal. Class 2 (Informational) shall include display, print, and audible alarm at occurrence and at return-to-normal. No acknowledgment of class 2 alarms is required unless otherwise shown.

2.9.4 Pop-up Note Function

A pop-up note function shall be included with the central station, providing the operator a capability of noting any data which may be associated with alarms or with any other event. A note created by an operator shall be automatically called up when any other workstation calls up the associated point, alarm, or alarm summary. The pop-up note function shall also support free form entry of data which can be used by any workstation operators as general reminders or instructions.

2.9.5 Real Time Clock Synchronization

****
NOTE: If real time clock synchronization is not required, this paragraph will be deleted.
****

The system shall synchronize each central station computer, real time clock, within one second and at least once per day automatically, without operator intervention and without requiring system shutdown. The central station computer shall automatically initiate a call once per day to the NIST clock to obtain the correct time and date and update the real time clock. The central station computer shall generate a report showing the time difference.

2.9.6 System Reaction

Under system normal heavy load, no more than [10] [_____] seconds shall

lapse from the time a digital status alarm or analog alarm occurs at a PLC until the change is displayed at the central station [and operator's workstation]. The total system response time from initiation of a control action command to display of the resulting status change shall not exceed [20] [_____] seconds under system normal heavy load conditions, assuming a zero response time for operation of the PLC's control device. The alarm printer shall continue to print out all occurrences, including time of occurrence, to the nearest second. All system normal heavy load conditions shall be introduced to the system via AIs and DIs.

2.9.6.1 Occurrence

System normal heavy load conditions are defined as the occurrence throughout the system of a total of three status changes, three digital alarms, three analog high or low limit alarms, and three analog quantity changes within the high and low limits during a single 1-second interval. This number of similar occurrences shall repeat on a continuous basis during successive 1-second intervals for a period of 2 minutes.

2.9.6.2 Location

System normal heavy load conditions, as specified, shall have 50% of the changes and alarms, including no less than one of each type, occurring at a single PLC with the remaining changes and alarms distributed among the remaining PLCs.

2.9.7 Report Generator

Software shall be provided to generate and format standard and custom reports for displaying, printing, and storing on disk. Reports shall use database values and parameters, values calculated using the real time static database or historical data base; with the reports subsequently stored on hard disk or zip drive. Dynamic operation of the system shall not be interrupted to generate a report. The report shall contain the time and date when the sample was taken, and the time and date when the report was printed.

2.9.7.1 Periodic Automatic Report

The system shall allow for specifying, modifying, or inhibiting the report to be generated, the time the initial report is to be generated, the time interval between reports, end of period, and the output peripheral.

2.9.7.2 Request Report Mode

The system shall allow for the operator to request, at any time, an immediate printout of any report.

2.9.8 Data Interchange

Software shall be provided to format and store on a removable diskette the data, trends, profiles, reports and logs as specified in a defined, standard format such as ASCII text or DIF for export and further processing by other software and/or computer systems.

2.9.9 Control Panel and DTS Circuit Alarms

The system shall supervise each control panel, I/O function and DTS circuit for alarm reporting, including: control panel not responding; control panel

responding (return to normal); control panel to central station DTS circuit high error rate; control panel to control panel DTS circuit high error rate; control panel/central station real time clock error more than 15 seconds (adjustable); control panel intrusion alarm; control panel offline; control panel online (return to normal); control panel failure (self-diagnostics); point not responding to command; and point change of state without command.

2.9.10 Central Station Database

The central station database shall be stored on disk and in memory. The static database shall be downloadable as required to control panels in the system.

2.9.10.1 Database Definition Process

Software shall be provided to define and modify each point in the database using operator commands. The definition shall include all physical parameters and constraints associated with each point. Each database item shall be callable for display or printing, including EEPROM, ROM and RAM resident data. Each point shall be defined and entered into central station database.

2.9.10.2 Dynamic Database

The dynamic database includes those variables which change with time or conditions including all DIs, AIs, PAs, and virtual (logic) points.

2.9.10.3 Dynamic Database Update

The dynamic database shall be updated from the field, allowing the operator to select update times from 0.1 seconds to 2.0 seconds.

2.9.10.4 Static Database

The static database includes those fixed parameters and constraints from all PLCs which define the characteristics of the system and I/O functions such as alarm limits, start/stop times, point names, PLC channel addresses, and sensor spans.

2.9.10.5 Central Station Static Database Update

A copy of each control panels static database shall be updated automatically once per day, each time an authorized change is submitted or upon demand from the central station database.

2.9.10.6 Workstation Access to Dynamic Data

Any workstation with proper access password and connected to the central station via the DTS, or via a dial-up telephone circuit, shall have access to the central station's dynamic data. Display of data shall commence within 5 seconds.

2.9.11 Historical Data Storage and Retrieval

A historical data storage and retrieval function shall be provided at the central station to collect and store dynamic data. This function shall be in addition to other data storage requirements. The function shall have the capability to collect and store alarm status changes, point values,

events and operator commands, and system responses. The storage function shall also have the capability to collect and store multiple sets of analog data at pre-specified sampling rates. This function shall have the capability to retain historical data on hard disk for pre-specified time periods, up to forty five days using last day roll over, for short-term analysis, and then output the data to the zip drive for long-term retention. The operator shall also be able to selectively recall short-term data stored on hard disk. Retrieval and printing of the contents of any selected historical data file shall be available using the data retrieval and report generation program. The output of the report generation program shall be capable of being viewed on the screen, printed in a report, or stored.

2.9.12 Trending

Any analog or calculated point shall be operator assignable to the trend program. Points shall be sampled at individually assigned intervals, selectable between one minute and 24 hours. The system shall automatically store the accumulated trend data to an ASCII disk file. The size of the trend data file shall be limited only by available disk space. The program shall print portions of the file as selected by the operator.

2.9.13 Analog Monitoring

The system shall measure, transmit, and display analog values, including calculated analog points. Differential measurements shall be displayed as positive or negative values with respect to their reference points shown. An analog change in value is defined as a change exceeding a preset differential value as specified. Each analog change in value shall be operator selectable and settable to provide for a minimum reporting change in value of one-half the specified end-to-end accuracy of the measured variable. Displays and reports shall express analog values in proper engineering units with sign. Provide 128 different sets of engineering unit conversions. Each engineering conversion unit shall include range, span, and conversion equation.

2.9.14 Analog Totalization

Any analog or calculated point shall be operator assignable to the totalization program. The analog totalization time period shall be defined uniquely for each point. At the end of the period, totals shall be stored on disk for future reference. Totalization shall then restart from zero for the next time period. The program shall keep track of the peak and total value measured during the current period and for the previous period. The operator shall be able to initiate a summary of totalization information on a point, unit, sub-system or system. The operator shall be able to set or reset each totalized value individually. The operator shall be able to define, modify, or delete the time period online.

2.9.15 LAN Software

A network operating system shall be supplied as part of the LAN software. The network operating system shall support network device access to the central station. The system shall provide workstation access to the central station as a virtual terminal. The network shall provide network access to shared peripherals. The LAN software shall provide for transparent communication with any node on the system. The LAN software shall support the following:

2.9.15.1 Access Control

Access control to the central station computer and workstations. Operators shall be able to perform all specified functions, given the proper passwords, including database definition/modification, graphic creation/modification, and trending.

2.9.15.2 Multiple Sessions

Support operation in multiple sessions.

2.9.15.3 Other Functions and Configurations

Other functions and configurations shown.

2.10 DATA COMMUNICATION REQUIREMENTS

****
NOTE: The designer will edit the following paragraph as needed to require only the data communications requirements that are necessary based on the requirements and complexity of the control system. A communications system layout or block diagram must be provided on the drawings to clearly show the communications system configuration requirements.
****

Control system data communications shall support the specified functions and control system configuration shown on the drawings.

2.10.1 Central Station/Workstation

Each workstation shall be able to communicate with the central station as a virtual terminal. The workstation shall be able to initiate uploads or downloads of programs and resident data, including parameters of connected systems PLCs and devices, constraints and programs in the central station.

2.10.2 Central Station/PLC

The central station shall be able to initiate an upload or download of PLC data programs.

2.10.3 Modem Communication

****
NOTE: Indicate on the communications system layout diagram, on the drawings, where modem communication is required. Coordinate this with the central station/workstation computer requirements.
****

Communication with other computer systems shall be accomplished using a modem and dialup circuit. The central station or workstation shall be able to initiate upload or download of data files, however, answering incoming calls shall not be possible (for system security reasons).

2.10.4 Error Detection and Retransmission

Asynchronous transmission system shall use cyclic code error detection methods. The predicted undetected error rate shall not exceed 1 bit in 1 billion. A message shall be in error if one bit is received incorrectly. The system shall retransmit messages with detected errors. Where a LAN is not utilized for data transmission, a 2-digit decimal number shall be operator assignable to each communication link representing the number of retransmission attempts. When the number of consecutive retransmission attempts equals the assigned quantity, the central station shall close down transmission to that particular device, and print an alarm message. The operator shall manually reopen any communications line after automatic closedown, subject to the same error checking and automatic closedown procedures in effect before the first automatic closedown. The system shall monitor the frequency of data transmission errors for display and logging.

2.11 CONSUMABLE SUPPLIES

****
NOTE: The designer will edit the following paragraph as needed to require only the supplies that are necessary based on the type and quantity of computer equipment required.
****

Provide the following consumable supplies, after the endurance test, to the Government. These extraordinary supplies shall not be used during system installation or testing.

CONSUMABLE SUPPLIES

blank zip cartridges	[10]	[_____]	each
diskettes 89 mm 3-1/2 inch	[2]	[_____]	boxes of 10 each
laser printer toner cartridges	[2]	[_____]	each
color printer ink cartridges	[2]	[_____]	per color
dot matrix printer ribbons	[2]	[_____]	each
color printer paper	[2]	[_____]	boxes
alarm printer fanfold paper	[1]	[_____]	box

2.12 FACTORY TEST

****
NOTE: Evaluate the need for factory tests. Take into account the size of the system, the complexity of the system, the devices that comprise the system as well as other pertinent information. If a factory test is deemed necessary, the factory test requirements below shall be tailored to the control system to be tested. If any factory test is deemed unnecessary, delete it from the following paragraphs.
****

The control system shall be tested at the factory prior to shipment. Written notification of planned testing shall be given to the Government at least 21 days prior to testing, and in no case shall notice be given until after the Contractor has received written Government approval of the test procedures.

2.12.1 Factory Test Setup

****
NOTE: Items not applicable to the factory test should be deleted.
****

Assemble and integrate the factory test setup as specified to prove that performance of the system satisfies all requirements of this project, including system communications requirements in accordance with the approved test procedures. The factory test shall take place during regular daytime working hours on weekdays. Equipment used shall be the same equipment that is to be delivered to the site. The factory test setup shall include the following:

	Factory Test
central station equipment	one each of the components
workstation	one of each type
control panel	not less than two control panels: at least one of each type used in the system plus at least one per DTS type
test set	one of each type
portable tester	one of each type
communications circuits	one of each type and speed to be utilized in the proposed system including bridges, modems, encoder/decoders, transceivers and repeaters.
surge protection equipment	for power, communications, I/O functions and networks
I/O functions	sufficient to demonstrate the I/O capability and system normal operation
software	software required for proper operation of the proposed system including application programs and sequences of operation

2.12.2 Factory Test Procedure

Test procedures shall define the tests required to ensure that the system meets technical, operational, and performance requirements. The test procedures shall define location of tests, milestones for the tests, and identify simulation programs, equipment, personnel, facilities, and supplies required. Provide for testing all control system capabilities and functions specified and shown. Ccover actual equipment and sequences to be

used for the specified project and include detailed instructions for test setup, execution, and evaluation of test results. The test reports shall document results of the tests. Surge testing need not be conducted acceptable documented proof can be provided that such testing has been satisfactorily demonstrated to the Government with identical surge protection applied. The procedures shall include the following:

	Test Procedure
equipment	block diagram
hardware and software	descriptions
commands	operator commands
I/O functions	test database points with failure modes
passwords	required for each operator access level
each type of digital and analog point in the test	description
test equipment	list
surge protection	circuit diagrams
inputs required (I/O point values and status) and corresponding expected results of each set of input	for each application program
default values	for the application program inputs not implemented or provided for in the contract documents for the application programs to be tested

2.12.3 Factory Test Report

Submit original copies of data produced during the factory test, including results of each demonstration procedure within 7 days after completion of each test. Arrange the report so that commands, responses, and data acquired are correlated to allow logical interpretation of the data.

PART 3 EXECUTION

3.1 EQUIPMENT INSTALLATION REQUIREMENTS

3.1.1 Installation

Install system components and appurtenances in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Adjust or replace devices not conforming to the required accuracies. Replace factory sealed devices, rather than adjusting.

a. Install instrumentation and communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.

b. Install wiring in exposed areas, including low voltage wiring, in metallic raceways or EMT conduit as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wiring in air plenum areas installed without conduit shall be plenum-rated in accordance with NFPA 70.

c. Submit detail drawings containing complete piping, wiring, schematic, flow diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Piping and Instrumentation (P&ID) drawings (prepared using industry recognized device symbols, clearly defined and describing piping designations to define the service and materials of individual pipe segments and instrument tags employing Instrument Society of America suggested identifiers). Include in the Drawings, as appropriate: product specific catalog cuts; a drawing index; a list of symbols; a series of drawings for each control system using abbreviations, symbols, nomenclature and identifiers as shown; valve schedules; compressed instrument air station schematics and ASME air storage tank certificates for each type and make of compressed instrument air station.

3.1.1.1 Isolation, Penetrations and Clearance from Equipment

Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exteriors shall be made watertight. Holes in concrete, brick, steel and wood walls shall be drilled or core drilled with proper equipment; conduits installed through openings shall be sealed with materials which are compatible with existing materials. Openings shall be sealed with materials which meet the requirements of NFPA 70 and Section 07 84 00 FIRESTOPPING. Installation shall provide clearance for control-system maintenance. Control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.1.2 Device Mounting

Devices shall be installed in accordance with manufacturers' recommendations and as shown. Control devices to be installed in piping shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Any deviations shall be documented and submitted to the Government for approval prior to mounting. Damaged insulation shall be replaced or repaired after devices are installed to match existing work. Damaged galvanized surfaces shall be repaired by touching up with zinc paint.

3.1.1.3 Pneumatic Tubing

Tubing shall be concealed in finished areas. Tubing may be run exposed in unfinished areas, such as mechanical equipment rooms. For tubing to be enclosed in concrete, rigid metal or intermediate metal conduit shall be provided. Tubing shall be installed parallel or perpendicular to building walls throughout. Maximum spacing between tubing supports shall be 1.5 m 5 feet. Each tubing system shall be tested pneumatically at 1.5 times the working pressure for 24 hours, with a maximum pressure drop of [0.15] [_____] kPa [1.0] [_____] psig with compressed air supply turned off. Joint leaks shall be corrected by remaking the joint. Caulking of joints will not be permitted. Tubing and two insulated copper phone wires for

installation checkout may be run in the same conduit. Tubing and electrical power conductors shall not be run in the same conduit; however, control circuit conductors may be run in the same conduit as polyethylene tubing.

3.1.1.4 Grooved Mechanical Joints

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be the products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded.

3.1.2 Sequences of Operation

Study the operation and sequence of local equipment controls, as a part of the conditions report, and note any deviations from the described sequences of operation on the contract drawings. Perform necessary adjustments to make the equipment operate in an optimum manner and shall fully document changes made.

3.2 INSTALLATION OF EQUIPMENT

Install equipment as specified, as shown and as required in the manufacturer's instructions for a complete and fully operational control system.

3.2.1 Control Panels

Control panels shall be located as indicated on the drawings. Devices located in the control panels shall be as shown on the drawings or as needed to provide the indicated control sequences.

3.2.2 Flow Measuring Device

Fluid flow instruments shall be installed in accordance with manufacturer's recommendations, unless otherwise indicated in the specification. The minimum straight unobstructed piping for the flowmeter installation shall be 10.0 pipe diameters upstream and 5.0 pipe diameters downstream. Meters for gases and vapors shall be installed in vertical piping, and meters for liquids shall be installed in horizontal piping, unless otherwise recommended by the manufacturer or indicated in the specifications.

3.2.2.1 Flow Nozzle

Flow nozzles flanges shall be installed so that the pressure taps are in a horizontal plane with the centerline of the pipe. Flow nozzles shall be installed for ease of accessibility for periodic maintenance. Differential pressure sensors shall be installed as close to the flow nozzle as possible.

3.2.2.2 Flow Switch

Flow switches shall be installed in such a manner as to minimize disturbance of the flow of fluid while maintaining reliable operation of the switch.

3.2.2.3 Magnetic Flowmeter

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NOTE: Locating magnetic flowmeters near large electric motors or transformers should be avoided.
****

Meter shall be installed in vertical piping so that the flow tube remains full of the process fluid under all operating conditions. A minimum of five pipe diameters straight run upstream of the flowmeter and two pipe diameters straight run downstream of the flowmeter shall be provided.

3.2.2.4 Natural Gas or Propane Flowmeter

Meters shall be installed in accordance with ASME B31.8. Permanent gas meters shall be installed with provisions for isolation and removal for calibration and maintenance, and shall be suitable for operation in conjunction with an energy monitoring and control system.

3.2.2.5 Orifice Plates

Orifice plates shall be installed for ease of accessibility for periodic maintenance. Differential pressure sensors shall be as close to the orifice plates as possible. Orifice plates for liquid measurement shall be located in horizontal pipe runs with the orifice plate flanges installed so that the pressure taps are in the horizontal plane with the centerline of the pipe. For liquid, the differential pressure transmitter shall be installed below the orifice taps. For gas measurement, the orifice plate flanges shall be installed so that the pressure taps are 45 degrees or more above the horizontal plane with the centerline of the pipe. For gas measurement the required differential pressure transmitter shall be physically installed above the orifice taps.

3.2.2.6 Paddle Flowmeter

Meter shall be installed using manufacturer's published procedures. Installers shall be trained for such installations in the pipes encountered. Provide certificates demonstrating installer's qualifications.

3.2.2.7 Annular Pitot Tubes

Annular pitot tubes shall be installed so that the total head pressure ports are set-in-line with the pipe axis upstream and the static port facing downstream. The total head pressure ports shall extend diametrically across the entire pipe. Annular pitot tubes shall not be used where the flow is pulsating or where pipe vibration is allowed.

3.2.2.8 Positive Displacement Flow Meters

Flow meters shall be installed horizontally, and aligned correctly in the direction of flow.

3.2.2.9 Turbine Meters

Turbine meters shall be installed so that the sensor is located in the center of the fluid flow pipe on the main axis. The minimum straight unobstructed piping for the flow meter installation shall be 10 pipe diameters upstream and 5 pipe diameters downstream.

3.2.2.10 Insertion Turbine Flowmeters

Turbine meters shall be installed without interruption to service. Install a welded flanged riser of appropriate pipe line rating, with a full opening valve bolted to it. Sensor shall be located in accordance with the manufacturer's instructions for the specified flow rates and installation conditions. Reduced diameter pipe sections shall be provided as necessary to achieve required flow velocities. Meters shall be installed using the hot-tap method with tools recommended by the manufacturer. The minimum straight unobstructed piping for the flow meter installation shall be 10 pipe diameters upstream and 5 pipe diameters downstream.

3.2.2.11 Ultrasonic Flowmeter

Meter shall be installed using manufacturer's published procedures for installation. Installers shall be trained for such installations in the pipes encountered. Provide certificates demonstrating installer's qualifications.

3.2.2.12 Variable Area Flowmeter

Meters shall be installed in a vertical piping section with full flow through the meter.

3.2.2.13 Venturi Flowmeter

The flowmeter shall be installed with its top above the pipeline in horizontal pipe run installations. The direction of flow shall be upward in vertical pipe run installations. The flowmeter shall be aligned to the direction of the flow and shall be rigidly mounted and vibration free. The minimum straight unobstructed piping for the flow meter installation shall be 10 pipe diameters upstream and 5 pipe diameters downstream.

3.2.2.14 Vortex Shedding Flowmeters

The flowmeter shall be installed with its top above the pipeline in horizontal pipe run installations. The direction of flow shall be upward in vertical pipe run installations. The flowmeter shall be aligned to the direction of the flow and shall be rigidly mounted and vibration free. The minimum straight unobstructed piping for the flow meter installation shall be 10 pipe diameters upstream and 5 pipe diameters downstream.

3.2.3 Level Instruments

3.2.3.1 Liquid Level Sensor (Bubble Type)

The air pressure regulating valve, air filter, moisture trap, air flow adjustment valve, level gauge, air isolation valve and pressure transducer shall be mounted on a panel where indicated on the drawings. The level gauge shall be labeled to identify the tank being measured. The isolation valve shall be located in the air supply line upstream of the moisture trap, air filter and pressure regulator. The air inlet line to the dip tube and the dip tube shall be mounted to a flange at the top of the tank. The dip tube shall extend to the bottom of the tank, leaving the manufacturer's recommended clearance between the dip tube and tank bottom. The dip tube material shall be compatible with the tank contents. The pressure regulating valve shall be adjusted to the outlet pressure recommended by the manufacturer. Where exposed, the air supply

line to the tank and from the tank to the level gauge and pressure transducer shall be protected from damage.

3.2.3.2 Capacitance Liquid Level Sensors

The sensing probes shall be located close to, and parallel with, the tank or sump wall.

3.2.3.3 Conductivity Switch

Level switches shall be installed vertically and in accordance with the manufacturer's instructions. Switches shall be accessible for maintenance and calibration. In applications where switches cannot be directly mounted to a tank by the threaded or flanged connection, a mounting bracket shall be provided for connection to the inside tank wall, maintaining the minimum recommended distance from the tank fill opening.

3.2.3.4 Displacement Type Liquid Level Switch

Level switches shall be installed in accordance with the manufacturer's instructions. Switches shall be accessible for maintenance and calibration. In applications where switches cannot be directly mounted to a tank by the threaded or flanged connection, a mounting bracket shall be provided for connection to the inside tank wall.

3.2.3.5 Mercury Float Switches

Switches shall be mounted in accordance with manufacturer's published instructions. Procedures shall be those used for equipment in hazardous locations.

3.2.3.6 Ultrasonic Sensor

Sensor shall be installed vertically in the top of the tank and in accordance with the manufacturer's instructions. Switches shall be accessible for maintenance and calibration. In applications where switches cannot be directly mounted to a tank by the threaded or flanged connection, a mounting bracket shall be provided for connection to the inside tank wall. Sensor shall be positioned to maximize the return echo signal and minimize vessel obstructions in the sensors line of sight. The minimum recommended distance from the tank fill opening and from the side of the tank shall be maintained .

3.2.4 Pressure Instruments

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NOTE: Do not use differential pressure switches on liquid pumps. Gage pressure switches are better suited for liquid application. Indicate by appropriate icon on the drawings where the switches are to be located and which type is to be used.

****

Pressure sensors and pressure transducers shall be verified by calibration. All pressure taps shall incorporate appropriate snubbers. Pressure sensors and pressure switches shall have valves for isolation, venting, and taps for calibration. Pressure switches and pressure transducers installed on liquid or steam lines shall have drains. Pressure transducers, differential pressure sensors and differential pressure

switches shall have nulling valves. Pressure switches shall be adjusted to the proper setpoint and shall be verified by calibration. Switch contact ratings and duty shall be selected for the application.

3.2.5 Temperature Instrument Installation

3.2.5.1 RTD

[When the RTD is installed in pipe or is susceptible to corrosion or vibration, the] [Each] RTD shall be installed in a thermowell. Thermowells shall be filled with conductive heat transfer fluid prior to installation of the RTD in the thermowell. RTDs used for space temperature sensing shall include a housing suitable for wall mounting. RTDs used for outside air sensing shall have an instrument shelter or sun shield as shown to minimize solar effects, and shall be mounted to minimize building effects. RTD assemblies shall be readily accessible and installed to allow easy replacement.

3.2.5.2 Temperature Switches

Temperature switches shall be installed as specified for RTDs. Temperature switches shall be adjusted to the proper setpoint and shall be verified by calibration. Switch contact ratings and duty shall be selected for the application.

3.2.5.3 Thermometers and Temperature Sensing Elements

Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

3.2.5.4 Thermocouples

Each thermocouple shall be installed in a protective tube or in a thermowell. Thermocouples shall be insulated from ambient temperature effects. Thermocouple wires shall not be installed in the same conduits as power wiring. Thermocouples shall not be used for measuring temperatures below 260 degrees C 500 degrees F. Type E thermocouples may be used when the atmosphere is chemically reducing environment. Type K thermocouples may be used when the atmosphere is a chemically oxidizing environment.

3.2.6 Process Analytical Instrumentation

3.2.6.1 Ammonia Monitor

The controller shall be located as shown on the drawings. The ammonia sensor shall be mounted as recommended by the manufacturer. The location of the sensor shall be representative of the area to be monitored and shall allow access to the sensor for periodic calibration. The sensor shall be located in a dry area or shall be protected from moisture without restricting the flow of ammonia gas to the sensor.

3.2.6.2 Carbon Dioxide Measurement

The controller shall be located in the control panel or other location as shown on the drawings. Where a sample tube is used, the size and maximum length of sample tubing shall be as recommended by the manufacturer. Sample tubing shall be not crimped or kinked.

3.2.6.3 Carbon Monoxide Measurement

Carbon monoxide controller and sensor shall be located as shown on the drawings or as recommended by the manufacturer. The location shall be representative of the area to be monitored. Installation shall be in accordance with the manufacturer's instructions.

3.2.6.4 Chlorine in Air

The controller shall be located in the control panel or other location as shown on the drawings. Where a sample tube is used, the size and maximum length shall be a recommended by the manufacturer. The sample tube shall not be crimped or kinked. The location of the [controller] [sample tube inlet] shall be near the bottom of the area to be monitored.

3.2.6.5 Chlorine in Water

The controller shall be located in the control panel or other location as shown on the drawings. The chlorine sensor shall be immersed in the fluid being monitored using an assembly that will allow removal of the sensor from the water. The sensors hall be located in an area of continuous flow.

3.2.6.6 Combustible Gas Sensor

The sensor and transmitter shall be located as shown or the drawings or as recommended by the manufacturer. The location of the sensor shall be representative of the area to be monitored and shall allow access to the sensor for periodic replacement.

3.2.6.7 Hydrogen Sulfide

The controller shall be located as shown on the drawings or as recommended by the manufacturer. Where a sample tube is used, the tube size and maximum length shall be a recommended by the manufacturer. The sample tube shall not be crimped or kinked. The location of the [controller] [sample tube inlet] shall be representative of the area to be monitored.

3.2.6.8 NOx Monitor

The controller shall be mounted in the control panel or as otherwise shown. Sensor shall be located in the flue as shown and in accordance with the manufacturer's recommendation. Installation shall prevent all leakage of flue gases at the sensor.

3.2.6.9 Oxygen and Ozone in Air Monitor

The controller shall be mounted in the control panel or as otherwise shown on the drawings. The oxygen sensor shall be located in accordance with the manufacturer's recommendations and as shown on the drawings. High and low alarm settings shall be set as required by the sequence of control. Settings shall be verified through the use of a manufacturer's standard calibration kit.

3.2.6.10 Dissolved Oxygen

The dissolved oxygen sensor shall be immersed in the fluid to be monitored using manufacturer's mounting assembly. The sensor shall be located in an area of continuous fluid flow. The transmitter shall be located remote from the sensor. The transmitter and wiring connections shall be in a

weathertight enclosure. [The transmitter shall be mounted to allow the digital readout to be easily viewed.]

3.2.6.11 PH and ORP Sensor

Pipe mounted flow sensor shall be located in a threaded tee or fitting to allow removal from the pipe. Submersible sensor shall be completely immersed in the fluid being monitored using an ensemble that will allow for removal of the sensor from the fluid for replacement. The sensor shall be located in an area of continuous flow. The transmitter shall be located [at the sensor] [remote from the sensor]. [The transmitter shall be mounted to allow the digital readout to be easily viewed].

3.2.6.12 Total Dissolved Solids

The sensor shall be [pipe] [tank] [submersible] type as indicated on the drawings. [Pipe mounted sensor shall be mounted in a threaded tee or fitting to allow removal of the sensor.] [Tank mounted sensor shall be mounted in a threaded fitting to allow removal of the sensor.] [Submersible sensor shall be mounted in an assembly that will allow removal of the sensor from the fluid for replacement.] The transmitter shall be located [at the sensor] [remote from the sensor]. The transmitter and wiring connections shall be located in a weathertight enclosure.

3.2.7 Instrument Shelters

Instrument shelters shall be installed in the location shown with the bottom 1.2 meter 4.0 feet above the supporting surface using legs and secured rigidly to minimize vibrations from winds. Instrument shelters shall be oriented with door facing North. Instruments located in shelters shall be mounted in the 3-dimensional center of the open space of the shelter.

3.2.8 Electric Power Devices

3.2.8.1 Potential and Current Transformers

Install potential and current transformers in enclosures unless otherwise shown. Current transformer leads shall be shorted when they are not connected to the measurement circuits.

3.2.8.2 Hour Meters

Meters shall be located in the control panel or as otherwise shown. Power to the meter shall be connected to the motor starter auxiliary contacts for pumps, blowers and other motor driven devices. For devices without motor starters, the meter shall be connected in parallel with the load. Where the meter voltage differs from the metered devices voltage, transformer shall be provided as necessary.

3.2.8.3 Watt-hour Meters

Install watt-hour meters and transducers in enclosures unless otherwise shown.

3.2.8.4 Transducers

Transducers shall be wired in accordance with the manufacturer's instructions, and installed in enclosures.

3.2.8.5 Current Sensing Relays and Current Transducers for Motors

When used to sense meter/fan/pump status, current sensing relays shall be used for applications under 4 kW 5 hp. Applications over 4 kW 5 hp shall use a current transducer.

3.2.9 Output Devices

Output devices (transducers, relays, contactors, or other devices) which are not an integral part of the control panel, shall be mounted in an enclosure mounted adjacent to the control panel, unless otherwise shown. Where H-O-A and/or override switches on the drawings or required by the control sequence, the switches shall be installed so that the control system controls the function through the automatic position and other controls work through the hand position.

3.2.10 Enclosures

All enclosure penetrations shall be from the bottom of the enclosure, and shall be sealed to preclude entry of water using a silicone rubber sealant.

3.2.11 Transformers

Transformers for control voltages below 120 vAc shall be fed from the nearest power panel or motor control center, using circuits provided for the purpose. Provide a disconnect switch on the primary side and a fuse on the secondary side. Transformers shall be enclosed in a steel cabinet with conduit connections.

3.3 WIRE, CABLE AND CONNECTING HARDWARE

3.3.1 LAN Cables and Connecting Hardware

LAN cables and connecting hardware shall be installed in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM and Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

3.3.2 Metering and Sensor Wiring

Metering and sensor wiring shall be installed in accordance with the requirements of ANSI C12.1, NFPA 70, Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION, UNDERGROUND and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.3.2.1 Power Line Surge Protection

Control panels shall be protected from power line surges. Protection shall meet the requirements of IEEE C62.41.1 and IEEE C62.41.2. Fuses shall not be used for surge protection.

3.3.2.2 Sensor and Control Wiring Surge Protection

Digital and analog inputs shall be protected against surges induced on control and sensor wiring. Protect digital and analog outputs against surges induced on control and sensor wiring installed outdoors and as shown. Fuses shall not be used for surge protection. Test the inputs and outputs in both the normal and common mode using the following two waveforms: The first waveform shall be 10 microseconds by 1000 microseconds with a peak voltage of 1500 volts and a peak current of 60 amperes. The second waveform shall be 8 microseconds by 20 microseconds

with a peak voltage of 1000 volts and a peak current of 500 amperes. Submit certified test results for surge protection.

3.4 SOFTWARE INSTALLATION

Load software required for an operational control system, including databases (for points specified and shown), operational parameters, and system, command, and application programs. Adjust, tune, debug, and commission all software and parameters for controlled systems to assure proper operation in accordance with the sequences of operation and database tables.

3.5 CONTROL DRAWINGS

Control drawings, [framed, non-fading half-size in laminated plastic] [reproducible, with corresponding CADD files] [_____], shall be provided for equipment furnished and for interfaces to equipment at each respective equipment location. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system manually shall be prepared in typed form, [framed as specified for the instrumentation and control diagrams] [reproducible, with corresponding word processor files] [_____] and posted beside the diagrams. Diagrams and instructions shall be submitted prior to posting. The framed instructions shall be posted before acceptance testing of the system.

3.6 FIELD TESTING AND ADJUSTING EQUIPMENT

Provide personnel, equipment, instrumentation, and supplies necessary to perform site testing. The Government will witness the PVT, and written permission shall be obtained from the Government before proceeding with the testing. Original copies of data produced, including results of each test procedure, during PVT shall be turned over to the Government at the conclusion of each phase of testing prior to Government approval of the test. The test procedures shall cover actual equipment and functions specified for the project.

3.6.1 Testing, Adjusting and Commissioning

****
NOTE: Delete reference to a factory test if no factory test is to be required.
****

After successful completion of the factory test as specified, the Contractor will be authorized to proceed with the installation of the system equipment, hardware, and software. Once the installation has been completed, test, adjust, and commission each control loop and system in accordance with NIST SP 250 and shall verify proper operation of each item in the sequences of operation, including hardware and software. Calibrate field equipment, including control devices, adjust control parameters and logic (virtual) points including control loop setpoints, gain constants, constraints, and verify data communications before the system is placed online. Test installed ground rods as specified in IEEE 142 and submit certification stating that the test was performed in accordance with IEEE 142. Calibrate each instrumentation device connected to the control system control network by making a comparison between the reading at the device and the display at the workstation, using a standard at least twice as accurate as the device to be calibrated. Check each control point

within the control system control network by making a comparison between the control command at the central station and field-controlled device. Deliver trend logs/graphs of all points showing to the Government that stable control has been achieved. Points on common systems shall be trended simultaneously. One log shall be provided showing concurrent samples taken once a minute for a total of [4] [_____] hours. One log shall be provided showing concurrent samples taken once every 30 minutes, for a total of [24] [_____] hours. Verify operation of systems in the specified failure modes upon Control system network failure or loss of power, and verify that systems return to control system control automatically upon a resumption of control system network operation or return of power. Deliver a report describing results of functional tests, diagnostics, calibrations and commissioning procedures including written certification to the Government that the installed complete system has been calibrated, tested, adjusted and commissioned and is ready to begin the PVT. The report shall also include a copy of the approved PVT procedure.

3.6.2 Performance Verification Test (PVT)

Submit test procedures for the PVT. The test procedure shall describe all tests to be performed and other pertinent information such as specialized test equipment required and the length of the PVT. The test procedures shall explain, in detail, step-by-step actions and the expected results, to demonstrate compliance with all the requirements of the drawings and this specification. The test procedure shall be site specific and based on the inputs and outputs, required calculated points and the sequence of control. Refer to the actions and expected results to demonstrate that the control system performs in accordance with the sequence of control. Include a list of the equipment to be used during the testing plus manufacturer's name, model number, equipment function, the date of the latest calibration and the results of the latest calibration.

Demonstrate that the completed Control system complies with the contract requirements. All physical and functional requirements of the project including communication requirements shall be demonstrated and shown. Demonstrate that each system operates as required in the sequence of operation. The PVT as specified shall not be started until after receipt of written permission by the Government, based on the written report including certification of successful completion of testing, adjusting and commissioning as specified, and upon successful completion of training as specified. Upon successful completion of the PVT, furnish test reports and other documentation.

3.6.3 Endurance Test

Use the endurance test to demonstrate the overall system reliability of the completed system. The endurance test shall be conducted in phases. The endurance test shall not be started until the Government notifies the Contractor in writing that the PVT is satisfactorily completed, training as specified has been completed, outstanding deficiencies have been satisfactorily corrected, and that the Contractor has permission to start the endurance test. Provide an operator to man the system 8 hours per day during daytime operations, including weekends and holidays, during Phase I endurance testing, in addition to any Government personnel that may be made available. The Government may terminate testing at any time when the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, commence an assessment period as described for Phase II. Upon successful completion of the endurance test, deliver test reports and other documentation, as specified, to the Government prior

to acceptance of the system.

3.6.3.1 Phase I (Testing)

****
NOTE: The designer will determine the required Phase I testing period. The testing period should be based on the system size and complexity.
****

The test shall be conducted 24 hours per day, 7 days per week, for [_____] consecutive calendar days, including holidays, and the system shall operate as specified. Make no repairs during this phase of testing unless authorized by the Government in writing.

3.6.3.2 Phase II (Assessment)

After the conclusion of Phase I, identify failures, determine causes of failures, repair failures, and deliver a written report to the Government. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing should be resumed. After delivering the written report, convene a test review meeting at the job site to present the results and recommendations to the Government. The meeting shall not be scheduled earlier than 5 business days after receipt of the report by the Government. As a part of this test review meeting, demonstrate that failures have been corrected by performing appropriate portions of the performance verification test. [The Government reserves the right to cancel the test review meeting if no failures or deficiencies occur during the Phase I testing. If the Government chooses to do so, the Contractor will be notified in writing.] Based on the Contractor's report and the test review meeting, the Government will determine if retesting is necessary and the restart point. The Government reserves the right to require that the Phase I test be totally or partially rerun. Do not commence any required retesting until after receipt of written notification by the Government. After the conclusion of any retesting which the Government may require, the Phase II assessment shall be repeated as if Phase I had just been completed.

3.6.3.3 Exclusions

The Contractor will not be held responsible for failures resulting from the following: Outage of the main power supply in excess of the capability of any backup power source, provided that the automatic initiation of all backup sources was accomplished and that automatic shutdown and restart of the control system performed as specified. Failure of a Government furnished communications link, provided that the PLC automatically and correctly operates in the stand-alone mode as specified, and that the failure was not due to Contractor furnished equipment, installation, or software. Failure of existing Government owned equipment, provided that the failure was not due to Contractor furnished equipment, installation, or software.

3.7 MANUFACTURERS' FIELD SERVICES

Obtain the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installing, adjusting, and testing of the equipment.

3.8 FIELD TRAINING

****

NOTE: The number of hours required to instruct a Government representative in operation and maintenance of the system will depend on the complexity of the system specified. Designer is to establish the number of hours of training based on equipment manufacturer recommendations, system complexity and consultation with the installation.

****

Field training oriented to the specific system shall be provided for designated personnel. Furnish a copy of the training manual for each trainee plus [two] [_____] additional copies. Manuals shall include an agenda, the defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Furnish audiovisual equipment and other training supplies and materials. Copies of the audiovisuals shall be delivered with the printed training manuals. The Government reserves the right to videotape training sessions for later use. A training day is defined as 8 hours of classroom instruction, excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility. Submit the training manual and schedule to receive approval from the Government at least 30 days before the training.

3.8.1 Preliminary Operator Training

Prior to the start of field testing, preliminary operator training shall be taught at the project site for [_____] consecutive training days. Upon completion of this course, each student, using appropriate documentation, should be able to perform elementary operations with guidance and describe the general hardware architecture and functionality of the system. This course shall include: general system architecture; functional operation of the system, including workstations; operator commands; application programs, control sequences, and control loops; database entry and modification; reports generation; alarm reporting; diagnostics; and historical files.

3.8.2 Additional Operator Training

Following the field testing, additional classroom training for operators shall be taught for [_____] consecutive training days; individual instruction sessions of [4] [_____] -hour periods in the morning (or afternoon) of the same weekday for [_____] consecutive weeks and an additional [_____] day classroom session for answering operator questions. Individual instruction shall consist of "hands-on" training under the constant monitoring of the instructor. Classroom training shall include instruction on the specific hardware configuration of the installed control system and specific instructions for operating the installed system. Schedule activities during this period so that the specified amount of time on the equipment will be available for each student. The final session will address specific topics that the students need to discuss and to answer questions concerning the operation of the system. Upon completion of the course, the students should be fully proficient in system operation and have no unanswered questions regarding operation of the installed control system. Each student should be able to start the system, operate the system, recover the system after a failure and describe the specific hardware architecture and operation of the system and be fully proficient in all system operations. Report the skill level of each student at the

end of this course.

3.8.3 Maintenance Training

****
NOTE: Fit training requirements to the systems.
****

Following the [endurance test] [_____], a minimum period of [five] [_____] training days shall be provided by a factory representative or a qualified Contractor trainer for [ten] [_____] designated personnel on maintenance of the equipment. The training shall include: physical layout of each piece of hardware, calibration procedures, preventive maintenance procedures, schedules, troubleshooting, diagnostic procedures and repair instructions.

3.8.4 Specialized Training

****
NOTE: Coordinate with specifications for the unit processes, adding or deleting parts.
****

Following the maintenance training, a minimum period of [five] [_____], total training day(s) shall be provided by a factory representative or a qualified Contractor trainer for [ten] [_____] people on the input devices.

3.8.4.1 Flow Meter Training

Each type of flow meter, to include calibration, maintenance and testing of flow elements and transducers.

3.8.4.2 Specialized Sensor Training

Each type of specialized sensor such as [chlorine,] [turbidity,] [pH,] [NOx,] [_____] to include calibration, maintenance and testing of sensing elements and transducers.

-- End of Section --