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UTILITY MONITORING AND CONTROL SYSTEM
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SECTION 13807
UTILITY MONITORING AND CONTROL SYSTEM (UMCS)

PART 1 GENERAL

1.1 REFERENCES

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

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\-ASTM B 88-\ (1995a) Seamless Copper Water Tube

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\-ASTM D 638-\ (1995) Tensile Properties of Plastics

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\-EIA TSB 67-\ (1995) Transmission Performance Specification for Field Testing of Unshielded Twisted Paracabling Systems

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\-IEEE Std 100-\ (1997) IEEE Standard Dictionary of Electrical and Electronic Terms

\-IEEE Std 142-\ (1991) IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems

\-IEEE Std 8802-3-\ (1996) Local and Metropolitan Area Network: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

\-IEEE Std 8802-4-\ (1990) Local Area Network: Token-Passing Bus Access Method and Physical Layer Specifications

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

\-ICEA S-80-576-\	(1994) Communications Wire and Cable for Wiring of Premises

INTERNATIONAL SOCIETY FOR MEASUREMENT AND CONTROL (ISA)

\-ISA MC96.1-\	(1982) Temperature Measurement Thermocouples

INTERNATIONAL TELECOMMUNICATIONS UNION (ITU)

\-(ITU) V.32 bis-\	(1993) Synchronous/Asynchronous Data Transmission, Full-Duplex Operation Over 2-Wire Dial-Up or Leased Lines
\-(ITU) V.34-\	(1994) Data Communication Over the Telephone Network - A Modem Operating at Data Signaling Rates of up to 28,800 bits for use on the General Switched Telephone Network and on leased Point-to-Point Two-Wire Telephone Type Circuits.
\-(ITU) V.42-\	(1993) Data Communications Over the Telephone Network Error-Correcting Procedures for DCEs Using Asynchronous-to-Synchronous Conversion
\-(ITU) V.42 bis-\	(1990) Data Compression Procedures for Data Circuit Terminating Equipment (DCE Using Error-Correction Procedures)

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\-MIL-STD 2202-\	(Basic) Energy Monitoring and Control Systems, Factory Test Procedures
\-MIL-STD 2203-\	(Basic) Energy Monitoring and Control Systems, Performance Verification and Endurance Test

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\-NEMA 250-\	(1991) Enclosures for Electrical Equipment
\-NEMA ST 1-\	(1988) Specialty Transformers (Except General-Purpose Type)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

\-NFPA 70-\	(1999) National Electrical Code
\-NFPA 90A-\	(1999) Installation of Air Conditioning and Ventilation Systems

NAVAL FACILITIES ENGINEERING SERVICE CENTER (NFESC)

\-NFESC ESA RELEASE 8-\	(1993) EMCS Energy Savings Analysis Program

UNDERWRITERS LABORATORIES (UL)

\-UL 94-\	(1991; Rev thru May 1996) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
\-UL 508-\	(1993) Industrial Control Equipment

\-UL 555S-\	(1993; Rev thru Apr 1995) Leakage Rated Dampers for Use in Smoke-Control Systems
\-UL 864-\	(1991; Rev thru May 1994) Control Units for Fire-Protective Signaling Systems
\-UL 916-\	(1998) Energy Management Equipment

1.2 SYSTEM DESCRIPTION

****
NOTE: Designer is to add location and site specific requirements.
****

The Utility Monitoring and Control System (UMCS) will be used to control and monitor operation of buildings and utility systems as specified and shown at [_____] paragraph System Requirements.

1.2.1 System Requirements

The Contractor shall furnish the UMCS, in accordance with \-UL 864-\ (where conformance with fire codes is required by law) and \-UL 916-\, configured as a distributed processing network of control and monitoring functions as shown and specified. All automatic controls provided under this specification shall utilize Direct Digital Control (DDC) and Supervisory Control as shown to provide the required sequences of operation. No pneumatic devices will be allowed except for control of valve or damper actuators. UMCS panels shall manage control and monitoring functions for equipment shown. The system shall provide for operator interaction, overall system supervision, coordination, control, and monitoring. The system shall provide monitoring and control functions shown and as required to accomplish operational sequences shown. Sensed data shall be obtained by the Network Controllers (NC), Unitary Controllers, and Universal Programmable Controllers, collectively referred to as Field Equipment Panels (FEP), 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 appropriate database/settings tables and sequences of operation shown in the drawings. The number of and location of Network Controllers shown on drawings shall be provided as a minimum. Computing devices, as defined in \-47 CFR 15-\, supplied as part of the UMCS shall be certified to comply with the requirements of Class B computing devices, while Network Controllers, Unitary Controllers, and Universal Programmable Controllers shall as a minimum meet the requirements of Class A computing devices, and shall be labeled as set forth in \-47 CFR 15-\. The Operator Workstation shall communicate with FEPs using Data Transmission System (DTS) and equipment as shown and specified in Paragraph DATA TRANSMISSION SYSTEMS. Every 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 UMCS shall represent a "point" where referred to in this specification. The Contractor shall provide hardware configured and sized to support specified functions, including expansion, as specified and shown. All I/O functions of an individually monitored and controlled system shall be implemented in one FEP. The existing control systems shall remain in operation until the new UMCS is ready for cutover.

1.2.2 HVAC Systems and Hydronic System Balancing

****
NOTE: Designer will determine if the installation requires this work to be accomplished. This is an optional task which will provide a known benchmark prior to the Contractor's commencing work.
****

The Contractor shall, as a part of the existing conditions report, describe the systems in terms of flows and pressures, prior to start of work. Flows and pressures shall be recorded and listed in the report submitted to the Government.

1.2.3 System Overall Reliability

The system shall be configured and installed to yield a mean time between failure of at least 5000 hours, calculated based on the configuration specified in paragraph RELIABILITY CALCULATION. Each UMCS FEP shall be designed, configured, installed and programmed to provide for independent stand-alone operation with minimal performance degradation upon failure of other system components to which it is connected or with which it communicates.

1.2.4 Symbols, Definitions, and Abbreviations

Symbols, definitions, and engineering unit abbreviations utilized in information displays and printouts shall conform to \-IEEE Std 100-\ and \-ASHRAE-81930-\, as applicable.

1.2.5 System Accuracy and Display

****
NOTE: Show sensor ranges and ratings on drawings for measurements such as pressure and flow. Add requirements for additional site specific measurements, including span and accuracy for any special application not included in this specification.
****

The system shall maintain the specified end-to-end accuracy from sensor to all workstation displays, including the effects of transmitters, transducers, and engineering units conversions, for one year for the applications specified and shall report and display changes in sensed values as specified. The system accuracy and display requirements are as follows:

1.2.5.1 Space Temperature

Space temperature with a range of \^10 to plus 32 degrees C plus or minus 0.4 degrees C^\ \~50 to plus 90 degrees F plus or minus 0.75 degrees F~\, for conditioned space (display and print to nearest \^0.1 degrees C^\ \~0.1 degrees F~\); \^minus 1 degrees to plus 54 degrees C plus or minus 0.6 degrees C^\ \~plus 30 to plus 130 degrees F plus or minus 1.0 degrees F~\ for unconditioned space (display and print to nearest \^0.1 degrees C^\ \~0.1 degree F~\).

1.2.5.2 Duct Temperature

Duct temperature with a range of \^plus 4 to plus 60 degrees C plus or minus 0.6 degrees C^\ \~plus 40 to plus 140 degrees F plus or minus 1.0 degrees F~\ (display and print to nearest \^0.1 degrees C^\ \~0.1 degrees F~\).

1.2.5.3 Outside Air (OA) Temperature

Outside air temperature with a range of \^minus 7 to plus 49 degrees C plus or minus 0.6 degrees C.^\ \~20 to plus 120 degrees F plus or minus 1.0 degrees F.~\

1.2.5.4 Water Temperature

Water temperature with a range of \^minus 1 degrees C to plus 38 degrees C^\ \~plus 30 to plus 100 degrees F~\ for chilled water, plus or minus \^0.4 degrees C^\ \~0.75 degrees F~\ (display and print to nearest \^0.1 degrees C^\ \~0.1 degrees F~\); a range of \^plus 21 to plus 121 degrees C^\ \~plus 70 to plus 250 degrees F~\ for heating hot water, plus or minus \^1.0 degrees C^\ \~2.0 degrees F~\ (display and print to nearest \^0.1 degrees C^\ \~0.1 degrees F~\); a range of \^minus 1 to plus 116 degrees C^\ \~plus 30 to 240 degrees F~\ for dual temperature water systems, plus or minus \^0.1 degrees C^\ \~2.0 degrees F~\ (display and print to nearest \^0.1 degrees C^\ \~0.1 degrees F~\); a range of \^minus 1 to plus 54 degrees C^\ \~plus 30 to plus 130 degrees F~\ for condenser water, plus or minus \^0.6 degrees C^\ \~1.0 degrees F~\ (display and print to the nearest

\^0.1 degrees C^\ \~0.1 degrees F~\); water temperatures for the purpose of performing \^Kilojoules^\ \~Btu~\ or kWh calculations using differential temperatures to within plus or minus \^0.3 degrees C^\ \~0.5 degrees F~\ using matched sensors (display and print to nearest \^0.1 degrees C^\ \~0.1 degrees F~\).

1.2.5.5 High Temperature

High temperature with a range of \^plus 93 to plus 538 degrees C plus or minus 1.0 degrees C^\ \~plus 200 to plus 1000 degrees F plus or minus 2.0 degrees F~\ (display and print to nearest \^1.0 degrees C^\ \~1.0 degrees F~\).

1.2.5.6 Relative Humidity

The r.h. with a range of 20 to 80% for indoor applications, plus or minus 3%; a range of 0 to 100% for high limit and outdoor air applications, plus or minus 3.0% (display and print to nearest 1.0%).

1.2.5.7 Pressure

Pressure in \^pascals^\ \~pounds per square inch~\ with a range for the specific application, plus or minus 2.0% of range (display and print to nearest \^pascals^\ \~pounds~\).

1.2.5.8 Flow

Flow with a range for the specific application, plus or minus 3.0% of range (display and print to nearest unit such as \^liters per second (l/s)^\ \~gallons per minute (gpm)~\ or \^cubic meters per second (m^3/s)^\ \~cubic feet per minute (cfm)~\).

1.2.5.9 Level

Level with a range for the specific application, plus or minus 1.0% of range (display and print to nearest unit).
1.2.5.10 Electrical Power Measurements

Electrical power measurements with a range for the specific application, plus or minus 1.0% of range (display and print to nearest kWh and kW).

1.2.5.11 Electrical Measurements

Electrical measurements with a range for the specific application plus or minus 1.0% of range (display and print to nearest 0.1 for volts and amperes, and to the nearest 0.01 for var and PF).

1.2.5.12 Miscellaneous Measurements

Miscellaneous measurements with a range for the specific application plus or minus 1.0% of range (display and print to nearest 0.1 of the specified units)

1.2.5.13 Analog Value Input

An analog value input to the system's equipment via an AI with a maximum error of 0.50% of range, not including the sensor or transmitter error. This accuracy is required over the specified environmental conditions.

1.2.6 Process Loop Accuracies

The system shall maintain the specified process control loop accuracies, including the effects of sensors, control devices, engineering units conversions, algorithms, and equipment controlled for one year for the

control loops shown. The accuracy requirements, unless otherwise shown in individual system sequences of operation, are:

1.2.6.1 Temperature

Space and duct temperatures shall be controlled within plus or minus \^1 degrees C.^\ \~1 degrees F.~\ Chilled and hot water supply loops shall be controlled to within plus or minus 5% of the required design range.

1.2.6.2 Humidity

Space humidity shall be controlled within plus or minus 5% of setpoint.

1.2.6.3 Pressure

Duct supply static pressures and liquid supply pressures shall be controlled to within plus or minus 5% of required design pressures.

1.2.6.4 Flow

Volumetric flow rate shall be controlled to within plus or minus 5% of required design flow.

1.3 ENVIRONMENTAL CONDITIONS

****
NOTE: Include in the package design requirements sufficient HVAC to ensure that the Operator Workstations temperature will be maintained at 23 degrees C (75 degrees F) including allowance for the Operator Station Equipment and personnel heating loads.
****

1.3.1 Field Equipment

The Network Controllers, Unitary Controllers, Universal Programmable Controllers, Input/Output (I/O) functions, and other field equipment shall be rated for continuous operation under ambient environmental conditions of \^2 to 49 degrees C^\ \~35 to 120 degrees F~\ dry bulb and 20 to 90% r.h., condensing. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location. Where installed outdoors, sensors shall be capable of operating between minus \^1 and 50 degrees C^\ \~30 and 122 degrees F~\ without suffering damage or affecting their calibration.

1.3.2 Operator Workstation (OWS) Equipment

Operator Workstation Equipment, unless designated otherwise, shall be rated for continuous operation under ambient environmental conditions of \^16 to 29 degrees C^\ \~60 to 85 degrees F~\ and r.h. of 20 to 80%, noncondensing.

1.3.3 Surge Protection

UMCS components shall be protected from the effects of surges as follows:

1.3.3.1 Power Line Surge Protection

Equipment connected to ac circuits shall be protected from power line surges. Equipment protection shall meet the requirements of \-IEEE C62.41-\. Fuses shall not be used for surge protection.

1.3.3.2 Sensor and Control Wiring Surge Protection

****
NOTE: If any additional inputs or outputs require surge protection, show the requirement for them on the drawings, either in a schedule or in the settings tables.
****

I/O functions as specified shall be protected against surges induced on control and sensor wiring installed outdoors and as shown. The inputs and outputs shall be tested in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Fuses shall not be used for surge protection.

1.3.3.3 Communications Circuits Surge Protection

Communication equipment shall be protected against surges induced on its communications circuits. Metallic cables and conductors which serve as communications circuits from OWS to NC, and between NC, Unitary Controllers, Universal Programmable Controllers, or other field hardware shall have surge protection installed at each end. Protection shall be furnished at equipment and additional triple electrode gas surge protectors rated for the application on each communications circuit shall be installed within one meter of the building cable entrance. The inputs and outputs shall be tested in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Fuses shall not be used for surge protection.

1.3.3.4 Network Surge Protection

Network surge protectors with male-female connectors shall be supplied and installed between the I/O port and the T-connector for every device connected to the LAN. Surge protector characteristics shall be as follows:

a. Response Time: 10 nanoseconds maximum.

b. Clamp Voltage: 9 Vac.

c. Energy Handling: 50 joules minimum.

d. Capacitance: 8 pF maximum.

1.3.4 Power Line Conditioner

****
NOTE: Power line conditioners should be considered for NC's for those locations where there is a concern of fluctuation in the power source.
****

[Power Line Conditioner shall be furnished for each NC. It shall provide both voltage regulation and noise rejection and shall be of ferro-resonant design, with no moving parts and no tap switching, while electrically

isolating the secondary from the power line side. The units shall be sized for 125% of the actual connected kVA load. Characteristics shall be as follows:

a. At 85% load, the output voltage shall not deviate by more than plus or minus 3% of nominal when the input voltage fluctuates between minus 15% to plus 10% of nominal.

b. During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus 3% of nominal. Full correction of load switching disturbances shall be accomplished within one cycle.

c. Total harmonic distortion shall not exceed 5% at full load.]

1.4 SUBMITTALS

1.4.1 Shop Drawings

Detailed shop drawings, containing no proprietary data, shall be submitted in accordance with the CONTRACT CLAUSES, and other sections of the contract. Shop drawings shall include, 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; damper schedules; compressed instrument air station schematics and ASME air storage tank certificates for each type and make of compressed instrument air station.

1.4.1.1 Product Specific Catalog Cuts

Product specific catalog cuts shall be in booklet form, indexed to the unique identifiers, and shall consist of data sheets that document compliance with the specification. Where multiple components are shown on a catalog cut, the application specific component shall be marked.

1.4.1.2 Valve Schedule

The valve schedule shall include a unique identifier corresponding to and in sequence with the existing identification scheme, size, flow coefficient (Cv), pressure drop at specified flow rate, spring range, positive positioner range, and actuator size, supported by close off pressure data, dimensions, and access and clearance requirements data for each valve furnished.

1.4.1.3 Damper Schedule

The damper schedule shall contain a unique identifier corresponding to and in sequence with the existing identification scheme, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, spring ranges, positive positioner ranges, locations of actuators and damper end switches, arrangement of sections in multisection dampers, and methods of connecting dampers, actuators, and linkages for each damper and actuator furnished. The damper schedule shall include the maximum expected velocity through the damper at the intended location and the maximum leakage rate at the operating static pressure differential. The damper schedule shall contain actuator selection data supported by calculations of the torque required to move and seal the dampers, and shall show access and clearance requirements.

1.4.1.4 Instrumentation Compressed-Air Station

Each instrumentation compressed-air station schematic diagram shall show equipment utilized, both new and existing, including compressor with motor output and voltage; starter; isolators; manual bypasses; tubing sizes; drain piping and drain traps; reducing valves; dryer; and data on manufacturer's names and model numbers, mounting, access, and clearance requirements. Air-compressor and air-dryer data shall include calculations of the air consumption of current-to-pneumatic transducers (IP's) 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 kilopascals.^\ \~80 psig.~\

1.4.2 Delivery of Technical Data and Computer Software

****

NOTE: The acquisition of all technical data, data bases and computer software items that are identified herein will be accomplished strictly in accordance with the Federal Acquisition Regulation (FAR) and the Department of Defense Acquisition Regulation Supplement (DOD FARS). Those regulations as well as the Army and Corps of Engineers implementations thereof should also be consulted to ensure that a delivery of critical items of technical data is not inadvertently lost. Specifically, the Rights in Technical Data and Computer Software Clause, DOD FARS 52.227-7013, and the Data Requirements Clause, DOD FAR 52.227-7031, as well as any requisite software licensing agreements will be made a part of the CONTRACT CLAUSES or SPECIAL CONTRACT REQUIREMENTS. In addition, the appropriate DD Form 1423 Contract Data Requirements List, will be filled out for each distinct deliverable data item and made a part of the contract. Where necessary, a DD Form 1664, Data Item Description, will be used to explain and more fully identify the data items listed on the DD Form 1423. It is to be noted that all of these clauses and forms are required to ensure the delivery of the data in question and that such data is obtained with the requisite rights to use by the Government.

Include with the request for proposals a completed DD Form 1423, Contract Data Requirements List. This form is essential to obtain delivery of all documentation. Each deliverable will be clearly specified, both description and quantity being required.

****

Technical data and computer software (meaning technical data which relates to computer software) which is specifically identified in this project, and which may be defined/required in other specifications, shall be delivered, strictly in accordance with the CONTRACT CLAUSES, and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. Final manuals and drawings shall be provided on hard copy as specified and on CD ROM. System and installation drawings shall be delivered in Intergraph Microstation format (.DGN). Data to be submitted shall be organized as follows:

1.4.2.1 Group I Technical Data Package

The Group I Technical Data Package shall include complete system, equipment, and software descriptions, with calculations used in sizing equipment required by this project. Descriptions and calculations shall show how the equipment will operate as a system to meet the performance requirements of this contract. The data package shall also include the following:

a. Equipment Data:

(1) UMCS block diagram.

(2) DTS layout, equipment, and functional description.

(3) Communication network description.

(4) Communication speeds.

(5) Network Controllers/Unitary Controller/Universal Programmable Controller installation and block diagrams.

(6) Network Controllers/Unitary Controller/Universal Programmable Controller I/O function capacity, including specified spare capacity.

(7) Network Controllers/Unitary Controller/Universal Programmable Controller memory size, type, and configuration.

(8) Network Controllers/Unitary Controller/Universal Progammable Controller physical layout.

(9) Details of connections to power sources, including grounding.

(10) Details of surge protection device installation.

(11) Sample of instrumentation and control wiring and installation drawings, showing wire routing on floor plans including terminal numbers, wire colors/numbers, and cable designations.

(12) OWS equipment and archive equipment installation and block diagrams.

(13) Command response time calculations.

(14) Alarm response time calculations for analog and digital alarms.

(15) System expansion capability and method of implementation.

b. Software Data:

(1) Network Controllers/Unitary Controller/Universal Programmable Controller operation, all modes specified.

(2) Operator Workstation equipment and archive equipment operations.

(3) Workstations operation.

(4) Automatic start-up operations.

(5) Database update procedures and response time calculations, not including latency time required by the LAN.

(6) Sample copy of each report specified.

(7) Color photographs or color graphic print representative of typical graphics.

(8) Library of graphics symbols.

(9) Library of application software.

(10) Data entry forms.

(11) Programming data and instructions.

c. System Overall Reliability Calculations: The data package shall include manufacturer's reliability data and calculations required to show compliance with the specified reliability in accordance with paragraph SYSTEM OVERALL RELIABILITY.

d. Certifications: All certifications shall be delivered as specified.

e. Installation Procedures and Requirements: Provide all information needed for interface of chiller panels and boiler panels with the UMCS.

1.4.2.2 Group II Technical Data Package

The Group II Technical Data Package shall include the existing conditions report and associated documentation as specified.

1.4.2.3 Group III Technical Data Package

The Contractor shall prepare test procedures for the factory test using \-MIL-STD 2202-\ as a technical and format requirement. The test procedures shall cover actual equipment and sequences to be utilized by the Contractor for the specific project and shall describe all tests to be performed, and other pertinent information such as specialized test equipment required, length of factory test, and location of the factory test. The procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with all requirements of this specification, and the methods for simulating the necessary conditions of operation to demonstrate performance of the system. The factory test procedures shall demonstrate the capability of the system to monitor and control equipment and to accomplish the control and monitoring shown and as required by the sequences of operation.

1.4.2.4 Group IV Technical Data Package

The Group IV Technical Data Package shall include the following:

a. Performance Verification Test (PVT) and Endurance Testing Data: The Contractor shall prepare test procedures for the PVT and endurance test using the requirements of \-MIL-STD 2203-\, excluding all surge and overvoltage tests, as a technical and format requirement. The test procedures shall describe all tests to be performed, and other pertinent information such as specialized test equipment required, and length of PVT. The test procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with all the requirements of this specification. Test procedures shall include tests for utilities, such as sewage systems, water distribution system, power distribution system, RF system and fuel oil storage system monitoring and control where applicable. Procedures shall be based on inputs shown, calculated points and the requirements of the sequences of operation.

b. Operation and Maintenance Manuals: A draft copy of the operation and maintenance manuals, as specified for the Group V technical data package, shall be included with the PVT procedures for use during procedure review and site testing.
c. Training Documentation: Lesson plans/training manuals for the training phases, and including a listing of reference materials.

d. Data Entry Forms: Completed data entry forms documenting data from the contract documents, Contractor's field surveys, and other pertinent information in the Contractor's possession required for complete installation of the database. The Contractor shall identify, and request from the Government, additional data needed to provide a complete and operational UMCS. The completed forms shall be delivered to the Government for review and incorporation of any additional information needed.

e. Drawings: Instrumentation and control wiring and installation drawings, showing wire routing on floor plans including terminal numbers, wire colors/numbers, and cable designations.

1.4.2.5 Group V Technical Data Package

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NOTE: Unless the installation has a different requirement, specify 2 copies of all manuals, except for the operator's manual, which should be specified to be 6 copies.
****

The Group V Technical Data Package shall consist of the operation and maintenance manuals. Final copies of the manuals, bound in hardback, loose-leaf binders, shall be delivered to the Government within 30 days after completing the endurance test. The draft copy used during site testing shall be updated with any changes required prior to final delivery of the manuals. Each manual's contents shall be identified on the cover. The manuals shall include the names, addresses, and telephone numbers of each subcontractor installing equipment and systems, and of the nearest service representatives for each item of equipment and each system. The manuals shall have a table of contents and tab sheets. Tab sheets shall be placed at the beginning of each chapter or section and at the beginning of each appendix. The final copies delivered after completion of the endurance test shall include modifications made during installation, checkout, and acceptance. The manuals include:

a. Functional Design Manual: The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and other requirements shall be included for each system operating mode.

b. Hardware Manual: The hardware manual shall provide detailed data describing equipment furnished, including:

(1) General description and specifications.

(2) Installation and checkout procedures.

(3) Equipment electrical schematics and layout drawings.

(4) System schematics and I/O wiring lists.

(5) Alignment and calibration procedures.

(6) Manufacturer's repair parts list indicating sources of supply.

(7) Interface definition for equipment, sub-system, and all other automative systems sharing data with UMCS or using UMCS inputs..

(8) DTS.

c. Software Manual: The software manual shall describe software functions, and shall include other information necessary to enable proper loading, testing, and operation. The manual shall describe and document software provided as part of the UMCS. Where the supplier's standard software packages are utilized, the software manual shall include complete user documentation.

(1) The software manual shall have separate sections for OWS, OWS equipment, and Archive equipment.

(a) Definitions of terms and functions.

(b) Procedures for system startup.

(c) Description of the application programs.

(d) Description of required sequences using control sequence software.

(e) Database format and data entry requirements.

(f) Directory of disk files.

(g) Parameter schedules.

(h) Operator commands.

(i) Report generator data format, output format, and content.

(j) Alarm messages and format.

(k) System access requirements.

(l) Description of communications protocols, including data formats, command characters, and a sample of each type of data transfer.

(m) Description of control sequence programming.

(2) The software manual shall have a separate section for Network Controller, Unitary Controller, and Universal Programmable Controller software, including:

(a) Definitions of terms and functions.

(b) Descriptions of the applications.

(c) Description of required sequences using control sequence software.

(d) Database format and data entry requirements.

(e) Alarm messages and format.

(f) System access requirements.

(g) Description of communications protocols, including data formats, command characters, and a sample of each type of data transfer.

d. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for equipment including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

e. Operator's Manual: The operator's manual shall fully explain procedures and instructions for operation of the system, including:

(1) OWS equipment.

(2) Archive equipment.

(3) LAN/WAN/DTS.

(4) System startup and shutdown procedures.

(5) Alarm presentation.

(6) Recovery and restart procedures.

(7) Data entry.

(8) Parameter schedules.

(9) Operator commands.

(10) Use of report generator.

(11) Report generator data format, output format, and content.

(12) Alarm messages and format.

(13) System access requirements.

(14) Graphics.

f. Operator's Condensed Manual: The operator's condensed manual shall contain complete outline instructions, guidance, and reference data sufficient to allow a trained operator to use the FEP portable computer specified. The manual shall be presented in a compact booklet form or on CD-ROM.

g. Installed Software Documentation: The installed software manual shall include original and backup copies of the run-time version of all object modules delivered for this project, on each type of media utilized, including CD ROM. In addition, a copy of the software shall be loaded on the OWS and on the portable computers.

1.4.2.6 Group VI Technical Data Package

The Group VI Technical Data Package shall consist of the updated as-built drawings revised to include system revisions and modifications. Copies of the updated as-built drawings shall be delivered to the Government after opposite season test and prior to final acceptance.

1.5 TESTING

The Contractor shall perform factory testing of the UMCS as specified. The Contractor is responsible for providing personnel, equipment, instrumentation, and supplies necessary to perform required testing. 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 specific test procedures. The test procedures shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test procedures shall define location of tests, milestones for the tests, and identify simulation programs, equipment, personnel, facilities, and supplies required. The test procedures shall provide for testing all capabilities and functions specified and shown. The test procedures shall be developed from the design documentation, using the requirements of \-MIL-STD 2202-\ and \-MIL-STD 2203-\ as a technical and format requirement. The procedures shall cover actual equipment and sequences to be used by the Contractor for the specified project and shall consist of detailed instructions for test setup, execution, and evaluation of test results. The test reports shall be used to document results of the tests. Reports shall be delivered to the Government within 7 days after completion of each test.

1.6 TRAINING

The Contractor shall conduct training courses for designated personnel in the maintenance, service, and operation of the system as specified, including specified hardware and software. The training shall be oriented to the specific system provided under this contract. Training manuals shall be delivered for each trainee with two additional copies delivered for archival at the project site. The manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. The Contractor is responsible for furnishing audiovisual equipment and other training material and supplies. Where the

Contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Government as a part of the printed training manuals. When training is conducted at Government facilities, the Government reserves the right to videotape the 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. For guidance in planning the required instruction, the Contractor should assume that attendees will be tradesmen such as electricians or boiler operators. Approval of the Contractor's training schedule shall be obtained from the Government at least 30 days prior to the training.

1.6.1 Operator's Training I

The first course shall be taught at the project site for a period of 5 consecutive training days at least 3 months prior to the scheduled PVT. A maximum of ten personnel will attend this course. 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:

a. General system architecture.

b. Functional operation of the system, including workstations.

c. Operator commands.

d. Application programs, control sequences, and control loops.

e. Color graphics generation.

f. Database entry and modification.

g. Reports generation.

h. Alarm reporting.

i. Diagnostics.

j. Historical files.

k. LAN administration.

l. Control Sequence Programming language.

1.6.2 Operator's Training II

The second course shall be taught at the project site for a period of 5 consecutive training days during or after the Contractor's field testing but prior to the commencement of the PVT. A maximum of 10 personnel will attend the course. No part of the training given during this course will be counted toward completion of the PVT. The course shall include instruction on the specific hardware configuration of the installed UMCS and specific instructions for operating the installed system. Upon completion of this course, 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.

1.6.3 Operator's Training III

The third course shall be taught while the endurance test is in progress for a total of 16 hours of instruction per student, in time blocks of 4 hours. A maximum of twenty personnel will attend this course. The schedule of instruction shall allow for each student to receive individual instruction for a 4-hour period in the morning (or

afternoon) of the same weekday for 4 consecutive weeks. The Contractor shall schedule his activities during this period so that the specified amount of time will be available for instructing the students. The course shall consist of "hands-on" training under the constant monitoring of the instructor. The instructor shall be responsible for determining the appropriate password to be issued to the student commensurate with each student's acquired skills at the beginning of each of these individual training sessions. Upon completion of this course, the students should be fully proficient in the operation of all system operations. The Contractor shall report the skill level of each student at the end of this course.

1.6.4 Operator's Training IV

The fourth course shall be taught at the project site for a period of 3 training days when approved by the Government, but no later than 6 months after completion of the endurance test. A maximum of 10 personnel will attend the course. The course will be structured to 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 UMCS.

1.6.5 Maintenance Training

The maintenance course shall be taught at the project site after completion of the Endurance Test for a minimum period of 5 training days. A maximum of 10 personnel will attend the course. This training shall not be scheduled at the same time as any session of operator training. The training shall include:

a. Physical layout of each piece of hardware.

b. Troubleshooting and diagnostic procedures.

c. Repair instructions.

d. Preventive maintenance procedures and schedules.

e. Calibration procedures.

f. Update of software modules and their installation.

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NOTE: Designer is to delete if not required by the user.
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1.6.6 Specialized Maintenance

Training Immediately following the maintenance training a minimum of one day of training shall be provided by a factory representative or a qualified Contractor trainer for each of the following:

a. Each type of flow meter, to include maintenance, testing and calibration flow elements and transducers. Training shall be provided for 6 people.

b. Each type of specialized sensor such as chlorine, turbidity, pH, NOx, to include maintenance, testing and calibration of sensing elements and transducers. Training shall be provided for 6 people.

1.7 MAINTENANCE AND SERVICE

The Contractor shall provide inspections and associated preventative maintenance, repair, and normal and emergency service calls, for the system including DTS. The Contractor shall furnish labor, supervision, tools, materials, equipment, transportation, and management necessary to provide maintenance, service and repair for

the UMCS in accordance with the requirements as specified. The Contractor shall also maintain and repair devices connected to and used by the UMCS in accomplishing its control and monitoring functions. This work includes inspection, testing, cleaning, lubrication, adjustment, calibration, and part or component replacement as specified. Work includes providing necessary preventive and unscheduled maintenance and repairs to keep the UMCS operating as specified, and accepted by the Government, and other services as specified. Work shall meet the specified standard and comply with manufacturer's recommendations and industry standards. The Contractor shall provide technical support via telephone during Contractor's regular working hours.

1.7.1 Work Coordination

The Contractor shall schedule and arrange work to cause the least interference with the normal Government business and mission. In those cases where some interference may be essentially unavoidable, the Contractor shall coordinate with the Government to minimize the impact of the interference, inconvenience, equipment downtime, interrupted service and personnel discomfort.

1.7.2 Work Control

a. The Contractor shall implement work control procedures to ensure timely accomplishment of work requirements, as well as to permit tracking of work in progress. The Contractor shall plan and schedule work to ensure material, labor, and equipment are available to complete work requirements within the specified time limits and in conformance with the specifications. Verbal scheduling and status reports shall be provided when requested by the Government. Work shall meet the specified standards, and comply with manufacturer's recommendations and industry standards. The Contractor shall comply with user, local, state and federal standards and applicable building and safety codes.

b. When the Contractor completes work on a system or piece of equipment, that system or piece of equipment shall be free of missing components or defects which would prevent it from functioning as originally intended and designed. Corrective or repair/replacement work shall be completed, including operational checks and cleanup of the job site. Except where otherwise noted, replacements shall conform to the specification. During and at completion of work, debris shall not be allowed to spread unnecessarily into adjacent areas nor accumulate in the work area itself. Such debris, excess material, and parts shall be cleaned up and removed at the completion of the job and/or at the end of each day that work is in progress.

c. The contractor shall follow all procedures to maintain facility security including guidelines and requirements of the installation where work is being performed.

1.7.3 Working Hours

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NOTE: Designer will determine working hours and enter.
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Working hours are from [7:30 A.M.] [_____] to [4:00 P.M.] [_____] Mondays through Fridays except legal holidays.

1.7.4 Equipment Repairs

Equipment repairs shall be initiated within 24 hours of first notification, and repairs shall be completed within 48 hours except for long lead items, e.g., valves. Repair is the restoration of a piece of equipment, a system, or a facility to such condition that it may be effectively utilized for its designated purposes. Repair may be overhaul, reprocessing, or replacement of nonfunctional parts or materials that have failed or deteriorated by action of the elements or usage and have not been corrected through maintenance, or replacement of the entire unit or system if beyond economical repair.

1.7.5 Replacement, Modernization, Renovation

The Government may replace, renovate, or install new equipment at Government expense and by means not associated with this contract. Replaced, improved, updated, modernized, or renovated systems and equipment interfaced to the system may be added to the Contractor's maintenance and service effort.

1.7.6 Access To UMCS Equipment

Access by the Contractor shall be in accordance with the following:

a. The Contractor shall be responsible for obtaining access to facilities and arrange that they be opened and closed during and after the accomplishment of the work effort. The Contractor should allow approximately 15 minutes delay time per access to each security controlled facility. For Contractor access to a controlled facility during other than regular working hours, the Contractor shall contact the Government for assistance. Service calls must still be completed within the time limits specified unless the cause of the problem is determined to be in UMCS equipment located within the controlled facility which required a delay to obtain entry, in which case the required response time will be extended by the amount of time access to the controlled facility was denied.

b. The Government will provide keys for access to UMCS equipment where the Government determines such key issuance is appropriate. The Government has no obligation to provide such keys.

c. The Contractor shall establish and implement methods of ensuring that keys issued to the Contractor by the Government are not lost or misplaced, are not used by unauthorized persons and are not duplicated. The Contractor shall develop procedures covering key control that shall be included in the quality control plan.

1.7.7 Preventive Maintenance Work Plan

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The Contractor shall strictly adhere to the approved work plan to facilitate Government verification of work. If the Contractor finds it necessary to reschedule maintenance, a written request shall be made to the Government detailing the reasons for the proposed change at least five days prior to the originally scheduled date. Scheduled dates shall be changed only with the prior written approval of the Government.

1.7.8 Records, Logs, and Progress Reports

The Contractor shall keep records and logs of each task, and shall organize cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for system devices on a building by building basis. The log shall contain digital points and initial analog span and zero calibration values. Complete logs shall be kept and shall be available for inspection on site, demonstrating that planned and systematic adjustments and repairs have been accomplished for the UMCS.

1.7.8.1 Service Call Reporting Requirements

The Contractor shall complete a service call work authorization form for each service call by close of business on the day when the service is completed.

1.7.8.2 Progress Reporting Requirements

The Contractor's progress reports shall include:

a. Service call authorization and completion forms (Emergency Service Call) to be delivered daily.

b. Service call authorization and completion forms (Normal Service and Emergency Service Call) to be delivered weekly.

c. Field equipment calibration records to be delivered weekly.

d. Telephone consultation log to be delivered monthly.

e. Maintenance inspection records to be delivered semiannually.

f. Historic files to be delivered semiannually.

1.7.9 Maintenance Requirements

The Contractor shall perform monthly, semiannual, and annual maintenance procedures or as described below, or more often if required by the equipment manufacturer.

1.7.9.1 Semiannual Maintenance

a. Clean OWS, Archive Equipment, FEPs, and interface panels including interior and exterior surfaces.

b. Run system diagnostics and correct diagnosed problems.

c. Fan checks and filter changes for UMCS hardware.

d. Mechanical adjustments, new ribbons, new cartridges for laser printers and other necessary adjustments
on printers.

e. Check and calibrate each field device; then compare its calibrated value against its reading at the Operator's Workstation. Check and calibrate 50% of the total analog points during the first semiannual inspection. Check and calibrate the remaining 50% of the analog points during the second semiannual inspection. Certify analog test instrumentation accuracy to be twice that of the device being calibrated. Check 50% of digital points for proper operation during the first semiannual inspection. Check the remaining 50% of digital points during the second semiannual inspection.

f. Resolve all outstanding problems.

1.7.9.2 Annual Maintenance

Includes all items in semiannual maintenance, plus any other maintenance requirements in addition to those covered in the semiannual maintenance requirements.

1.7.9.3 Maintenance Procedures

a. I/O Functions: I/O function calibration checks shall include before and after calibration readings (deviation of reading from actual value as measured by a known calibration standard). Contractor shall utilize analog test instrument with calibration traceable to the National Institute of Standards and Technology, and shall provide calibration documentation at the request of the Government. Analog test instrumentation shall be at least twice as accurate as the device being calibrated. Calibrations shall be within the tolerances of the original equipment. The Contractor shall adjust devices not conforming to the required accuracies, except those which are factory set and sealed. These factory sealed devices shall be replaced (not adjusted). The Contractor shall take UMCS equipment off-line

for calibration in accordance with manufacturers' requirements; no equipment malfunctions or erroneous alarms shall occur due to Contractor calibration actions. Equipment that cannot be calibrated shall be replaced at no cost to the Government. For each analog and digital point being controlled by the UMCS, the Contractor shall command each point and verify its proper operation, and the proper operation of connected equipment such as fans, valves, and dampers. Where practicable, create the field conditions for change of state of DIs and verify proper reporting at the Operator's Workstation.

b. FEPs: FEP maintenance shall include condition of paint, cabinet door seals, cabinet door locks, terminal strip connections, circuit card cage, circuit cards, power supplies, connectors, interconnecting cables and electrical connections, and power line conditioner. Maintenance of the FEP's CPU, memory, input/output functions and software shall also be included. In addition, voltage measurements shall be made and required adjustments made to bring the voltage levels to within manufacturers' tolerances; verification of proper operation of indicating lamps and switches shall be made; verification that equipment cabinet is at earth ground potential shall be made; and transient and lightning protection shall be inspected for signs of damage.

c. Operator Workstations: Operator Workstations maintenance shall require the Contractor to request Government approval prior to beginning required maintenance, 14 calendar days prior to the required start of maintenance. The system components will not be permitted to be off-line for more than 16 hours total for each scheduled maintenance. The Contractor shall run utilities to verify the structure and consistency of the hard disk file systems, performed on each disk. The Contractor shall perform a complete backup of the system prior to running diagnostics; this backup will be performed with the system online.

d. Printer: Printer maintenance shall include required lubrication and cleaning of the printing mechanism and the cleaning of the case and keyboard, replacement of the ribbon or printing cartridge, complete testing and documentation. All work and material which is necessary shall be provided.

e. Software/Firmware: Software/firmware maintenance includes operating systems, application programs, and files required for the proper operation of the UMCS whether resident on disk, in Random Access Memory (RAM), in all types of Programmable Read Only Memory (PROM), or in Read Only Memory (ROM). User-developed software is not covered by this contract, except that the UMCS software/firmware must be maintained to allow user creation, modification, deletion, and proper execution of such user-developed software as specified. Software/firmware must be maintained to fully perform functions as specified in the manufacturer's documentation. The Contractor shall perform diagnostics and corrective reprogramming as required to maintain total UMCS operations as specified. The Contractor shall back up software before performing any computer hardware and software maintenance. In order to maintain the software/firmware in accordance with the requirements of this contract, the Contractor may provide and install software/firmware updates at the Contractor's expense upon obtaining written approval from the Contracting Officer. Software/firmware updates and other modifications shall not degrade the performance or decrease the functionality of any part of the UMCS, and shall be provided with the same Rights in Technical Data and Computer Software as the original software/firmware. Documentation and magnetic media shall be modified to reflect the updates and modifications. The Contractor shall not modify any database parameters without approval from the Government. Any approved changes and additions to the database shall be properly documented, and the appropriate manuals shall be updated.

f. DTS: DTS maintenance shall include testing transmission media and equipment to verify signal levels, system data rates, errors and overall system performance.

1.7.10 Service Call Reception

a. The Contractor shall have procedures for receiving and responding to service calls 24 hours per day, seven days a week, including weekends and holidays. A single telephone number shall be provided by the Contractor for receipt of service calls during regular working hours. For service calls after regular working hours, the Contractor may provide a calling list of no more than three telephone numbers; the Contractor may alternatively provide a pager telephone number. Telephone calls shall be answered within 30 seconds, or pager calls returned within 10 minutes, by an individual fully familiar with the maintenance and service procedures. Service calls shall be considered received by the Contractor at the time and date the telephone call is placed by the authorized Government representative.

b. The Contractor shall separately record each service call request, as received. The form shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. The Contractor shall complete a service call work authorization form for each service call.

c. The Contractor shall respond to each service call request within two (2) working hours. The status of any item of work must be provided within 4 hours of the inquiry during regular working hours, and within 16 hours after regular working hours. Response time is defined as the time allowed the Contractor after initial notification of a work requirement to be physically on the premises at the work site with appropriate tools, equipment, and materials, ready to perform the work required.

d. A Government representative will advise the Contractor by phone or in person of all maintenance and service requests, as well as the classification of each based on the definitions specified. A description of the problem or requested work, date and time notified, location, classification, and other appropriate information will be placed on a Service Call Work Authorization Form by the Government and made available for pickup by the Contractor, or sent via fax to the Contractor by 12 noon the following Government workday.

1.7.11 Service Call Work Warranty

The Contractor shall provide a 90 day unconditional warranty on service call work. The warranty shall include labor and material necessary to restore the equipment involved in the initial service call to a fully operable condition. In the event of failure of Contractor service call work that causes damage to additional equipment in the system the Contractor is liable for labor and material to restore that equipment to full operation. Contractor response to service call warranty work shall be the same as required by the initial service call.

1.7.12 System Modifications

The Contractor shall make recommendations for system modification in writing to the Government. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected. The Contractor shall make available to the Government operating and application software updates during the life of this contract. The Government will notify the Contractor if the updates can be installed. Maintenance releases of the UMCS system software shall be provided at no additional cost to the Government. These updates shall be accomplished in a timely manner, fully coordinated with UMCS operators, and shall be incorporated into the operations and maintenance manuals, and software documentation. There shall be at least one scheduled update near the end of the contract period, at which time the Contractor shall make available the latest released version of the Contractor's software, and shall install and validate it upon approval by the Government.

1.7.13 Telephone Consultation and Remote Software Service

The Contractor shall provide up to [48] [__] hours per year of telephone consultation to Government personnel. The Government will initiate telephone consultation calls during regular working hours for the purposes of identifying and resolving apparent operational problems with the UMCS. The Contractor shall provide personnel fully familiar with the subject matter of the Government initiated call. Approximately 60% of telephone consultation will require a skill level equivalent to a system analyst, and approximately 40 % of the telephone consultation will require a skill level equivalent to a computer programmer. The Contractor shall keep a log of the dates, times, names of Government personnel, and duration of each call, and shall advise the designated Government personnel when more than 4 hours of consultation time has been expended in any month. The Contractor shall not provide over 4 hours of consultation per month without authorization from the Government. The Contractor shall submit a copy of the log to the Government each month.

1.7.14 System Manager

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The Contractor shall provide a system manager on exclusive assignment for the UMCS during normal first shift working hours to interface with Government personnel and Contractor personnel. The system manager shall not be involved with field work such as field calibration of sensors, field service calls, and field maintenance of equipment, but shall manage this work from Operator Workstation. The system manager shall perform general tasks such as preparation of custom programs and reports, installation of software, backups, preparation of custom graphics and updates of the point database. The system manager shall be responsible for checking the UMCS daily, including weekends and holidays, by logging into the system at a minimum of twice each day, once in the morning and once in the evening. The system check shall include monitoring alarms and system failures. The system manager's response to these alarms and system failures shall be to immediately contact Government personnel for further instructions. Specific procedures and phone listings of assigned Government personnel will be furnished to the Contractor after award.

1.8 DATA TRANSMISSION SYSTEMS (DTS)

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NOTE: Include in the project specification one or more of the following CEGS for the appropriate DTS to be required at the project site: Section 16792 WIRE LINE DATA TRANSMISSION SYSTEM, Section 16768 FIBER OPTICS DATA TRANSMISSION SYSTEM, Section 16798 TWO-WAY RADIO DATA TRANSMISSION SYSTEM, or Section 16794 COAXIAL CABLE DATA TRANSMISSION MEDIA.
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Data Transmission Systems shall be provided as indicated in Section [_____] and as shown.

PART 2 PRODUCTS

2.1 EQUIPMENT REQUIREMENTS

2.1.1 Materials and Equipment

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products. 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 Enclosures

Electrical, electronic, and electro-pneumatic devices not located within an FEP shall be mounted in an enclosure unless otherwise specified or shown. Enclosures 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 12; those for installation in clean, dry indoor occupied space may be Type 1; other locations as otherwise specified or shown. Enclosures for equipment installed outdoors shall be Type 4 or as shown, and shall contain a thermostatically controlled space heater to maintain the enclosure above the dew point if required by the equipment installed.

2.1.3 Key Operated Switches

Hand-Off-Automatic (HOA), off-automatic, three-way momentary contact on-off, and similar use switches shall be key operated with switches keyed alike, or such switches shall be protected by a key locked enclosure (except where shown as non-key operated). Switches shall be rated for a minimum of 600 Vac, 5A, and shall be mounted in an enclosure as specified or shown. Dual auxiliary contacts shall be provided for the automatic position to provide position sensing at the FEP. Auxiliary contacts shall be rated at least 120 Vac, 1 A.

2.1.4 Nameplates

Laminated plastic nameplates shall be provided for equipment devices and panels furnished. Each nameplate shall identify the function, such as "override switch for circuit xxx " or "Pressurization control panel xxx." 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 ACTUATORS

Actuators shall be pneumatic, electric or electronic as shown. Actuators shall fail to their spring return-positions as shown on signal or power failure and shall have a visible position indicator. Actuators shall open or close the devices to which they are applied within 30 seconds after a full scale input signal change. Electric or electronic actuators operating in parallel or in sequence shall have an auxiliary actuator driver. Pneumatic actuators shall be rated for \^172 kilopascals^\ \~25 psig~\ operating pressure except for high pressure cylinder type actuators. Modulating actuators in control sequences involving two or more devices operating in sequence, sequencing two or more stages, increments, or steps of capacity, or when actuators are operating at 75% or more of rated capacity, or wherever accurate positioning is required to achieve the specified control sequences, shall be provided with positive positioners. Actuators shall smoothly operate the devices to which they are applied. Actuators shall fully open and close the devices to which they are applied and shall have a full stroke response time of 60 seconds or less. The actuator stroke shall be limited by an adjustable stop in the direction of power stroke.

2.2.1 Pneumatic Operators

The Contractor shall provide piston or diaphragm type operators with full range or split range springs to provide the sequence specified and the failure mode specified. Contractor shall provide positioners where specified and where necessary to prevent overlap of heating and cooling when one controller operates more than one device and to provide the proper "dead band" between heating and cooling.

2.2.2 Electric Operators

The Contractor shall provide gear type electric operators. Each operator shall deliver the torque required for continuous uniform movement of the valve or damper and shall have an end switch to limit travel or shall withstand, without damage, continuous stalling. Operators shall function properly with a range of 85 to 110% of rated line voltage. Drive train gears shall be steel or copper alloy. Shafts shall be hardened steel running in sleeve bearings of copper alloy, hardened steel, nylon, or ball bearings. Operators and gear trains shall be

totally enclosed in dust proof housings with rigid conduit connections. Gear trains shall be oil immersed or permanently lubricated. Two-position operators shall be of the single direction, spring return, or reversing type. Proportioning operators shall be capable of stopping at any point in the cycle and starting in either direction, from any point. Reversing and proportioning operators shall have limit switches to limit travel in either direction, unless the operator is a stall type. Valve operators shall be equipped with a spring yield device so that when in a relaxed position, the device shall maintain a pressure on the valve disc equivalent to the system pressure at the valve. Failure mode operation shall include the accessories required to hold the controlled device in the desired failure mode position.

2.2.3 Damper Actuators

Damper actuators shall be rated for at least 125% of the maximum motive power necessary to operate against the pressure shown. The actuator stroke shall be limited by an integral adjustable stop in the direction of power stroke. The actuators shall be provided with mounting and connecting hardware arranged for placing the actuator parallel to the plane of the damper.

Air Distribution Terminal Unit Damper Actuator: Air distribution terminal unit damper actuator shall open or close the device to which it is connected within 60 seconds. Spring return not required.

2.2.4 Valve Actuators

Valve actuators shall be rated for at least 125% of the motive power necessary to operate the valves over their full range of operation against the total and differential pressures shown, including torque required to seat or unseat resilient seated butterfly valves.

2.2.5 Positive Positioners

Positive positioners are required for pneumatic actuators. Each positive positioner shall provide a mechanical feedback mechanism and an adjustable operating range and starting point. Positioners shall be capable of applying actuator's full rated motive power to maintain the position called for by the control signal. Positioners shall be provided whenever controlled devices are operated in a sequence of two or more stages, whenever an actuator is operating at 75% or more of its rated capacity, or whenever accurate positioning is required to achieve the specified control sequences.

2.3 AUTOMATIC CONTROL VALVES

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NOTE: Designer will calculate and show the Cv for each valve on the drawings. Parameters to be controlled or displayed will be specified only in degrees F or IP units as applicable.

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Valves shall have stainless steel stems and stuffing boxes with extended necks to clear the piping insulation. Valve bodies shall be designed for not less than \^812 kilopascals^\ \~125 psig~\ working pressure or 150% of the system operating pressure, whichever is greater. Valve leakage rating shall be a maximum of 0.01% of rated Cv at a differential pressure of \^345 kilopascals^\ \~50 psig~\ or 125% of that expected for the application, whichever is greater. Valves shall have visible valve position indicator.

2.3.1 Butterfly Valve Assembly

Butterfly valve shall be threaded lug type suitable for dead-end service, with carbon steel bodies and noncorrosive discs, stainless steel shafts supported by bearings, and elastomeric renewable seats suitable for temperatures from \^minus 29 to plus 121 degrees C.^\ \~minus 20 to plus 250 degrees F.~\ Valves shall have a manual means of operation independent of the actuator.

2.3.2 Two-Way Valves

Two-way modulating valves shall have equal-percentage characteristics.

2.3.3 Three-Way Valves

Three-way modulating valves shall provide linear flow control with constant total flow throughout full plug travel.

2.3.4 Duct Coil and Terminal Unit Coil Valves

Control valves with either flare type or solder type ends shall be provided for duct or terminal unit coils. Flare nuts shall be furnished for each flare type end valve.

2.3.5 Valves for Chilled Water, Condenser Water, and Glycol Service

2.3.5.1 Valve Bodies

Bodies for valves \^38 mm^\ \~1-1/2 inches~\ and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from \^51 to 76 mm^\ \~2 to 3 inches~\ inclusive shall be of brass, bronze or iron. Bodies for \^51 mm^\ \~2 inch~\ valves shall have threaded ends. Bodies for valves from \^63 mm^\ \~2-1/2 inches~\ and larger shall have flanged end connections. Valve Cv shall be within plus or minus 25% of the Cv shown.

2.3.5.2 Valve Trim and Flow Requirements

Internal valve trim shall be brass or bronze except that valve stems may be Series 300 stainless steel and shall provide equal percentage flow characteristics.

2.3.5.3 Valve Capacity
Valves \^102 mm^\ \~4 inches~\ and larger shall be butterfly valves.

2.3.6 Valves for Hot Water Service Below \^121 degrees C^\ \~250 degrees F~\

2.3.6.1 Valve Bodies for Hot Water Applications

Bodies for valves \^38 mm^\ \~1-1/2 inches~\ and smaller shall be brass or bronze, with threaded or union ends. Bodies for \^51 mm^\ \~2 inch~\ valves shall have threaded ends. Bodies for valves \^64 mm^\ \~2-1/2 inches~\ and larger shall have flanged end connections. Valve Cv shall be within plus or minus 25% of the Cv shown.

2.3.6.2 Valve Trim for Hot Water Applications

Internal trim (including seats, seat rings, modulating plugs, and springs) of valves controlling water hotter than \^99 degrees C^\ \~210 degrees F~\ shall be Series 300 stainless steel and shall provide equal percentage flow characteristics.

2.3.6.3 Valve Trim and Flow for \^99 degrees C^\ \~210 degrees F~\ Service

Internal trim for valves controlling water \^99 degrees C^\ \~210 degrees F~\ or less shall be brass or bronze and provide equal percentage flow characteristics.

2.3.6.4 Nonmetallic Valve Parts for \^121 degrees C^\ \~250 degrees F~\ Service

Nonmetallic parts of hot water control valves shall be suitable for a minimum continuous operating temperature of \^121 or 10 degrees C^\ \~250 or 50 degrees F~\ above the system design temperature, whichever is higher.

2.3.6.5 Valves Larger than \^102 mm^\ \~4 Inches~\

Valves \^102 mm^\ \~4 inches~\ and larger shall be butterfly valves.

2.3.7 Valves for Steam Service

Bodies for valves \^38 mm^\ \~1-1/2 inches~\ and smaller shall be all brass or bronze, with threaded or union ends. Bodies for valves from \^51 to 76 mm^\ \~2 to 3 inches~\ inclusive shall be of brass, bronze, or iron. Bodies for valves \^102 mm^\ \~4 inches~\ and larger shall be iron. Bodies for \^51 mm^\ \~2 inch~\ valves shall have threaded ends. Internal valve trim shall be Series 300 stainless steel and shall provide linear flow characteristics.

2.3.8 Valves for High Temperature Hot Water Service

Valves for High Temperature Hot Water Service Above \^121 degrees C^\ \~250 degrees F~\: Valve bodies shall be rated ANSI Class 300, as in \-ASME B16.34-\. Valve and actuator combination shall be normally closed. Bodies shall be carbon steel, globe type with welded ends on valves \^25 mm^\ \~1 inch~\ and larger. Valves smaller than \^25 mm^\ \~1 inch~\ shall have socket-weld ends. Packing shall be virgin polytetrafluoroethylene. Valve Cv shall be within plus or minus 25% of the Cv shown. Internal valve trim shall be Series 300 stainless steel with resilient seat to provide bubble tight shutoff against differential pressure of \^690 kilopascals^\ \~100 psig~\ and provide equal percentage flow characteristics.

2.4 DAMPERS

2.4.1 Damper Assembly

2.4.1.1 Damper Blades

A single damper section shall have blades no longer than \^1.2 m^\ \~48 inches~\ and shall be no higher than \^1.8 m.^\ \~72 inches.~\ Maximum damper blade width shall be \^203 mm.^\ \~8 inches.~\ Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. All blade operating linkages shall be within the frame so that blade connecting devices within the same damper section will not be located directly in the air stream. Damper axles shall be a minimum of \^13 mm^\ \~1/2 inch~\ plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed \^10 pascals^\ \~0.04 inch water gauge~\ at \^5 m/s^\ \~1,000 fpm~\ in the wide open position. Frames shall be at least \^51 mm^\ \~2 inches~\ in width. Dampers shall be tested in accordance with \-AMCA 500-\.

2.4.1.2 Damper Links

Operating links external to dampers (such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers) shall withstand a load equal to at least twice the maximum required damper operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crank arms shall control the open and closed positions of dampers. Damper actuators shall be mounted parallel to the plane of the damper.

2.4.2 Damper Types

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NOTE: Indicate on the drawings the type of damper to be provided. Refer to TM 5-815-3 for guidance on the type of damper to be selected.

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Modulating dampers shall be opposed-blade type and two-position dampers shall be parallel-blade type.

2.4.3 Outside Air, Return Air, and Relief Air Dampers

The dampers shall be modulating, opposed-blade type. Blades shall have interlocking edges and shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Dampers shall not leak in excess of \^0.56 cubic meters/min^\ \~20 cfm per square foot~\ at \^10 pascals^\ \~4 inches water gauge~\ static pressure when closed. Seals shall be suitable for an operating temperature range of minus \^4 to 93 degrees C.^\ \~40 to 200 degrees F.~\ Dampers shall be rated at not less than \^10 m/s^\ \~2,000 fpm~\ air velocity.

2.4.4 Mechanical and Electrical Space Ventilation Dampers

The dampers may be of the parallel or opposed-blade type. Dampers shall not leak in excess of \^2 cm per square meters^\ \~80 cfm per square foot~\ at \^10 pascals^\ \~4 inches water gauge~\ static pressure when closed. Dampers shall be rated at not less than \^7 m/s^\ \~1,500 fpm~\ air velocity.

2.4.5 Smoke Dampers

Smoke-damper and actuator assemblies required per \-NFPA 90A-\ shall meet Class II leakage requirements of \-UL 555S-\. Dampers shall be rated not less than \^10 m/s^\ \~2,000 fpm~\ air velocity.

2.5 INSTRUMENTATION AND CONTROL

2.5.1 Temperature Instruments

2.5.1.1 Resistance Temperature Detector (RTD)

RTD shall be platinum, with an accuracy of plus or minus 0.1% at \^0 degrees C.^\ \~32 degrees F.~\ RTD shall be encapsulated in epoxy, Series 300 stainless steel, anodized aluminum, or copper. Each RTD shall be furnished with a matched RTD transmitter as specified, mounted integrally.

2.5.1.2 Continuous Averaging RTD

Continuous averaging RTD shall have an accuracy of plus or minus \^2 degrees C^\ \~1.0 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. Each averaging RTD shall be furnished with an RTD transmitter selected to match the resistance range of the averaging RTD.

2.5.1.3 RTD Transmitter

The RTD transmitter shall be selected to match the resistance range of the RTD. The transmitter shall be a 2 wire device, producing a linear 4 to 20 mAdc output corresponding to the required temperature span. The output error shall not exceed 0.1% of calibrated span.

2.5.1.4 Temperature Switch

Temperature switch shall have a repetitive accuracy of plus or minus 1% 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 for the application.

2.5.1.5 Thermocouple

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 Vdc. Thermocouple shall be Type E, Type K, Type J, or Type R. Thermocouple error shall not exceed that

specified in \-ISA MC96.1-\. Each thermocouple shall be furnished with a thermocouple transmitter as specified, mounted integrally with the thermocouple or as shown. All wire/cable from thermocouple to transmitter shall be of the type necessary to match the thermocouple used.

2.5.1.6 Thermocouple Transmitter

Transmitter selected shall match the type of thermocouple provided. The transmitter shall produce a linear 4 to 20 mAdc output corresponding to the required temperature span. The transmitter shall include automatic cold junction reference compensation with span and offset adjustments, and upscale open thermocouple detection.

2.5.1.7 Thermowell

Thermowell shall be monel, brass, or copper for use in copper 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 transmitter.

2.5.1.8 Instrument Shelter

Instrument shelter for outside-air temperature and humidity sensing elements shall prevent the sun from directly striking the sensing elements. The instrument shelter shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings. Instrument shelter shall be fabricated from wood and painted white. Shelter shall have louvered sides, double tops, and slotted bottoms.

2.5.1.9 Sunshield

Sunshield for outside-air temperature sensing elements shall prevent the sun from directly striking the temperature sensing elements. The sunshield shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings. The top of each sunshield shall have a fiberglass rainshield projecting over the face of the sunshield. The sunshield shall be painted white.

2.5.2 Thermostat

Thermostat ranges shall be selected so that the nominal setpoint is the midpoint of the range.

2.5.2.1 Modulating Room

Thermostat modulating room thermostat shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Each thermostat shall have an adjustable throttling range of minus \^16 to 13 degrees C^\ \~4 to 8 degrees F~\ for each output.

2.5.2.2 Nonmodulating Room

Thermostat Contacts shall be Form C, wired to identified terminals. The maximum differential shall be \^2 degrees C.^\ \~2 degrees F.~\ Thermostat covers shall be made of metal or heavy-duty plastic, and shall be capable of being locked by an allen-head wrench or a special tool. Thermostat shall have manual switches as required by the application.

2.5.2.3 Microprocessor-Based Room Thermostat

Microprocessor-based thermostat shall have built-in keypads for scheduling of day and night temperature settings. Access to the scheduling mode shall be by a password control code. When out of the scheduling mode, thermostats shall have continuous display of time, with am and pm indicator, continuous display of day of week, and either continuous display of room temperature with display of temperature setpoint on demand, or

continuous display of temperature setpoint with display of room temperature on demand. In the programmable mode, the display shall be used for setting and interrogating time program on-off setpoints for all 7 days of the week. The time program shall allow 4 separate temperature setback intervals per day. The thermostat shall have means for temporary and manual override of the program schedule, with automatic program restoration after the scheduled interval. Thermostat shall maintain the schedule in memory for 30 days in the event of a power outage. The maximum differential shall be \^2 degrees C.^\ \~2 degrees F.~\ When used for heat pump applications, the thermostat shall have an emergency heat switch.

2.5.2.4 Nonmodulating Capillary Thermostats and Aquastat

a. Each thermostat shall have a capillary length of at least \^1.5 meters,^\ \~5 feet,~\ shall have adjustable direct-reading scales for both setpoint and differential, and shall have a \^10 degrees C^\ \~10 degrees F~\ adjustable differential.

b. Aquastat shall be of the strap-on type, with \^10 degrees C^\ \~10 degrees F~\ fixed differential.

c. Duct Mounted Low Temperature Device: Low temperature protection thermostat shall be manual reset, low temperature safety thermostat, with Form A and Form B contacts and a \^6 meter^\ \~20 foot~\ element which shall respond to the coldest \^0.5 meters^\ \~18 inch~\ segment.

2.5.2.5 Modulating Capillary Thermostat

Each thermostat shall have either one output signal, two output signals operating in unison, or two output signals operating in sequence, as required for the application. Thermostat shall have adjustable throttling ranges of \^4 to 8 degrees C^\ \~4 to 8 degrees F~\ for each output.

2.5.3 Relative Humidity Instrument

The r.h. sensors shall use bulk polymer or thin film capacitive type nonsaturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. The sensors shall include removable protective membrane filters. Sensors shall have a range of 20 to 80%, with an accuracy of plus or minus 2% of full scale with a temperature dependence of less than plus or minus 2% from minus 10 to plus 60 degrees C. A transmitter located at the sensor shall be provided to convert the sensor output to a linear 4 to 20 mAdc output corresponding to the required humidity span. The transmitter shall include noninteracting zero and span adjustments. Where required for exterior installation, sensors shall be capable of surviving below freezing temperatures and direct contact with moisture without affecting sensor calibration.

2.5.4 Air Flow Instrumentation

2.5.4.1 Electronic Air-Flow-Measurement Station and Transmitter

a. Station: Each station shall contain an array of velocity sensing elements and straightening vanes, integral or separate, inside a flanged sheet-metal casing. The velocity sensing elements shall be RTDs. The sensing elements shall be distributed across the duct cross-section in the quantity and pattern set forth for measurements and instruments of \-ASHRAE-81930-\ for the traversing of ducted air flows. Each array shall have a minimum of one velocity sensing element \^0.1 square meter^\ \~per square foot~\ of duct cross-sectional area. The resistance to air flow through the air-flow measurement station shall not exceed \^20 pascals^\ \~0.08 inch water gauge~\ at an air flow of \^10 m/s.^\ \~2000 fpm.~\ Station construction shall be suitable for operation at air flows of up to \^25 m/s^\ \~5000 fpm~\ over a temperature range of \^4 to 50 degrees C,^\ \~40 to 120 degrees F,~\ and accuracy shall be plus or minus 3% over a range of \^1.3 to 13 m/s^\ \~250 to 2500 fpm~\ scaled to air volume.

b. Transmitter: Each transmitter shall produce a linear, temperature compensated 4-to-20 mAdc output corresponding to the velocity measurement. The output error of the transmitter shall not

exceed 0.5% of the calibrated measurement. The transmitter shall provide local airflow volume indication in \^liters per second.^\ \~cubic feet per minute.~\

2.5.4.2 Pitot-Tube Air-Flow-Measurement Stations and Transmitter

a. Station: Each station shall contain an array of velocity sensing elements and straightening vanes inside a flanged sheet-metal casing. The velocity sensing elements shall be of the multiple pitot-tube type with averaging manifolds. The sensing elements shall be distributed across the duct cross-section in the quantity and pattern set forth for measurement and instruments of \-ASHRAE-81930-\ for the traversing of ducted air flows. Each array shall have a minimum of one velocity sensing element per square foot of duct crossectional area. The resistance to air flow through the air-flow-measurement station shall not exceed \^20 pascals^\ \~0.08 inch water gauge~\ at an air flow of \^10 m/s.^\ \~2000 fpm.~\ Station construction shall be suitable for operation at air flows from \^2.5 to 25 m/s^\ \~500 to 5000 fpm~\ over a temperature range of \^minus 18 to plus 66 degrees C,^\ \~minus 0 to plus 150 degrees F,~\ and accuracy shall be plus or minus 3% over a range of \^2.5 to 13 m/s^\ \~500 to 2500 fpm~\ scaled to air volume.

b. Transmitter: Each transmitter shall produce a linear 4-to-20 mAdc output corresponding to the velocity pressure measurement. 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% of full scale, and overall transmitter accuracy shall be plus or minus 0.25% of the calibrated measurement. Each transmitter shall include non-interacting offset and span adjustments. The transmitter shall provide local airflow volume indication in \^liters per second.^\ \~cubic feet per minute.~\

2.5.5 Pressure Instrument

2.5.5.1 Pressure Transducer

The pressure transducer shall withstand up to 300% of rated pressure, with an accuracy of plus or minus 1% of full scale selected to put the expected range of the measured variable in the middle third of the transducer's range. The sensing element shall be either capsule, diaphragm, bellows, bourdon tube, or solid state as applicable for the installation. A transmitter located at the transducer shall be provided to convert the sensing element output to a linear 4 to 20 mAdc output corresponding to the required pressure span. The output error shall not exceed 0.1% of calibrated span. The transmitter shall include non-interacting zero and span adjustments.

2.5.5.2 Pressure Switch

Pressure switch shall have a repetitive accuracy of plus or minus 5% of their operating range and shall withstand up to 150% of rated pressure. Sensors shall be diaphragm or bourdon tube. Switch actuation setpoint shall be adjustable over the operating pressure range with a differential adjustment span of 20 to 40% of the range of the switch. The switch shall have Form C snap-action contacts rated for the application. Gauge pressure switches shall have an adjustable differential setting.

2.5.5.3 Pneumatic Electric (PE) Switch

Each switch shall have an adjustable setpoints range of \^20 to 137 kilopascals,^\ \~3 to 20 psig,~\ an adjustable differential from \^13 to 41 kilopascals,^\ \~2 to 6 psi,~\ and a Form C contact rated for the application.

2.5.5.4 Differential Pressure Instrument

The instrument shall be a pressure transmitter with an integral sensing element. The over pressure rating shall be a minimum of 300% of the operating pressure. The sensor/transmitter assembly accuracy shall be plus or minus 2% of full scale. The transmitter shall be a 2-wire, loop-powered device. The transmitter shall produce

a linear 4-to-20 mAdc output corresponding to the pressure measured. Each transmitter shall have non-interacting offset and span adjustments.

2.5.5.5 Differential Pressure Switch

Each switch shall be an adjustable diaphragm or bellows operated device with taps for sensing lines for connection of duct pressure fittings designed to sense air pressure. These fittings shall be of the angled-tip type with tips pointing into the air stream. The differential pressure switch range shall be \^124 to 1492 pascals.^\ \~0.5 to 6.0 inches water gauge.~\ The adjustable differential shall be a maximum of \^37 pascals^\ \~0.15 inch water gauge~\ at the low end of the range and \^87 pascals^\ \~0.35 inch water gauge~\ at the high end of the range. Two Form C contacts rated for the application shall be included.

2.5.5.6 Room Pressurization Sensor

a. Sensor shall measure the differential pressure between a reference pressure area (hallway or outdoor) and the pressurized area (laboratory or isolation area). Sensor shall be complete with the required pressure sensing elements for the two points. All fittings, tubing, and mounting equipment necessary for the required application shall be provided.

b. Sensor range shall be from \^minus 24 to plus 24 pascals^\ \~0.1 to plus 0.1 inches~\ of water column. Sensor shall provide a linearized 4 to 20 mAdc signal for remote monitoring. Sensor shall be a 2-wire, loop-powered device with local indication.

2.5.6 Flow Instrument

2.5.6.1 Orifice Plate

Orifice plate shall be made of an austenitic stainless steel sheet of \^3.3 mm^\ \~0.125 inch~\ nominal thickness with an accuracy of plus or minus 1% of full flow. The orifice plate shall be flat within \^0.1 mm.^\ \~0.002 inches.~\ The orifice surface roughness shall not exceed \^0.5 micro meters.^\ \~20 micro inches.~\ 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 diameter, whichever is smaller. The upstream edge of the orifice shall be square and sharp. Where orifice plates are utilized, concentric orifice plates shall be used in all applications except steam flow measurement in horizontal pipelines.

2.5.6.2 Flow Nozzle

Flow nozzle shall be made of austenitic stainless steel with an accuracy of plus or minus 1% of full flow. 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 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 shall not cause the accuracy to degrade beyond the specified limit. 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.

2.5.6.3 Venturi Tube

Venturi tube shall be made of cast iron or cast steel and shall have an accuracy of plus or minus 1% of full flow. 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 micro meter^\ \~50 micro inch~\ finish, including the short curvature leading from the converging entrance section into the throat.

2.5.6.4 Annular Pitot Tube

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. Sensor shall have an accuracy of plus or minus 2% of full flow and a repeatability of plus or minus 0.5% of measured value. Transmitter shall be electronic and shall produce a linear output of 4 to 20 mAdc corresponding to the required flow span. The transmitter shall include noninteracting zero and span adjustments.

2.5.6.5 Insertion Turbine Flowmeter

a. General: Turbine flowmeter accuracy shall be plus or minus 1% 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% of reading. The meter flow sensing element shall operate over a range of ambient to \^187 degrees C^\ \~370 degrees F~\ with a pressure loss limited to 1% of operating pressure at maximum flow rate. The flowmeter electronics shall be scaled and rescaled in the field when application data changes. Field preamplifiers shall be included for signal boosting and conditioning of frequency (flow), pressure, and temperature signals from sensors. Design of the flowmeter probe assembly shall incorporate integral flow, temperature, and pressure monitoring. The minimum straight unobstructed piping for the flowmeter installation shall be 10 pipe diameters upstream and 5 pipe diameters downstream. The internal temperature transmitter shall be required to monitor various temperature ranges for each specific application with end limitations of \^0 to 204 degrees C.^\ \~32 to 400 degrees F.~\ The integral pressure transmitter shall be required to monitor the various pressure ranges required by specific applications with end limits of \^0 to 2 mega pascals.^\ \~0 to 300 psig.~\ The flowmeter shall be designed for installation in pipe sizes of \^72 mm^\ \~3 inches~\ and larger to accommodate maximum probe insertion depths up to \^1 meter.^\ \~44 inches.~\

b. Retractor Assembly: 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 shall be constructed of Series 300 stainless steel and designed to protect the turbine rotor during insertion into pipeline. Retraction of the turbine rotor shall be accomplished by using a hand wheel with a rotation of 6 threads per \^mm^\ \~inch~\ (acme thread) and a non-rising stem to minimize the number of hand wheel turns. Design of the retractor assembly shall include an isolation valve providing a means of removal of the meter from service to allow for the replacement of parts and field maintenance. The meter retraction length shall be suitable for the required insertion depth as shown for each specific metering application. The Contractor shall determine the exact insertion depth required for each individual application.

c. Turbine Rotor Assembly: The turbine rotor assembly shall be constructed of Series 300 stainless steel and use teflon seals. The assembly shall be affixed to the pickup/stem and shall include a stainless steel set screw and safety wire. The rotor assembly shall be field replaceable. The turbine rotor shall be designed to allow compensation for bearing wear without affecting rotor calibration. The turbine rotor shall have an overrange operating requirement of 150% of maximum flow for up to 5 seconds. The turbine rotor response time from minimum to maximum flow shall be less than 10 milliseconds. The rotor shall be calibrated at the factory in an actual flow of similar material over the specified flow range for each utility service. The calibration shall include a minimum of six calibration points and must be 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 provided 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.

d. Pressure Transmitter: A pressure transmitter shall be an integral part of the flowmeter assembly. Pressure transmitter shall be a microprocessor-based type utilizing a sealed capacitance sensing element providing a 4 to 20 mAdc output signal for input to the flow processor for pressure compensation of process flow. Transmitter range shall be from \^0 to 2 mega pascals.^\ \~0 to 300 psig.~\ Pressure transmitter body material and bolting components shall be Series 300 stainless steel. Accuracy of the pressure transmitter shall be plus or minus 0.25% over calibrated span.

e. Temperature Transmitter: A temperature transmitter shall be an integral part of the flowmeter assembly. The transmitter shall be microprocessor-based type utilizing digital technology to ensure accuracy providing a 4 to 20 mAdc output signal to interface to the system, except for compressed air and natural gas applications, which shall include an interface to the flow processor for temperature compensation of process flow. Transmitter shall provide local indication of process variable and shall be integrally attached to a platinum RTD temperature sensor assembly including a Series 300 stainless steel thermowell of proper length to provide a unitized configuration for installation in the field. Accuracy of the temperature transmitter shall be plus or minus 0.05 % for minimum/maximum span.

f. Flow Processor: The flow processor shall be factory supplied with an enclosure housing the electronics. A plexiglass window suitable for reading the mechanical totalizer and the LED readout shall be provided in the cover. Enclosures shall have removable hinged, key-locked front doors, with locks keyed alike. The Contractor shall turn over 20 keys to the Government. The flow processor shall operate from a 120 Vac, 60 Hz power source, and shall provide 24 Vac plus or minus 5% for the powering of the turbine meter, and temperature and pressure preamplifiers. The processor shall include a lithium cell battery backup power source for maintaining the programmed data during any power loss time interval up to 6 month duration. The flow processor shall accept a variable frequency signal which is proportional to the flow with six-point linearity, a 4 to 20 mAdc signal from the temperature transmitter and a 4 to 20 mAdc signal from the pressure transmitter. The temperature and pressure signals shall be used for calculating compensated flow in the processor. The flow processor shall provide an input to the UMCS as a 4 to 20 mAdc signal for process variable pressure. The flow processor shall provide a Form A or B PA signal representing totalized flow into the UMCS. The flow processor shall have a front cover-mounted 16 digit, tactile feedback keypad with functionally labeled keys. It shall also contain an 8 character alphanumeric LCD display for displaying flow data, a 6 digit, nonresettable mechanical flow totalizer, and an input fault indicator for processor self-diagnostics and operational fault monitoring. All programs, flow equations, and process flow data shall be user selectable from the keypad and menu-driven display.

2.5.6.6 Vortex Shedding Flowmeter

The vortex shedding flowmeter shall produce an analog 4 to 20 mAdc signal that is linearly proportional to the volumetric flow rate. The accuracy shall be within plus or minus 0.8% of the actual flow. The electronic transmitter for the vortex shedding flowmeter shall be internal or external mounting within \^45 meters^\ \~150 feet~\ of the flow sensor and shall include noninteracting zero and span adjustments. The flow meter body shall be made of austenitic stainless steel. The vortex shedding flowmeter body shall not require removal from the piping in order to replace the shedding sensor.

2.5.6.7 Positive Displacement Flow Meter

The flow meter shall be a direct reading, gerotor, nutating disk or vane type displacement device rated for liquid service as shown. 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 \^liters,^\ \~gallons,~\ and a sweep-hand dial to indicate down to 1 \^liter.^\ \~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. Output accuracy shall be plus or minus 2% of the flow range. The maximum pressure drop at full flow shall be \^34 kilopascals.^\ \~5 psig.~\

2.5.6.8 Flow Meters, Paddle Type

Sensor shall be non-magnetic, with forward curved impeller blades designed for water containing debris. Sensor accuracy shall be plus or minus 2% of rate of flow, minimum operating flow velocity shall be \^meter per second.^\ \~1 foot per second.~\ Sensor repeatability and linearity shall be plus or minus 1%. Materials which will be wetted shall be made from non-corrosive materials and shall not contaminate water. The sensor

shall be provided with isolation valves and shall be rated for installation in pipes of \^76 mm to 1 m^\ \~3 to 40 inch~\ diameters. The transmitter shall provide a 4 to 20 mAdc output linearly proportional to flow. The transmitter housing shall be NEMA 4.

2.5.6.9 Flow Switch

Flow switch shall have a repetitive accuracy of plus or minus 10% of actual flow setting. Switch actuation shall be adjustable over the operating flow range. The switch shall have Form C snap-action contacts, rated for the application. The flow switch shall have non flexible paddle with magnetically actuated contacts and be rated for service at a pressure greater than the installed conditions. Flow switch for use in sewage system shall be rated for use in corrosive environments encountered.

2.5.6.10 Gas Utility Flow Meter

Gas utility flow meter shall be diaphragm or bellows type (gas positive displacement meters) for flows up to \^liters/sec^\ \~2500 SCFH~\ and axial flow turbine type for flows above \^liters/sec,^\ \~2500 SCFH,~\ designed specifically for natural gas supply metering, and rated for the pressure, temperature, and flow rates of the installation. Meter shall have a minimum turndown ratio of 10 to 1 with an accuracy of plus or minus 1% 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 \^3 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.

2.5.7 Level Instrument

2.5.7.1 Liquid Level Switch for Water Distribution Systems

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 or flanged 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 watertight 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 for the application. 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.

2.5.7.2 Mercury Float Switch

Float switch assemblies for use in sewage 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 type oil resistant thermoplastic cable with 4 No. 18 gauge stranded copper conductors, rated for 600 Volt application.

2.5.7.3 Liquid Level Sensor

Liquid level sensor shall produce an analog 4 to 20 mAdc signal that is proportional to the level to be measured. Sensor shall be capacitance type, with a two-wire transmitter. The two wires will transmit the output signal and power the transmitter. The transmitter shall have noninteracting zero and span adjustments, and have an accuracy of plus or minus 0.1% of calibrated span.

2.5.7.4 Liquid Level Sensor (Bubbler Type)

Fuel oil liquid level sensor shall be of the hydrostatic balance type, operating from compressed air. Items a, b, e, f, and h below shall be mounted on a panel with nameplate to identify the connected tank. Each fuel oil tank gauging system shall contain the following:

a. Air set -compressed air pressure regulating valve, air filter and moisture trap.

b. A sight feed bubbler with built-in adjusting needle valve.

c. Tank entry gland with air supply and equalized pilot signal connections.

d. A \^12 mm^\ \~1/2 inch~\ schedule 80 dip tube.

e. A direct reading circular gauge (\^0.3 meters^\ \~12 inch~\ dia.) calibrated for the connected tank and tank liquid.

f. 3-valve connections to circular gauge and pressure transducer to allow for zero setting and calibration check.

g. Connecting bubbler supply and equalized pilot signal copper tubing with minimum field made joints.

h. A pressure transducer, selected to correspond to the range required to gauge the connected tank.

2.5.8 Electrical Instruments

2.5.8.1 Potential Transformer

Potential transformer shall be compatible with the kilowatt-hour meters, power factor transducers, and voltage transducers specified. Transformer shall conform to \-IEEE C57.13-\. The Contractor shall be responsible for determining the actual voltage ratio of each transformer.

2.5.8.2 Multi-Ratio Current Transformer

Current transformer shall be compatible with the kilowatt-hour meter, power factor transducer, and current transducer specified. Current transformer shall conform to \-IEEE C57.13-\. The Contractor shall be responsible for determining the actual ratio of each transformer.

2.5.8.3 Kilowatt-Hour Meters

Kilowatt-hour (KWh) meters shall be in accordance with \-ANSI C12.1-\ and have pulse initiators for remote monitoring of consumption. Pulse initiator shall consist of Form C contacts with a current rating not to exceed 2 A and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA and a life rating of one billion operations. Meters shall have KYZ terminals for output to smart field panels. Meter sockets shall be in accordance with \-ANSI C12.1-\

2.5.8.4 Power Factor Transducers

Power factor transducers shall measure the power factor on a three phase load, and produce a proportional 4-20 mAdc output signal, linear with phase angle over the range of 60 degrees lag through 60 degrees lead. An integral power supply shall be provided if required for the analog output signal. The transducer shall have an accuracy of plus or minus 0.5% of full scale, and shall include offset and span adjustments.

2.5.8.5 Current Transducers

Current transducers used for electrical metering shall accept an ac current input and provide a proportional 4-20 mAdc output, with an accuracy of plus or minus 0.25% of full scale. An integral power supply shall be provided if required for the analog output signal. The current transducer shall have a full scale input range of 0 to 5 amperes ac. The device shall have a means for calibration. A current transformer shall be provided as required for the application.

2.5.8.6 Voltage Transducers

Voltage transducers shall accept an ac voltage input and provide a proportional 4-20 mAdc output, with an accuracy of plus or minus 0.25% of full scale. An integral power supply shall be provided if required for the analog output signal. The voltage transducer shall have a full scale input range of 0 to 300 Volts ac. The device shall have a means for calibration. A potential transformer shall be provided as required for the application. Line side fuses for transducer protection shall be furnished.

2.5.8.7 Var Transducer

Var transducer shall measure the reactive volt amperes of a three phase system, and produce a proportional 4 to 20 mAdc output signal. The transducer shall be externally powered from a 120 Vac source. The transducer shall have an accuracy of plus or minus 0.25% of full scale, and shall include offset and span adjustments.

2.5.8.8 Phase Angle Transducer

Phase angle transducer shall have an accuracy of plus or minus 1% at 25 degrees C and shall measure the phase angle between two voltage inputs or between one voltage input and one current input. The full scale range shall be capable of ranges from minus 45 degrees to plus 180 degrees, 60 Hz. The output shall be 4 to 20 mAdc linear with the calculated full scale phase angle range. Voltage inputs shall be 95 to 135 Vac, 60 Hz, and the current input shall be 0.5 to 5 Amperes, 60 Hz.

2.5.8.9 Watthour Transducer

Watthour transducer shall have an accuracy of plus or minus 0.25% of full scale for KW and KWh outputs from full lag to full lead power factor. Input ranges for KW and KWh transducer shall be selectable without requiring the changing of current or potential transformers. The output shall be 4 to 20 mAdc.

2.5.8.10 AC Voltmeter

AC voltmeter shall be transformer rated, 150 volt, 60 Hz input, for measuring, three phase, wye service with 120 volt potential transformers. External dropping resistor shall be provided if required. Voltmeter shall provide plus 1% accuracy at full scale. Mounting shall be flush type. The meter face shall span 250 degrees, and shall be scaled to match the primary voltage.

2.5.8.11 AC Voltmeter Switch

Voltmeter switch shall be rated for the application and shall have seven positions, one position for each phase to neutral and one position for each phase to phase and "off." Contacts shall be rated for 20 amperes, 600 Vac. Switch shall have a 7 position escutcheon plate indicating each position including "off." Switch shall have metal shaft and removable handle.

2.5.8.12 AC Ammeter

AC ammeter shall be transformer rated, 5 ampere, 60 Hz input, for use with current transformers. Ammeter shall provide plus or minus 1% accuracy at full scale. Scale shall span 250 degrees. Mounting shall be flush type.

2.5.8.13 AC Ammeter Switch

Ammeter switch shall be rated for the application and shall short circuit all current circuits except the one being read. Contacts shall be rated for 20 amperes, 600 volts AC. Switch shall have 4-position escutcheon plate indicating each position and "off." Switch shall have metal shaft and removable handle.

2.5.8.14 Current Sensing Relay for Motors

Current sensing relay shall provide a normally-open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, noninductive. There shall be a single hole for passage of current carrying conductors. Relay shall be of the split core type, designed for use with existing electrical installations. The devices shall be sized for operation at 50% rated current based on the connected load. Voltage isolation shall be a minimum of 600 volts.

2.5.8.15 Current Transducer for Motors

Current transducer shall be a single-phase, 60 Hz device, with a 4 to 20 mAdc signal output accurate to plus or minus 1% full scale. Transducer output shall be derived from the average absolute value of the input calibrated in terms of the root mean square value of the sine wave input. Transducer shall be externally-powered from a 120 Vac power source. Transducer shall be of the split core type, for use with existing electrical installations. Linearity shall be plus or minus 0.25% full-scale.

2.5.9 Position Sensor

2.5.9.1 End (Limit) Switch

Limit switch shall be of the enclosed or sealed type as required for the application. Switch contacts shall be Form C snap-action with utilization category and ratings selected for the application.

2.5.9.2 Damper End Switch

Each end switch shall be a hermetically-sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade and shall directly sense damper position.

2.5.9.3 Potentiometer

Potentiometer may be either rotary or linear, depending on the application of each position indicator. Position potentiometers shall have a linearity of plus or minus 5% and shall indicate position from 0 to 100% open.

2.5.10 Output Devices

Output device contacts shall be rated for the application. Coils shall be equipped with transient suppression devices to limit transients to 150% of rated coil voltage.

2.5.10.1 Interposing Relay

Interposing relay shall be used to provide remote circuit control of remote equipment, or to provide device status input for those devices which do not have an auxiliary relay contact output available. Relay contacts shall be enclosed in a dust proof enclosure. Relay shall be rated for a minimum of one million mechanical operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Interposing relay shall also meet the following requirements.

Rating: 150 Vac/ 150 Vdc coil, 10 Amperes contacts.

Working Voltage: 120 Vac/ 48 Vdc to 150 Vdc, nominal.

Contact Arrangement: DPDT (2 Form C).

Base: Plug-in socket, suitable for panel mounting.

2.5.10.2 Control Relay

Control relay contacts shall have utilization category and ratings selected for the application, with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relay shall be rated for a minimum life of 200,000 electrical operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less.

2.5.10.3 Time Delay Relay

Time delay relay contacts shall have utilization category and ratings selected for the application with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Delayed contact opening or closing shall be adjustable from 1 to 60 seconds with a minimum accuracy of plus or minus 2 % of setting.

2.5.10.4 Latching Relay

Latching relay contacts shall have utilization category and ratings selected for the application with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relay shall be rated for a minimum life of 200,000 electrical operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relay operation shall require separate control circuits for switchover from one position to another.

2.5.10.5 Reed Relay

Reed relay shall be encapsulated in a container housed in a plastic, epoxy, or metal case. Contacts shall have utilization category and ratings selected for the application. Operating and release times shall be 1 millisecond or less. Relay shall be rated for a minimum life of 10 million mechanical operations and 500,000 electrical operations..

2.5.10.6 Contactor

Contactor shall be of the electrically operated, mechanically held type. Contactor operation shall require separate control circuits for switchover from one position to another. Positive locking shall be obtained without the use of hooks, latches, or semipermanent magnets. Contacts shall be double break silver to silver type. Number of contacts, utilization category and ratings shall be selected for the application. Operating and release times shall be 100 milliseconds or less.

2.5.10.7 Solid State Relay

Input-output isolation shall be greater than 1000 megohms with a breakdown voltage of 1500 V rms or greater at 60 Hz. Relays shall be rated for a minimum life of 10 million operations. The ambient temperature range shall be at least \^minus 30 to plus 60 degrees C.^\ \~minus 20 to plus 140 degrees F.~\ Input impedance shall not be less than 500 ohms. Relay shall have utilization category and ratings selected for the application. Operating and release times shall be 1 millisecond or less.

2.5.10.8 Electric Solenoid Operated Pneumatic (EP) Valve

EP valve shall have three port operation: common, normally open, and normally closed. EP valve shall have an outer cast aluminum body with internal parts constructed of brass, bronze, or stainless steel. EP valve shall be rated for \^344 kilopascals^\ \~50 psig~\ when used in control system operation at \^172 kilopascals^\ \~25

psig~\ or less, or rated at \^1 megapascals^\ \~150 psig~\ when used in control system operation from \^172 to 689 kilopascals.^\ \~25 to 100 psig.~\ EP valve operation shall be rated for a minimum of \^104 degrees C.^\ \~220 degrees F.~\

2.5.10.9 Current to Pneumatic (IP) Transducer

IP transducer shall be matched to the AOs to provide a linearly proportional pneumatic output compatible with the pneumatic control loop to be interfaced. The IP transducer shall have pressure calibration adjustments and shall withstand pressures at least 150% of the maximum range. The pneumatic output shall be linearly proportional within 1% of the electric input. IP transducer shall include independent offset and span adjustment. IP transducer shall be rated for \^minus 18 to plus 60 degrees C^\ \~0 to plus 140 F~\ continuous operation. The body shall be cast aluminum with internal parts constructed of brass, bronze, or stainless steel. Provide output pressure gauge for each pneumatic output. Provide an in line filter for the incoming air supply and a manual adjustable override for the IP transducer pneumatic output.

2.5.10.10 Motorized Potentiometer

Motorized potentiometer shall be reversible brushless alnico or samarium cobalt permanent magnet dc motors with rotary potentiometer coupled to the motor or gearhead output shaft. Motors shall be \^22 mm^\ \~7/8 inch~\ nominal diameter or larger, with a minimum rated life of 1,000 operating hours or 200,000 revolutions. Motors shall accept signals for clockwise rotation and for counterclockwise rotation. With no signal present, the motor shall remain stationary. Rotary potentiometers shall be wire wound or conductive plastic, single or multi-turn potentiometers with a minimum rated life of 200,000 revolutions. Potentiometers shall have a maximum resistance tolerance of plus or minus 10% and a maximum linearity tolerance of plus or minus 1%. Potentiometers shall be rated for a minimum of one watt at \^52 degrees C.^\ \~125 degrees F.~\ Motorized potentiometers shall be housed in enclosures meeting both NEMA 4 and NEMA 13 ratings and shall be suitable for operation at ambient temperatures of \^2 to 50 degrees C.^\ \~35 to 120 degrees F.~\

2.5.10.11 Potentiometer-to-Current Transducer

Potentiometer-to-current transducers shall have an accuracy of plus or minus 0.1% of span for 3-wire potentiometer inputs between 100 and 10,000 Ohms full scale. Potentiometer-to-current transducer shall provide continuous span adjustments between 75 and 100% of the input range and continuous zero offset adjustment between 0 and 10% of the input range. Potentiometer-to-current transducers shall provide excitation current to the potentiometer and shall drive a 4 to 20 mAdc output signal with 500 volts peak-to-peak isolation between input and output terminals. Potentiometer-to-current transducer shall be suitable for operation at ambient temperatures of \^minus 7 to plus 79 degrees C.^\ \~minus 20 to plus 175 degrees F.~\

2.5.10.12 Current to Resistance Transducer

Current-to-resistance transducer shall have an accuracy of plus or minus 1% of span for 4 to 20 mA. Input transducer shall provide continuous span adjustment between 0 to 100% resistance output. Resistance output range shall match application and be suitable for operation at ambient temperatures of \^0 to 70 degrees C.^\ \~32 to 158 degrees F.~\

2.5.11 Indicating Thermometer

2.5.11.1 Thermometer for Pipes and Ducts

Thermometer for insertion in ductwork and piping systems shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating fluid column, white face, black numbers, and a \^229 mm^\ \~9 inch~\ scale. Thermometer for piping systems shall have rigid stems with straight, angular, or inclined pattern. Thermometer stems shall have expansion heads as required to

prevent breakage at extreme temperatures. On rigid stem thermometers, the space between bulb and stem shall be filled with a heat-transfer medium.

2.5.11.2 Air Duct Thermometer

Air duct thermometer shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.5.11.3 Averaging Thermometer

Averaging thermometer shall have \^89 mm^\ \~3-1/2 inch~\ (nominal) dial, with black legend on white background, and pointer traveling through a 270-degree arc.

2.5.11.4 Ranges and Accuracy

Thermometer shall have an accuracy of plus or minus 1% of full scale with the following ranges:

a. Mixed air temperature: \^minus 18 to plus 38 degrees C^\ \~0 to plus 100 F~\ in \^1 degree C^\ \~1 degree F~\ graduations.

b. Return air temperature: \^minus 18 to plus 38 degrees C^\ \~0 to plus 100 degrees F~\ in \^1 degree C^\ \~1 degree F~\ graduations.

c. Cooling coil discharge temperature: \^minus 18 to plus 38 degrees C^\ \~0 to plus 100 degrees F~\ in \^1 degree^\ \~1 degree F~\ graduations.

d. Chilled water temperature: \^minus 1 to plus 27 degrees C^\ \~30 to plus 80 degrees F~\ in \^1 degree C^\ \~1 degree F~\ graduations.

e. Condenser water temperature: \^4 to 49 degrees C^\ \~40 to 120 degrees F~\ in \^1 degree C^\ \~1 degree F~\ graduations.

f. Heating coil discharge temperature: \^minus 1 to plus 82 degrees C^\ \~minus 30 to plus 180 degrees F~\ in \^2 degrees C^\ \~2 degrees F~\ graduations.

g. Hydronic heating systems below 220 F: \^4 to 115 degrees C^\ \~40 to 240 degrees F~\ in \^2 degrees C^\ \~2 degrees F~\ graduations.

h. High temperature hot water: \^38 to 288 degrees C^\ \~100 to 550 degrees F~\ in \^5 degrees C^\ \~5 degrees F~\ graduations.

2.5.12 Pressure Gauge

Gauge shall be \^64 mm^\ \~2-1/2 inch~\ (nominal) size, back-connected, suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Accuracy shall be plus or minus 3% of scale range. Gauge shall meet \-ASME B40.1-\.

2.5.12.1 Pneumatic Actuator Gauge

Gauge for indicating signal output to pneumatic actuators shall have an outer scale of \^20 to 103 kilopascals^\ \~3 to 15 psig~\ in \^kilopascals^\ \~1 psig~\ graduations.

2.5.12.2 Air-Storage Tank and Filter and Dryer Gauge

Gauge for air-storage tanks and gauge for use before and after dirt-and-oil filters or dryers, shall have a scale of \^1 megapascals^\ \~0 to 160 psig~\ with \^2 megapascals^\ \~2 psig~\ graduations.

2.5.12.3 Ranges and Graduations

Gauge for hydronic system applications shall have ranges and graduations required to meet equipment pressure ranges.

2.5.12.4 Low Differential Pressure Gauge

Gauge for low differential pressure measurements shall be \^114 mm^\ \~4-1/2 inch~\ (nominal) size with two sets of pressure taps, and shall have a diaphragm actuated pointer with magnetic coupling, white dial with black figures, and pointer zero adjustment. Gauge shall have ranges and graduations as shown. Accuracy shall be plus or minus 2% of scale range.

2.5.13 Miscellaneous Instruments

2.5.13.1 pH Sensor

The sensor shall be suitable for applications and chemicals encountered in water treatment systems of boilers, chillers and condenser water systems. Construction, wiring, fittings and accessories shall be corrosion and chemical resistant with fittings for tank or suspension installation. Housing shall be polyvinylidene fluoride with O-rings made of chemical resistant materials which do not corrode or deteriorate with extended exposure to chemicals. The sensor shall be encapsulated. Periodic replacement shall not be required for continued sensor operation. Sensors shall use a ceramic junction and pH sensitive glass membrane capable of withstanding a pressure of \^689 kilopascals at 66 degrees C.^\ \~100 psig at 150 degrees F.~\ The reference cell shall be double junction configuration. Sensor range shall be 0 to 12 pH, stability 0.05, sensitivity 0.02, and repeatability of plus or minus 0.05 pH value, response of 90% of full scale in one second and a linearity of 99% of theoretical electrode output measured at \^24 degrees C.^\ \~76 degrees F.~\ Transmitter shall have a preamplifier to transmit a linear 4 to 20 mA signal at least \^1.5 kilometers.^\ \~5000 feet.~\

2.5.13.2 Oxygen Analyzer

Oxygen analyzer shall consist of a zirconium oxide sensor for continuous sampling and an air-powered aspirator to draw flue gas samples. The analyzer shall be equipped with filters to remove flue air particles. For boiler applications, sensor probe temperature rating shall be \^815 degrees C.^\ \~1500 degrees F.~\ For incinerator applications, sensor probe temperature rating shall be \^1649 degrees C.^\ \~3000 degrees F.~\ Sensor shall provide a 4 to 20 mAdc output linear within plus or minus 2% of span and a repeatability error of less than 1% of span. Sensor electronics and power supplies shall be housed in NEMA 4 enclosure. Sensor electronics and power supplies shall be rated for operation under environmental conditions of minus \^9 to plus 93 degrees C.^\ \~15 to plus 200 degrees F.~\ The sensor assembly shall be equipped for flue flange mounting.

2.5.13.3 Carbon Monoxide Analyzer

Carbon monoxide analyzer shall consist of an infrared light source in a weather proof steel enclosure for duct or stack mounting. An optical detector/analyzer in a similar enclosure, suitable for duct or stack mounting shall be provided. Both assemblies shall include internal blower systems to keep optical windows free of dust and ash at all times. The third component of the analyzer shall be the electronics cabinet. Automatic flue gas temperature compensation and manual/automatic zeroing devices shall be provided. Unit shall provide 4 to 20 mAdc output to the UMCS. Unit shall read temperatures to \^1649 degrees C,^\ \~3000 degrees F,~\ and the response time shall be less than 3 seconds to 90% value. Repeatability shall be plus or minus 2% of full scale with an accuracy of plus or minus 3% of full scale.

2.5.13.4 Passive Infrared Sensors

Sensor shall have at least a 4 level multiple cell viewing lens, and a viewing angle of 180 degrees, and shall detect the difference between the infrared emissions from a human body and the background space. Sensor shall have auto-off switch with adjustable time delay of 10 seconds to 12 minutes, and shall operate in lighting intensities of \^54 lux to 4.3 kilolux.^\ \~5 to 400 footcandles.~\ Sensor coverage shall be at least \^46 square meters.^\ \~500 square feet.~\ It shall work with solid state ballasts and PL lamps with a housing for wall installation or in existing wall switch light boxes.

2.5.13.5 Vibration Switch

Vibration switch shall be solid state, enclosed in a NEMA 4 or 4X housing with sealed wire entry. Unit shall have two independent sets of Form C switch contacts with one set to shutdown equipment upon excessive vibration and a second set for monitoring alarm level vibration. The vibration sensing range shall be a true rms reading, suitable for the application. The unit shall include either displacement response for low speed or velocity response for high speed application. The frequency range shall be at least 2 Hz to 200 Hz. Contact time delay shall be 3 seconds. The unit shall have independent start-up and running delay on each switch contact. Alarm limits shall be adjustable and setpoint accuracy shall be plus or minus 10% of setting with repeatability of plus or minus 2%.

2.5.13.6 Conductivity Sensor

Sensor shall include local indicating meter and transmitter and shall be industrial grade and suitable for measurement of conductivity of water in boilers, chilled water systems, condenser water systems, distillation systems, or potable water systems as shown. Sensor shall sense from 0 to 10 microSeimens per centimeter (uS/cm) for distillation systems, 0 to 100 uS/cm for boiler, chilled water, and potable water systems and 0 to 1000 uS/cm for condenser water systems. Contractor shall field verify the ranges for particular applications and adjust the range as required. Contractor shall submit a complete water quality analysis of a sample of the process to be monitored with the submittal of the sensor manufacturer's catalog data. The transmitter shall provide a temperature compensated (from 0 to 100 degrees C), linearized 4 to 20 mAdc output. The accuracy shall be plus or minus 2% of the full scale reading. Sensor shall have automatic zeroing and shall require no normal maintenance or periodic recalibration.

2.5.13.7 Compressed Air Dew Point Sensor

Sensor shall include transmitter and shall be industrial grade and suitable for measurement of dew point from minus \^40 to plus 27 degrees C.^\ \~40 to plus 80 degrees F.~\ The transmitter shall provide both dry bulb and dew point temperatures on separate 2 wire 4 to 20 mAdc linearized outputs. The end to end accuracy of the dew point shall be plus or minus five (\^5 degrees C^\ \~5 degrees F~\) and the dry bulb shall be plus or minus \^1 degree C.^\ \~1 degree F.~\ Sensor shall be automatic zeroing and shall require no normal maintenance or periodic recalibration. Sensor shall be rated for up to \^1 megapascals^\ \~150 psig~\ service.

2.5.13.8 Refrigerant Leakage Monitor

Monitor shall include transmitter and shall be industrial grade and suitable for measurement of specific refrigerant in use in the area monitored. Sensor shall measure the specified refrigerant at quantities from 1 to 1000 parts per million (ppm) using infrared sensor technology. If multiple pickups are required, a multi-zone system shall be provided. If multiple refrigerants are used, separate modules specifically adjusted for each monitored refrigerant shall be provided. Coverage for each zone shall be a minimum of \^850 cubic meters.^\ \~30,000 cubic feet.~\ The monitor shall provide a linearized 4 to 20 mAdc signal from the worst case zone and shall have a local LCD indication in ppm, and local indicators indicating leakage detected, alarm level detected, sensor trouble and normal operation for each zone and for each refrigerant. The alarm level indication and the leakage level indication shall be visual and audible locally, with a silence button. The alarm level detected and leakage detected indications shall be activated based on local adjustable setpoints marked in ppm and shall close separate Form C contacts for local safety interlocks or UMCS monitoring. Sensor shall have automatic zeroing and shall require no normal maintenance or periodic recalibration.

2.5.13.9 Oxygen Depletion Monitor

Monitor shall continuously monitor oxygen level and provide local visual and audible alarm indications when the level drops below 19.5%. Monitor shall have local sensor trouble and sensor normal lights and shall close one dry contact on alarm and a separate one on trouble indications. The accuracy shall be plus or minus 1% of oxygen level. Monitor shall have automatic zeroing and shall require no normal maintenance or periodic recalibration. Monitor shall be powered from a 120 Vac, single phase, 60 Hz power source.

2.5.13.10 NOx Monitor

Monitor shall continuously monitor and give local indication of boiler stack gas for NOx content. It shall be a complete system designed to verify compliance with the Clean Air Act standards for NOx normalized to a 3% oxygen basis and shall have a range of from 0 to 100 ppm. Sensor shall be accurate to plus or minus 5 ppm. Sensor shall provide a linearized 4 to 20 mAdc output of NOx and oxygen and a dry alarm contact that closes when above a locally adjustable NOx setpoint. Sensor shall have normal, trouble and alarm lights. Sensor shall have heat traced lines if the stack pickup is remote from the sensor. Sensor shall be complete with automatic zero and span calibration using a timed calibration gas system, and shall require no normal calibration. Panel shall be powered from 120 Vac, single phase, 60 Hz.

2.5.13.11 Turbidity Sensor

Sensor shall include local indicating meter, sensing element and a transmitter and shall be industrial grade and suitable for measurement of turbidity of water. Sensor shall sense from 0 to 1000 Nephelometric Turbidity Units (NTU). Range shall be field-verified for the particular application and adjusted as required. The transmitter shall provide a temperature compensated (from 0 to 100 degrees C), linearized 4 to 20 mAdc output. The accuracy shall be plus or minus 5% of full scale reading. Sensor shall have automatic zeroing and shall require no normal maintenance or periodic recalibration. Sensor shall be powered by a 120 Vac, single phase, 60 Hz power source.

2.5.13.12 Total Dissolved Solids (TDS) Sensor

The TDS sensor shall measure the conductivity of the water using a conductivity sensor and display the total dissolved solids value in milligrams per liter (mg/L) of dissolved NaCl equivalent. The total dissolved solids shall be assumed to be approximately 2.2 times the conductivity in uS/cm.

2.5.13.13 Water Quality Hardness Sensor

The hardness sensor shall measure the total mineral content dissolved in the water. The sensor shall be a conductivity sensor that is calibrated in mg/L of dissolved minerals.

2.5.13.14 Condenser Water Quality Controller

The controller shall consist of a pre-wired panel for continuously monitoring and controlling TDS, pH and chemical treatment in the water system. The total dissolved solids in the water shall be monitored and controlled by a voltage regulated, linear, temperature compensated conductivity controller. Controller shall be linear over its full measuring range of 100 to 6,000 micro seimens per centimeter, and shall have a built-in 20 Amp heavy-duty relay. Power, bleed-off, trouble status, alarm status (digital) and conductivity (analog) shall be displayed on the front panel. Accuracy shall be plus or minus 1/2% of full scale. The pH shall be monitored and controlled by a pH controller with adjustable high and low setpoints and indicating lamps. Controller shall be linear over its full measuring range of 0 to 14 pH. An HOA selector switch, indicating lamp and acid feed limit timer shall be provided for acid pump control. The pH (analog), valve, trouble and alarm status (digital) shall be displayed on the front panel. Accuracy shall be plus or minus 1/2% of full scale. Chemical feed control pumps and panel housing pumps for control of conductivity and biocide shall be provided. The chemical feed shall be controlled on an adjustable time proportioning basis utilizing either the conductivity or pH control modes. One sample stream flow assembly shall be provided consisting of a

conductivity probe mounted in a flow tee, and a pH flow cell. Sample stream flow assembly shall be completely piped with necessary nipples, elbows and shutoff valves, and shall include a fail safe sample stream flow switch to automatically shut down if there is a loss of system flow. Sample stream flow assembly shall include a vertical section of clear pipe with flow indicating devices. Control system shall automatically return to operation upon resumption of flow. One bleed-off or blow-down solenoid and throttling valve shall be provided, sized for bleed-off requirements of the system. Three chemical feed pumps, positive-displacement type, with ball-type check valves, 120 Vac, 60 Hz fractional hp motor drives and discharge pressure relief valves shall be provided. All pumps shall be of suitable material of construction for the chemicals to be injected into the system. Feed and frequency rates shall be suitable for flowrates shown and shall be adjustable while pumps are running. Discharge tubing shall be provided. An individual chemical feed pump of the type specified shall be provided for feeding, acid or caustic as required, biocide, scale and corrosion inhibitor. Injection assembly or assemblies with PVC diffuser tubes and check valves shall be provided for injecting chemicals into the system. The chemicals shall not be injected into the sample stream flow assembly. Solenoid valve shall be provided with flow switch and controls to stop flow in metering line when condenser pumps are off. It shall be housed in a NEMA 4X enclosure with controls visible with door closed, and shall include:

a. A 24-hour, 7-day digital program timer with tower proof-of-run contacts input to control the feeding of a biocide on a weekly or semi-weekly basis when the tower is run.

b. Conductivity controller for TDS control with indicating meter.

c. A pH controller with acid feed limit timer and indicating meter. Audible and visual alarm actuated on low pH or if acid feed limit time is exceeded (timer and alarm shall force bleed until low pH condition is corrected).

d. Internal wiring harnesses (color coded, clearly identified and brought to a master terminal board).

e. Grounded ac receptacles for chemical treatment pump and utility use.

f. Main power switch and indicating lamp, with legend plate.

g. Line voltage safety switch interlock with door to shut off line voltage to controls when adjustment or maintenance is required.

h. HOA selector switches and indicating lamps for bleed-off control, chemical feed and acid feed (with legend plates).

i. Alarm silence button.

j. Front panel fuses.

2.5.13.15 Chlorine Detector

The detector shall measure concentrations of chlorine in water in the range 0 to 20 ppm with a repeatability of plus or minus 1% of full scale and an accuracy of plus or minus 2% of full scale. The transmitter shall provide a 4 to 20 mAdc output and shall be housed in a noncorrosive NEMA 4X enclosure. Detector shall include a local panel with adjustable alarm trip level, local audio and visual alarm with silence function.

2.5.13.16 Floor Mounted Leak Detectors

Leak detectors shall use electrodes mounted at slab 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 which detector is in the alarmed state. The indicator shall be manual reset type.

2.5.13.17 Compressed Air Filter

A coalescing refilter, together with an automatic drain valve, shall be provided for removal of liquids. The flow through the refilter shall be from inside to outside and reduce a 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 refilter 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. Refilter pressure drop shall be less than \^21 kilopascals^\ \~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 refilter 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.

2.5.14 Humidifier Switch

Humidifier switch shall have 2 contacts; one to humidifier and one to FEP.

2.6 TUBING

2.6.1 Copper

Copper tubing shall conform to \-ASTM B 88-\ and shall have sweat fittings and valves. Exposed tubing shall be hard drawn, rack mounted where multiple tubes run in parallel. Bends shall be tool made or use fittings. Concealed tubing shall be hard or soft drawn. Multiple tubes may be bundled when concealed.

2.6.2 Polyethylene Tubing

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:

a. Burst Pressure Requirements: \^3.8 megapascals at 24 degrees C^\ \~550 psig at 75 degrees F~\ to \^1.2 megapascals to 66 degrees C^\ \~175 psig at 150 degrees F~\ (minimum).

b. Stress Crack Resistance: \-ASTM D 1693-\, 200 hours minimum.

c. Tensile Strength (minimum): \-ASTM D 638-\, \^14 megapascals.^\ \~2000 psi.~\

d. Density (average): \-ASTM D 792-\, 920 kg/m3.

e. Flow Rate (average): \-ASTM D 1238-\, 0.30 decigram per minute.

2.6.2.1 Flammability Requirements

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.

2.6.2.2 Barrier and Jacket

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

2.6.3 Stainless Steel Tubing

Stainless steel tubing shall conform to \-ASTM A 269-\, and shall have stainless steel compression fittings.

2.7 WIRE AND CABLE, TRANSFORMERS AND TERMINAL BLOCKS

2.7.1 Wire and Cable

Wire and cable jacket material shall be flame retardant PVC, or fluoropolymer as required for the application per \-NFPA 70-\. Multiconductor cable shall have an outer jacket. Wire and cable not indicated as GFE shall be provided.

2.7.1.1 Control Wiring

a. Digital Functions: Control wiring for digital functions shall be 18 AWG minimum with 600 volt insulation.

b. Analog Functions: Control wiring for analog functions shall be 18 AWG minimum with 600 volt insulation, twisted and each pair shielded, 2, 3, or 4 wire to match analog function hardware.

2.7.1.2 Sensor Wiring

Sensor wiring shall be 20 AWG minimum twisted and shielded, 2, 3, or 4 wire to match analog function hardware.

2.7.1.3 Terminal Blocks

Terminal blocks shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

2.7.2 Transformer

Step-down transformer shall be utilized where control equipment operates at lower than line circuit voltage. Transformer, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Transformer shall be sized so that the connected load is 80% of the rated capacity or less. Transformer shall conform to \-UL 508-\ and \-NEMA ST 1-\.

2.7.3 Nonconducting Wiring Duct

Nonconducting wiring duct in control panels shall have slotted sides, snap-on duct covers, fittings for connecting ducts, mounting clips for securing ducts, and wire-retaining clips.

2.8 FEP HARDWARE

All I/O functions of individual monitored and controlled systems shall be implemented in one FEP.

2.8.1 Network Controller

Network Controllers (NC) shall be microcomputer-based with sufficient memory provided to perform all specified and shown NC functions and operations. All functions, constraints, database information, operator developed programs and any other data shall be downloadable from the OWS. NC shall communicate with all other NC and UMCS operator workstations on a peer-to-peer basis. NC shall operate in an independent stand-alone mode, which is defined as all NC operations as specified performed by the NC without any continuing input from the OWS. The NC shall be capable of controlling a mix of Unitary Controllers and

Universal Programmable Controllers over a secondary communication line. NC shall not be installed with more than 85% of its capacity used in order that additional FEPs can be added for future expansion.

NCs shall have a hardware real-time clock that is synchronized with the operator workstation clock at least daily. If real-time clock function is not provided as specified, clock functions shall be accomplished by the NC. NC software shall be coordinated with FEP software to provide calendar, scheduling, trending, alarming and network management functions. NC alarm processing shall include alarm and return-to-normal recognition, storage, management, analysis, and routing to any user defined location. NC and network failures shall be treated and annunciated as alarms. NC shall record time and date, location, equipment ID, acknowledge time and date, and who issued the acknowledgement.

2.8.1.1 Integral Features

The NC shall include:

a. Main power switch.

b. Power on indicator.

c. An intrusion detection device, connected as an alarm.

2.8.1.2 Communication Interfaces

Communications interfaces for each DTS circuit between NC and the Operator Workstation and between NC and Unitary Controllers and Universal Programmable Controllers shall be provided. The DTS will provide for transmission speeds necessary to comply with performance requirements specified. Each NC shall also be provided with a communications port for a portable computer for all operation and programming functions.

2.8.1.3 Memory and RTC Backup

The NC memory and real time clock functions shall be backed-up for a minimum of 72 hours in the event of a power failure. If rechargeable batteries are provided, automatic charging of batteries shall be provided and a low battery alarm message shall be sent to the OWS and a local indication provided.

2.8.1.4 Duplex Outlet

A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within \^1.8 meters^\ \~6 feet~\ of the NC.

2.8.1.5 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each NC.

2.8.1.6 Failure Mode

a. Upon a detectable failure of the NC, either due to failure of the NC hardware or of the DTS, the NC shall revert to the failure mode as shown. Upon failure of the NC hardware, the NC shall cease operation and stop communications with other UMCS components. Unitary Controllers and Universal Programmable Controllers connected to the affected NC shall respond to this failure as specified and shown.

b. Upon failure of communications between NC and operator workstation, the NC shall operate in an independent stand-alone mode. Unitary Controllers and Universal Programmable Controllers connected to the affected NC shall continue to report to the NC.

2.8.2 Universal Programmable Controller

The Universal Programmable Controller (UPC) shall be a microprocessor based controller designed and programmed to control and monitor systems as shown. Resident programs shall be contained in reprogrammable nonvolatile memory. Each UPC shall contain necessary power supplies, transformers, memory, I/O functions and communications interfaces necessary to perform its required functions and to provide control and monitoring of connected equipment and devices. It shall contain all necessary I/O functions to connect to field sensors and controls. It shall provide for operation as a device connected to the system via a NC.

2.8.2.1 Integral Features

The UPC shall include as a minimum:

a. Main power switch.

b. Portable computer connector

c. I/O functions to match the application requirements.

d. 8-hour backup for volatile memory.

e. Calendar and real-time clock functions, with 8-hour backup.

f. On-off-auto switch for DOs.

g. Auto-manual switch and potentiometer for AOs.

2.8.2.2 Specific Requirements

Each UPC shall be fully accessible from the UMCS operator workstations, NC, and portable computer as specified and shown.

2.8.2.3 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each enclosure.

2.8.2.4 Duplex Outlet

A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within \^1.8 meters^\ \~6 feet~\ of the UPC enclosure.

2.8.2.5 Portable computer

A portable computer shall be provided for each type of Universal Programmable Controller installed. One additional portable computer shall be provided for every 50 units. The portable computer shall connect to the controller directly for readout of variables, override control, servicing, troubleshooting and adjustment of control parameters. The portable computer shall communicate in English language for inquiry, reporting, and programming purposes. When used remotely or locally the terminal shall:

a. Indicate system status.

b. Display point status.

c. Display, set and change setpoints.

d. Manually override setpoints.

e. Set and change PID control loop gains.

f. Select application mode.

g. Assign Universal Programmable Controller address.

h. Change unoccupied/occupied periods.

2.8.2.6 Failure Mode

Upon loss of communications with NC, the UPC shall perform in stand-alone mode. The UPC shall utilize alternate parameters (setpoints, temperatures, etc.) if global parameters from the NC are not available. Upon power or UPC hardware failure, the Universal Programmable Controller shall revert to the failure mode of operation as shown.

2.8.3 Unitary Controller

The Unitary Controller shall be a microprocessor based, stand-alone, dedicated purpose controller, communicating with the NC, designed and programmed to control air distribution system mixing boxes, terminal units, heat pumps, fan coil units, self-contained DX units or VAV boxes as shown. Each Unitary Controller shall contain resident programs and parameters in firmware or reprogrammable nonvolatile memory for each specific application implemented. Each Unitary Controller shall contain necessary power supplies, transformers, memory, I/O functions and communications interfaces necessary to perform its required functions and to provide control and monitoring of connected equipment and devices. It shall contain all necessary I/O functions to connect to field sensors and controls. I/O operation shall be fully supervised to detect I/O function failures. It shall provide for operation as a device connected to the system via an NC.

2.8.3.1 Integral Features

The Unitary Controller shall include:

a. Main power switch.

b. Communication interface to Network Controller..

c. All I/O functions required to implement the requirement as shown.

d. Portable computer connector

2.8.3.2 Specific Requirements

a. Unitary Controller components for new air distribution terminal units shall be furnished to the air distribution terminal unit manufacturer for factory mounting and calibration. Existing air distribution terminal units shall be controlled by field installed Unitary Controllers.

b. Accessibility and Interfaces: Each Unitary Controller shall be fully accessible for purposes of application selection, control parameters, setpoint adjustment, and monitoring from the UMCS operator workstations and NC as specified and shown. They shall also be accessible with a portable computer connected to a communications port on the Unitary Controller.

c. For VAV Unitary Controllers, the portable computer shall connect to a communication port on the wall sensor, and shall allow entering parameters required for operation, test, adjust, and balance.

2.8.3.3 Portable Computers

Provide two portable computers, with necessary connecting cables, for each type of Unitary Controllers installed. One additional portable computer shall be provided for every 100 terminal units of each type of Unitary Controller installed. The portable computer shall connect to the controller directly for readout of variables, override control, servicing, troubleshooting and adjustment of control parameters. The device shall communicate in English language for inquiry, reporting, and programming purposes. When used remotely or locally the terminal shall:

a. Indicate system status.

b. Display point status.

c. Set and change PID control loop gains

d. Display, set, and change setpoint.

e. Manually override setpoint.

f. Assign controller address.

g. Adjust offsets for sensor calibration.

h. Input parameters for software applications.

2.8.3.4 Failure Mode

Upon loss of communications with NC, the Unitary Controller shall perform in stand-alone mode. The UC shall utilize alternate parameters (setpoints, temperatures, etc.) if global parameters from the NC are not available. Upon power or UC hardware failure, the UC shall revert to the failure mode of operation as shown.

2.8.4 I/O Functions

2.8.4.1 FEP I/O Functions

FEP I/O functions shall be defined as functionally part of the Unitary Controller or Universal Programmable Controller as specified, and communicate over a dedicated communication circuit.

2.8.4.2 The AI function

The AI function shall monitor each analog input, perform A-to-D conversion, and hold the digital value in a buffer for interrogation. The A-to-D conversion shall have a minimum resolution of 10 bits. Signal conditioning shall be provided for each AI. All AIs shall be individually calibrated for zero and full scale. The AI shall incorporate common mode noise rejection of 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of 20 dB at 60 Hz from a source impedance of 10,000 ohms. Input signals shall be within the ranges of 0 to 10 Vdc. or 4 to 20 mAdc, or resistance range to match the sensing device.

2.8.4.3 The AO function

The AO function shall accept digital data, perform D-to-A conversion, and output a signal within the ranges of 0 to 10 Vdc or 4 to 20 mAdc. D-to-A conversion shall have a minimum resolution of 8 bits. All AOs shall be individually calibrated for zero and full scale. Short circuit protection on voltage outputs and open circuit protection on current outputs shall be provided

2.8.4.4 The DI Function

The DI function shall accept on-off, open-close, or other change of state (two state data) indications.

2.8.4.5 The DO function

The DO function shall provide contact closures for momentary and maintained operation of output devices. Closures shall have a minimum duration of 0.1 second. DO relays shall have a breakdown voltage between contacts and coil of at least 500 volt peak. Electromagnetic interference suppression shall be furnished on all output lines to limit transients to nondamaging levels. Minimum contact rating shall be one-half ampere at 24 Vac.

2.8.4.6 The Pulse Accumulator (PA) Function

The PA function shall have the same characteristic as the DI, except that a buffer shall be provided to totalize pulses and allow for interrogation by the system. The PA shall accept rates up to 10 pulses per second. The accumulator points shall totalize pulses received from dry contacts. A sensing voltage shall be supplied from the FEP. Accumulator points shall accept Form C contacts (both the "Y" and "Z" contacts on kilowatt-hour meter KYZ contacts shall be monitored) and Form "A" or "B" contact inputs. Each PA shall totalize a count of up to 65,536, and shall be able to be read at any time without loss of input data. When each PA reaches its maximum value, it shall automatically reset to zero, and begin counting pulses again.

2.8.4.7 The Binary Coded Decimal (BCD) Function

The BCD function shall have the same characteristics as the DI, except that, in addition, a buffer shall be provided to totalize inputs and allow for interrogation by the NC. The BCD function shall have 16-channel optically isolated buffered inputs to read four digit numbers. The BCD function shall accumulate inputs at rates up to 10 inputs per second.

2.8.4.8 Input Reliability

The FEP shall monitor input signals from sensing devices, and provide an alarm to the operator workstation if the signal is outside a known reliable range. The FEP shall revert to a failure mode for the control loop if the associated sensing device is considered unreliable.

2.8.5 Portable Computer

Portable computers shall be provided for connection to any FEP as specified. It shall include carrying case, connecting cables, extra battery, charger and a compatible network adapter. The portable computer shall:

a. Run FEP diagnostics.

b. Load all FEP memory resident programs and information, including parameters and constraints.

c. Display any AI, DI, or PA input in engineering units.

d. Control any AO or DO.

e. Provide an operator interface, contingent on password level, allowing the operator to use full English language words and acronyms.

f. Display database parameters.

g. Modify database parameters.

h. Accept FEP software and information via a communications port at the operator workstation computers provided, for subsequent loading into a specific FEP. Provide all necessary software and hardware required to support this function.

i. Disable/enable each FEP.

2.9 FEP SOFTWARE

All FEP software described in this specification shall be furnished as part of the complete UMCS. The FEP software specified are software functions that are contractor and site specific as to which FEP device (i.e., NC, UPC, and UC) the software resides.

2.9.1 Operating System

FEPs shall contain an operating system that controls and schedules that FEP's activities in real time. The FEP shall maintain a point database in its memory that includes all parameters, constraints, and the latest value or status of all points connected to that FEP. The execution of FEP application programs shall utilize the data in memory resident files. The operating system shall include a real time clock function that maintains the seconds, minutes, hours, date and month, including day of the week. Each FEP real time clock shall be automatically synchronized with the system's real time clocks at least once per day to plus or minus 10 seconds. The time synchronization shall be accomplished without operator intervention and without requiring system shutdown. The UMCS operator workstation clock shall automatically update FEP real-time clocks for daylight savings time. The operating system shall allow local loading of software and data files from the Portable Computer/ Workstation. It shall also support data entry and diagnostics using a portable computer attached directly to the FEP.

2.9.1.1 Startup

The FEP shall have startup software that causes automatic commencement of operation without human intervention, including startup of all connected I/O functions. A FEP restart program based on detection of power failure at the FEP shall be included in the FEP software. Upon restoration of power to the FEP, the program shall restart equipment and restore loads to the state at time of power failure, or to the state as commanded by time programs or other overriding programs. The restart program shall include start time delays between successive commands to prevent demand surges or overload trips. The startup software shall initiate operation of self-test diagnostic routines. Upon failure of the FEP, if the database and application software are no longer resident or if the clock cannot be read, the FEP shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made. If the database and application programs are resident, the FEP shall resume operation after an adjustable time delay of from 0 to 600 seconds. The startup sequence for each FEP shall include a unique time delay setting for each control output when system operation is initiated.

2.9.1.2 Operating Mode

Each FEP shall control and monitor functions as specified, independent of communications with the operator workstation. This software shall perform all FEP functions and FEP resident application programs as specified using data obtained from I/O functions and based upon the FEP real time clock function. When communications circuits between the FEP and the operator workstation are operable, the FEP shall obtain real time clock updates transmitted from the system's real time clock and any required global data values. The FEP software shall execute commands after performing constraints checks in the FEP. Status and analog values, including alarms and other data shall be transmitted to the operator workstation when communications circuits are operable. If communications are not available, each FEP shall function in stand-alone mode and operational data, including the latest status and value of each point and results of calculations normally transmitted to the operator workstation, shall be stored for later transmission to the operator workstation. Storage for the latest 1024 values shall be provided at each NC. Each FEP shall accept software downloaded from the operator workstation. Constraints shall reside at the FEP.

2.9.1.3 Failure Mode

Upon failure, each FEP shall perform as specified.

2.9.2 Functions

The Contractor shall provide all software necessary to accomplish the following functions, as appropriate, fully implemented and operational, within each NC, Unitary Controller, and Universal Programmable Controller.

a. Scanning of inputs.

b. Control of outputs.

c. Reporting of analog changes outside a selectable differential.

d. Reporting of unauthorized digital status.

e. Reporting of alarms automatically to operator workstation.

f. Reporting of I/O status to operator workstation upon request.

g. Maintenance of real time, updated by the operator workstation at least once a day.

h. Communication with the operator workstation.

i. Execution of FEP resident application programs.

j. Averaging or filtering of all AIs.

k. Constraints checks (prior to command issuance).

l. Diagnostics.

m. Portable computer operation as specified.

n. Reset of pulse accumulator by operator based on time and value.

2.9.2.1 Analog Monitoring

The system shall measure and transmit all analog values including calculated analog points. An analog change in value is defined as a change exceeding a preset differential value as specified. The record transmitted for each analog value shall include a readily identifiable flag which indicates the abnormal status of the value when it deviates from operator selectable upper and lower analog limits. Analog values shall be expressed in proper engineering units with sign. Engineering units conversions shall be provided for each measurement. Each engineering units conversion set shall include range, span, and conversion equation. A vocabulary of engineering unit descriptors shall be provided, using at least three alphanumeric characters to identify information in the system.

2.9.2.2 Logic (Virtual) Points

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 are not point parameters as defined in paragraph: I/O POINT DATABASE/PARAMETER DEFINITION. 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 by the Contractor. The calculated analog point shall have point identification in the same format as any other analog point. The calculated point shall be used in any program where the real value is not obtainable directly. Constants used in calculations shall be changeable online by the operator. Calculated point values shall be current for use by the system within 10 seconds of the time of any input changes.

2.9.2.3 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.

2.9.2.4 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. At the end of the period, the totals shall be stored. 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 set or reset each totalized value individually. The time period shall be able to be operator defined, modified or deleted online.

2.9.2.5 Energy Totalization

The system shall calculate the heat energy in \^Joules,^\ \~Btus,~\ for each energy source consumed by the mechanical systems specified, totalize the calculated \^Joules,^\ \~Btus,~\ the instantaneous rate in \^Joules^\ \~Btus~\ per hour, and store totals in thousands of \^joules (ki).^\ \~Btus (MBtu).~\ The \^Joules^\ \~Btus~\ calculated shall be totalized for an adjustable time period. The time period shall be defined uniquely for each \^Joules^\ \~Btu~\ totalization.

2.9.2.6 Trending

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.

2.9.3 I/O Point Database/Parameter Definition

Each I/O point shall be defined in a database residing in the FEP. The definition shall include all physical parameters associated with each point. Each point shall be defined and entered into the database by the Contractor, including as applicable:

a. Name.

b. Device or sensor type (i.e., sensor, control relay, motors).

c. Point identification number.

d. Unit.

e. Building number.

f. Area.

g. Installation.

h. FEP number and channel address.

i. KW (running).

j. KW (starting).

k. Sensor range.

l. Controller range.

m. Sensor span.

n. Controller span.

o. Engineering units conversion (scale factor).

p. Setpoint (analog).

q. High reasonableness value (analog).

r. Low reasonableness value (analog).

s. High alarm limit (differential return to normal).

t. Low alarm limit differential (return to normal).

u. High alarm limit (analog).

v. Low alarm limit (analog).

w. Alarm disable time period upon startup or change of setpoint.

x. Analog change differential (for reporting).

y. Alarm class and associated primary message test.

z. High accumulator limit (pulse).

aa. Status description.

bb. Run time target.

cc. Failure mode as specified and shown.

dd. Constraints as specified.

2.9.4 Alarm Processing

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

2.9.4.1 Digital Alarms Definition

Digital alarms are those abnormal conditions indicated by DIs as specified and shown.

2.9.4.2 Analog Alarms Definition

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. Analog alarm limits shall be stored in the FEP database. Each analog alarm limit shall have an associated unique limit differential specifying the amount by which a variable must return into the proper operating range before being annunciated as a return-to-normal-state. All limits and differentials shall be entered online by the operator in units of the measured variable, without interruption or loss of monitoring of the point concerned. 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 alarm limit becomes effective. The system shall automatically suppress analog alarm reporting associated with a digital point when that digital point is turned off.

2.9.4.3 Pulse Accumulator Alarms Definition

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. Limits shall be stored in the FEP database.

2.9.5 Constraints

2.9.5.1 Equipment Constraints Definitions

Each control point in the database shall have FEP resident constraints defined and entered by the Contractor, including as applicable:

a. Maximum starts (cycles) per hour.

b. Minimum off time.
c. Minimum on time.

d. High limit (value in engineering units).

e. Low limit (value in engineering units).

2.9.5.2 Constraints Checks

All control devices connected to the system shall have the FEP memory resident constraints checked before each command is issued to insure that no equipment damage will result from improper operation. Each command shall be executed by the FEP only after all constraints checks have been passed. 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. Values outside the reasonableness limits shall be rejected and an alarm message sent to the operator workstation. Status changes and analog point values shall be reported to the workstation upon operator request, such as for reports, alphanumeric displays, graphic displays, and application programs. Each individual point shall be capable of being selectively disabled by the operator from the workstation. Disabling a point shall prohibit monitoring and automatic control of that point.

2.9.6 Diagnostics

Each FEP shall have self-test diagnostic routines implemented in firmware. The tests shall include routines that exercise memory. Diagnostic software shall be usable in conjunction with the portable tester/workstation. The software shall display messages in English to inform the tester's operator of diagnosed problems.

2.9.7 Summer-Winter Operation Monitoring

The system shall provide software to automatically change the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system from summer to winter and vice versa. The software shall provide automatic commands to applications programs to coordinate proper summer or winter operation. Change-over setpoints shall be operator selectable and settable. The program shall include features to perform these functions on a group of mechanical rooms, group of buildings, and for a complete installation.

2.9.8 Control Sequences and Control Loops

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NOTE: Control sequences described and illustrated in TM 5-815-3, HVAC Controls, will be incorporated into the contract package where applicable to the work being performed, with appropriate changes made to account for the fact that the UMCS is utilizing DDC Controls. Other sequences to be implemented will be developed by the designer to meet site requirements, in the same general format as that utilized in TM 5-815-3. The designer will define allowable process control loop accuracies as a part of the sequences, if they differ from those specified in paragraph: Process Control Loops Accuracy Requirements.
****

Specific functions to be implemented are defined in individual system control sequences and database tables shown in the drawings, and shall include, as applicable, the following:

2.9.8.1 PID Control: This function shall provide proportional control and proportional plus integral control and proportional plus integral plus derivative control.

2.9.8.2 Two Position Control: This function shall provide control for a two state device by comparing a set point against a process variable and an established deadband.

2.9.8.3 Floating Point Control: This function shall exercise control when an error signal exceeds a selected deadband, and shall maintain control until the error is within the deadband limits.

2.9.8.4 Signal Selection: This function shall allow the selection of the highest or lowest analog value from a group of analog values as the basis of control. The function shall include the ability to cascade analog values so that large numbers of inputs can be reduced to one or two outputs.

2.9.8.5 Signal Averaging: This function shall allow the mathematical calculation of the average analog value from a group of analog values as the basis of control. The function shall include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control.

2.9.8.6 Reset Function: This function shall develop an AO or PI control setpoint based on up to two AIs and one operator specified reset schedule.

2.9.8.7 Cooling/Heating Operation Program: Software shall be provided to change, either automatically or on operator command, the operating parameters, monitoring of alarm limits, and start-stop schedules for each mechanical system where such a change from cooling to heating and vice versa is meaningful. The software shall provide commands to application programs to coordinate cooling or heating mode operation. Software shall automatically switch facilities from cooling to heating, and vice versa, based on schedules or temperatures. All HVAC equipment and systems shall be assigned to the program.

2.9.9 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. The system shall require the latest highest priority command addressed to a single

point to be stored for a period of time longer than the longest time constraint in the on and off states, insuring that the correct command shall be issued when the time constraint is no longer in effect or report the rejected command. Override commands entered by the operator shall have higher priority than those emanating from applications programs.

2.9.10 Resident Application Software

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NOTE: The data base and settings tables described and illustrated in EI 16010 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.
****

The Contractor shall provide resident applications programs developed in accordance with paragraph CONTROL SEQUENCE PROGRAMMING to achieve the sequences of operation, parameters, constraints, and interlocks necessary to provide control of the systems connected to the UMCS. All application programs shall be resident and shall execute in the FEP, and shall coordinate with each other, to insure that no conflicts or contentions remain unresolved. The Contractor shall coordinate the application programs specified with the existing equipment and controls operation, and other specified requirements. A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the ON and OFF states, insuring that the correct command shall be issued when the time constraint is no longer in effect or the rejected command shall be reported. Override commands entered by the operator shall have higher priority than those emanating from application programs.

2.9.10.1 Program Inputs and Outputs

The Contractor shall use program inputs listed for each application program to calculate the required program outputs. Where the 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. AIs to application programs shall have an operator adjustable deadband to preclude short cycling or hunting. Program outputs shall be real analog or digital outputs or logic (virtual) points as required to provide the specified functions. The Contractor shall select the appropriate input and output signals to satisfy the requirements for control of all systems as shown.

2.9.10.2 Sequences of Operation

The sequences shown describe the actions of the control systems for the HVAC process variables, such as temperature, humidity or pressure.

a. HVAC system shall be automatically started and stopped whenever the hand-off-automatic switch is in the automatic position or manually started and stopped by the hand/off positions.

b. HVAC System Operating - When the HVAC system is operating, the HVAC system outside air, and return air dampers shall function as described for specific modes of operation unless control of the damper is overridden by the fire and smoke control system. Smoke dampers shall open before fans are allowed to start. Interlocked exhaust fans shall be stopped in the unoccupied and ventilation delay modes and their dampers shall be closed. Interlocked exhaust fans shall run in the occupied mode and their dampers shall open. Cooling coil control valves and cooling circulating pumps shall function as described for the specific operation unless their control is overridden by the freeze protection system. Heating coil valves shall remain under control of the system.

c. HVAC System Not Operating - When an HVAC system is off, all interlocked fans shall stop, the smoke dampers shall close, the outside air and relief air dampers shall close, the return air damper shall open,

all stages of direct expansion cooling shall stop, the system shall pump down if it has a pump down cycle, all humidification shall stop, and all valves shall return to their respective specified or shown positions.

d. Variable Volume Fan Start-Up - Variable volume fan shall be started in the unloaded condition (inlet vanes closed or minimum speed as applicable).

e. Control - The application software shall utilize proportional, proportional plus integral, or proportional plus integral plus derivative control with automatic self-tuning of the process variables shown.

f. Status - Equipment operation shall be verified using the sensors shown or specified..

g. Alarms - The operation of the equipment shall be subject to the operational modes, conditions and logic described. A status feedback time delay (adjustable) shall be initiated on equipment startup or setpoint change to allow equipment to reach its operating setpoint.

2.9.10.3 Scheduled Start-Stop Program

This program shall start and stop equipment based on a time of day schedule for each day of the week, and on a holiday schedule. To eliminate power surges, an operator adjustable time delay shall be provided between consecutive start commands.

a. Program Inputs:

(1) Month/Day of week/holiday.
(2) Time of day.
(3) Equipment Start/Stop Schedule
(4) Equipment status..
(5) Equipment constraints.
(6) Consecutive start time delay.

b. Program Outputs: Start/stop signal.

2.9.10.4 Optimum Start-Stop Program

This program shall start and stop equipment as specified for the scheduled start-stop program, but shall include a sliding schedule based on indoor and outdoor air conditions. The program shall take into account the thermal characteristics of the structure, and indoor and outdoor air conditions, using prediction software to determine the minimum time of HVAC system operation needed to satisfy space environmental requirements at the start of the occupied cycle, and determine the earliest time for stopping equipment at the day's end without exceeding space environmental requirements. An adaptive control algorithm shall be utilized to automatically adjust the constants used in the program.

a. Program Inputs

(1) Month/Day of week/holiday..
(2) Time of day.
(3) Cooling or heating mode of operation.
(4) Equipment status.
(5) Cooling and heating building occupancy schedules.
(6) Space temperature(s).
(7) Building heating constant (operator adjustable and automatically optimized).
(8) Building cooling constant (operator adjustable and automatically optimized).
(9) OA temperature.
(10) Required space temperature at occupancy (heating).
(11) Required space temperature at occupancy (cooling).

(12) Equipment constraints.

2.9.10.5 Day-Night Setback Program

The software shall limit the rise or drop of space temperature (or specified fluid temperature) during unoccupied hours. Whenever the space temperature (or specified fluid temperature) is above (or below for heating) the operator assigned temperature limit, the system shall be turned on until the temperature is within the assigned temperature limit.

a. Program Inputs:

(1) Month/Day of week/holiday.
(2) Time of day.
(3) Cooling or heating mode of operation.
(4) Cooling and heating occupancy schedules.
(5) Equipment status.
(6) Space temperature (or specified fluid temperature).
(7) Minimum space temperature (or specified fluid temperature) during unoccupied periods.
(8) Maximum space temperature (or specified fluid temperature) during unoccupied periods.
(9) Equipment constraints.

b. Program Outputs: Start/stop signal.

2.9.10.6 Dry-Bulb Economizer Program

The software shall reduce the HVAC system cooling requirements when weather conditions allow the use of outside air for cooling. Ambient weather conditions shall be monitored by the UMCS through the weather station sensors. The economizer program shall be inhibited if the OA dry-bulb temperature exceeds an operator selectable value. When outside air conditions are favorable for economizer operation, based on the dry bulb changeover value (a predetermined difference between the OA and RA temperatures), the FEP shall enable economizer operation. When the economizer operation is enabled, the OA, return air, and exhaust air dampers shall be positioned to maintain the required mixed air temperature. Mixed air temperature shall be set equal to the required unit supply air temperature. When economizer operation is disabled, the OA dampers, return air dampers, and relief air dampers shall be positioned to provide minimum required OA.

a. Program Input

(1) Changeover conditions.
(2) OA dry bulb temperature.
(3) Return air dry bulb temperature.
(4) Mixed air dry bulb temperature.
(5) Supply air temperature setpoint.
(6) Maximum allowable OA air dry bulb temperature.
(7) Equipment constraints.

b. Program Output: Damper actuator/cooling control signal.

2.9.10.7 Ventilation-Recirculation-Flush Program

The software shall reduce the HVAC system thermal load for three modes of operation as follows:

a. Ventilation mode: In this mode, the system shall precool the space prior to building occupancy. When the outside air temperature is lower than the space temperature, the outside air damper and exhaust air damper shall open to their maximum positions and the return air damper shall close to its minimum position.

b. Recirculation mode: In this mode, the system shall preheat the space prior to building occupancy. When the outside air temperature is lower than the space temperature, the outside air damper and the exhaust air damper shall close and the return air damper shall open to its maximum position. The outside air damper and the exhaust air damper shall be closed at all other times during unoccupied periods, except for economizer operation during day/night setback periods. For systems without mechanical cooling, this program shall, in addition to the above requirements, act as an economizer. The UMCS shall modulate the outside, return, and exhaust air dampers to maintain the required mixed air temperature setpoint. When this program is released, the outside and exhaust air dampers shall return to their minimum positions, and the return air damper shall return to its maximum position.

c. Flush Mode:

The software shall use the HVAC supply system to provide sufficient outside air for ventilation purpose and flush building spaces prior to occupancy. The UMCS shall modulate the outside, return, and exhaust air dampers and control valves to maintain the air supply temperature setpoints while the flush program is in effect. When this program is released, the outside and exhaust air dampers shall return to their unoccupied positions. This program will be coordinated with the optimum start stop program and ventilation recirculation program.

d. Program Inputs

(1) Day of week.
(2) Time of day.
(3) Outside air temperature.
(4) Equipment status.
(5) Cooling or heating mode operation.
(6) Cooling or heating occupancy schedule (fixed or calculated).
(7) Space temperature.
(8) Equipment constraints.
(9) Ventilation flush mode duration (proportioned to HVAC system OA minimum capacity and building volume).
(10) Supply air temperature
(11) Flush time.

e. Program Output

(1) Damper actuator control signal.
(2) Heating valve actuator control signal.
(3) Cooling valve actuator control signal.

2.9.10.8 Hot Deck Cold Deck Temperature Reset Program

The software shall use space, mixed air, and deck temperatures to calculate the hot deck cold deck temperature setpoints in dual duct and multizone HVAC systems. The program shall select the zones with the greatest heating and cooling requirements; establish the HVAC minimum hot and cold deck temperature differentials required to meet the zone temperatures; modulate valves to maintain deck temperature setpoints; and modulate zone dampers to maintain space temperature setpoints, without exceeding space humidity limits (where shown).

a. Program Inputs

(1) Space temperature setpoint.
(2) Space humidity limit (where shown).
(3) Mixing box damper position or proportional signal from primary element.
(4) Hot deck temperature.
(5) Cold deck temperature.

(6) Zone temperatures (where shown).
(7) Space r.h. (where shown).
(8) Minimum space temperature during occupied periods.
(9) Maximum space temperature during occupied periods.
(10) Equipment constraints.

b. Program Outputs

(1) Hot deck valve actuator control signal.
(2) Cold deck valve actuator control signal.
(3) Zone damper or mixing box actuator(s) control output signal.

2.9.10.9 Reheat Coil Reset Program

The software shall select the zone with the least amount of heat required. The program shall reset the cold deck discharge temperature upward until it satisfies the zone with the lowest demand, or until the zone humidity control requirements cannot be met.

a. Program Inputs

(1) Zone r.h. high limit.
(2) Zone temperature (where shown).
(3) Zone r.h. (where shown).
(4) Cold deck temperature.
(5) Reheat coil valve positions or proportional signals from primary elements.
(6) Minimum space temperature during occupied periods.
(7) Maximum space temperature during occupied periods.
(8) Equipment constraints.

b. Program Output: Cold deck valve actuator control signal.

2.9.10.10 Heating and Ventilating Unit Program

The software shall control hot water/steam coil valve position to maintain space/supply air temperatures for heating and ventilating units. This program shall be coordinated with the ventilation-recirculation program for damper control and the scheduled or optimum start-stop program for fan control.

a. Program Inputs

(1) Space temperature.
(2) Space temperature setpoint.
(3) Supply air temperature.
(4) Supply air temperature setpoint.

b. Program Outputs

(1) Heating or steam coil valve actuator control signal.
(2) Damper actuator control signal.

2.9.10.11 Air Volume Control Program

The software shall monitor supply and return/exhaust air flow volumes and modulate fan controls to maintain required air flow volumes and/or ratio or fixed differential of supply to return air flows. This program shall be coordinated with the ventilation-recirculation program and the economizer program for damper control and with static pressure control requirements for fan control.

a. Program Inputs

(1) Supply air flow.
(2) Return/exhaust air flow.
(3) Required supply air flow - high and low limits.
(4) Required return/exhaust air flow - high and low limits.
(5) Volume offset or ratio, as appropriate.

b. Program Outputs

(1) Supply fan volume control.
(2) Return/exhaust fan volume control.

2.9.10.12 Air Distribution Unitary Controller Software

Software shall be provided for the management and control of the air distribution terminal units. Software shall allow for operator definition of multiple air distribution terminal units as functional groups which may be treated as a single entity; monitoring, alarming and reporting of terminal unit parameters on an individual or group basis; and remote setpoint adjustment on an individual or group basis.

a. Functions:

(1) Volume control in response to temperature.
(2) Volume flow limits, minimum and maximum.
(3) Occupied and unoccupied operation with associated temperature and volume limits.
(4) Temperature setpoint override.

b. Program Inputs

(1) Space temperature.
(2) Space temperature setpoint.
(3) Space temperature setpoint limits.
(4) Supply airflow volume.
(5) Supply airflow volume high and low limits.

c. Program Outputs

(1) Supply volume control signal.
(2) Auxiliary fan start/stop signal.
(3) Supplemental heat control signal.

2.9.10.13 Chiller Selection Program

Chiller program shall be used for chiller selection as well as control and monitoring of chillers. The software shall select the most efficient chiller or combination of chillers based on chiller operating data to satisfy the cooling load. Based on chiller operating data, energy input vs chilled water output, the chiller with the highest efficiency shall be selected to satisfy the cooling load calculated by prediction software. The program shall calculate equipment electrical energy input based on percent full load, current, or other inputs provided, and equipment nameplate data. The program shall prevent the chiller from going to full load for a predetermined period to allow the system to stabilize, in order to determine the actual cooling load. The program shall follow the chiller manufacturer's startup and shutdown sequence requirements. Interlocks between chilled water pumps, condenser water pumps, and chiller shall be in accordance with the chiller manufacturer's requirements.

a. Program Inputs

(1) Efficiency curves.
(2) Chiller water supply temperatures.
(3) Chiller water return temperatures.
(4) Chiller water flows.
(5) Entering condenser water temperatures.
(6) Leaving condenser water temperatures.
(7) Condenser water flows.
(8) Instantaneous kW to chillers.
(9) Instantaneous kW to chilled water pumps (if variable).
(10) Instantaneous kW to condenser water pumps (if variable).
(11) Instantaneous kW to cooling tower fans (if variable).
(12) Common chilled water supply temperatures.
(13) Common chilled water return temperatures.
(14) Total chilled water flow.
(15) Chilled water pumps status.
(16) Refrigerant pressure, suction and discharge.
(17) Equipment constraints.
(18) Steam flow.

b. Program Outputs

(1) Start-stop signals for chillers (manual or automatic to control panel).
(2) Start-stop signals for chilled water pumps (manual or automatic to control panel).
(3) Start-stop signals for condenser water pumps (manual or automatic to control panel).
(4) Start-stop signals for cooling tower fans (manual or automatic to control panel).
(5) Chilled water supply temperature setpoint control signal.
(6) Chiller efficiency.

2.9.10.14 Chilled Water Temperature Reset Program

****
NOTE: The chiller water temperature reset program should be carefully examined prior to specifying its use on a variable volume pumping system.
****

The software shall reset the chilled water temperature supplied by a water chiller. The program shall reset the chilled water temperature upward or downward to meet the required space temperature or humidity setpoints. The program shall monitor the positions of the chilled water control valves (percent of opening) and space temperatures.

a. Program Input:

(1) Chilled water valve position.
(2) High limit for space dry bulb temperature.
(3) Chiller supply water temperature.
(4) High chilled water operating temperature.
(5) Low chilled water operating temperature.
(6) High limit for space r.h.
(7) Equipment constraints.

b. Program Output: Chilled water supply temperature setpoint control signal.

2.9.10.15 Condenser Water Temperature Reset Program

The software shall reset the condenser water temperature from a fixed temperature downward when the OA wet bulb temperature will produce lower condenser water temperature. Program shall be coordinated with the chiller control loop algorithms for chiller supply, return water temperatures and safety interlocks.

a. Program Inputs:

(1) Maximum condenser water operating temperature.
(2) Minimum condenser water operating temperature.
(3) Condenser water supply temperature.
(4) OA dry bulb temperature.
(5) OA r.h.
(6) Condenser water cooling equipment thermal approach characteristics.
(7) Equipment constraints.

b. Program Output: Condenser water supply temperature setpoint control signal.

2.9.10.16 Chiller Demand Limit Program

The software shall limit maximum available chiller cooling capacity in fixed steps as shown to limit electrical demand. Each fixed step shall be considered as one point in the demand limiting program. Each chiller demand control step shall be assigned an equipment priority level.

a. Program Inputs:

(1) Chiller percent capacity.
(2) Minimum cooling capacity.
(3) Equipment priority schedules.
(4) Equipment constraints.

b. Program Output

(1) Calculated percent load point.
(2) Control signal to chiller controller/panel, new setpoint (manual or automatic as shown).

2.9.10.17 Hot Water OA Reset Program

The software shall reset the hot water temperature supplied by the boiler or converter in accordance with the OA temperature or other specified independent variable. The hot water supply temperature shall be reset downward or upward from a fixed temperature proportionally, as a function of OA temperature or other specified independent variable.

a. Program Inputs

(1) Reset schedule.
(2) OA dry bulb temperature or other specified independent variable.
(3) Hot water supply temperature.
(4) Maximum hot water supply temperature.
(5) Minimum hot water supply temperature.
(6) Equipment constraints.

b. Program Output: Valve actuator control signal.

2.9.10.18 Hot Water Distribution Program

The software shall control the hot water distribution temperature to individual building zones. The zone hot water distribution temperature shall be reset downward or upward from a fixed temperature proportionally as a function of OA temperature or other specified independent variable by modulating the respective zone mixing valve. The zone pump shall be stopped when the OA temperature exceeds the specified setpoint. When parallel pumps are used, the software shall alternate pump operation and shall start the standby pump (after a time delay) upon failure of the operating pump.

a. Program Inputs

(1) Zone hot water distribution temperature.
(2) Reset schedule.
(3) OA dry bulb temperature or other specified independent variable.
(4) Maximum zone hot water distribution temperature.
(5) Zone pump status.
(6) Equipment constraints.

b. Program Outputs

(1) Zone mixing valve control.
(2) Zone pump start/stop signal.

2.9.10.19 Domestic Hot Water Generator Program

The software shall control the domestic hot water temperature by adjusting the hot water heating control valve.

a. Program Inputs

(1) Domestic hot water temperature.
(2) Domestic hot water temperature setpoint.

b. Program Output: Hot water heating control valve actuator control signal.

2.9.10.20 Lighting Control Program

The software shall turn lights on and off based on the time of day and the day of week, including holidays. The program shall generate additional commands at operator adjustable intervals to assure that lights are off (relay operated zoned lighting only).

a. Program Inputs

(1) Month/Day of week/holiday.
(2) Time of day
(3) Cooling and heating start-stop schedules.
(4) Equipment status.
(5) Times of day for additional off commands (where applicable).

b. Program Output: On/off signal.

2.10 OPERATOR WORKSTATION EQUIPMENT

2.10.1 Operator Workstation

The operator workstation shall be a standard unmodified digital computer of modular design, with the following minimum requirements.

- Microprocessor: minimum 2.2GHz clock speed
- Memory: 1024MB, expandable. to 2GB
- Diskette Drive: 3.5" (1.44MB)
- DVD Re-Writeable Drive: minimum speeds (2.4x/8x/12x/10x/32x); 2.4x DVD (re-write), 8x DVD (read), 12x CD-R (write), 10x CD-RW (re-write), 32x CD (read) speeds
- Hard Drive: minimum 120GB;
- Multimedia Drive: 16x speed DVD-ROM
- Video Graphics Card, video memory: minimum 64MB SDRAM
- Sound card with stereo speakers
- Real-time Clock
- Front Mounted Ports: 2 USB, 1 serial port and 1 IEEE 1394 port
- Total Drive Bays: External (2) 3.5", (3) 5.25"; Internal (2) 3.5"
- Total Expansion Slots: 5 PCI; 1 AGP
- Total External Ports: 6 USB; 2 Serial; 1 parallel; 2 PC/2; 3 IEEE 1394 ports
- Data/Fax Modem
- Network Card: Integrated 10/100Base-T networking interface
- Keyboard: QWERTY, 105 keys in ergonomic shape with 2 USB ports
- Mouse: USB Optical Scrolling, two-button Mouse

2.10.2 Color Monitor

The monitor shall be sized as shown, but no less than \^432 mm,^\ \~19 inches,~\ viewable area with a minimum resolution of 1280 by 1024 pixels, nonintegrated, and a maximum dot pitch of 0.24 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.

2.10.3 Dot Matrix Alarm Printer

The dot matrix alarm printers shall have a minimum 96 character standard ASCII character set based on \-ANSI X3.64-\ and \-ANSI X3.154-\ and with graphics capability. The printers shall have adjustable sprockets for paper width up to 11 inches, print at least 80 columns per line and have a minimum speed of 200 characters per second. Character spacing shall be selectable at 10, 12 or 17 characters per inch. The printers shall utilize sprocket-fed fanfold paper. The units shall have programmable control of top-of-form. Printers shall include floor stands with paper racks.

2.10.4 Laser Printer

The laser printer shall meet the following requirements:

a. Resolution: 1200 by 1200 dots per inch.

b. Printing Time: 16 pages per minute.

c. Data Buffer Size: 32 Megabytes.

d. Media Size: 8.5 X 11 inches.

e. Interfaces: Parallel port.

f. Paper Cassette: 500 sheet capacity.

2.10.5 Network Laser Printer

The laser printer shall meet the following requirements:

a. Resolution: 1200 by 1200 dots per inch.

b. Printing Time: 16 pages per minute.

c. Data Buffer Size: 32 Megabytes.

d. Media Size: 8.5 X 11 and 8.5 X 14 inches.

e. Interfaces: Parallel port & LAN interface.

f. Paper Cassette: 500 sheet capacity.

2.10.6 Network Color Laser Jet Printer

The color printer shall use laser jet technology, and shall meet the following requirements:

a. Resolution: 600 by 600 dots per inch.

b. Printing Time: 12 pages per minute.

c. Memory 192 megabytes.

d. Data Buffer Size: 32 Megabytes.

e. Colors: 256 printable colors.

f. Media Type: Paper and transparency film.

g. Media Size: 8.5 X 11 and 8.5 X 14 inches.

h. Interfaces: Parallel port & LAN interface.

i. Paper Cassette: 250 sheet capacity.

2.10.7 LAN Equipment

All LAN equipment shall fully comply with \-IEEE Std 8802-3-\ (10 BASE 2 or 10 BASE T) Ethernet networks.

****
NOTE to Designer:

1. For projects that require multiple types of cable jackets or special types of cable, indicate the type of each cable on the drawings. For cables which require special jackets, such as those subject to corrosive environments, provide a description of the environmental requirements.

2. Select the appropriate cable jacket rating (such as CMR, CMG, CMP, OFNG, OFNR, or OFNP) based on NEC or local code requirements. If there is a potential for mixed rating of the same cables, use the highest rating only.

3. Use fiber optic cable for backbone data service, unless expanding an existing site where

other backbone cable types are required or requested by user. Unshielded twisted pair cable is not recommended for backbone cable, but if requested by the user, should meet or exceed the performance of the horizontal distribution (station) cable.

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2.10.7.1 Unshielded Twisted Pair (UTP) Cable and Accessories

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NOTE: The category for cable, jacks and blocks should be the same throughout each circuit and system. In general, only Category 5 should be used for data circuits. Verify these criteria with the user.

Use T568A wiring configuration only unless adding to an existing system where T568B wiring configuration is already in use.
****

a. Riser cable shall meet the requirements of \-ICEA S-80-576-\ and \-EIA 568A-\ for Category 5, 100-ohm unshielded twisted pair cable. Cable shall be label verified. Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level. Conductors shall be solid untinned copper [24 AWG] [22 AWG]. Cable shall be rated [CMR] [CMP] per \-NFPA 70-\.

b. Horizontal cable shall meet the requirements of \-EIA 568A-\ for Category 5 horizontal cable. Cable shall be label verified. Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level. Conductors shall be solid untinned copper 24 AWG. Cable shall be rated [CMG] [CMP] per \-NFPA 70-\.

c. Backbone cable shall meet the requirements of \-EIA 568A-\ for Category 5 UTP cable. Cable shall be label-verified. Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level. Cable shall be rated [CMP] [CMR] [CMG] per \-NFPA 70-\. Cable shall have band markings every \^2.5 meters^\ \~8 feet~\ for transceiver tap placement.

d. Outlets shall be eight-position modular jacks that meet the requirements of \-EIA 568A\ for Category 5 connecting hardware. Outlet wire terminations shall be insulation displacement type. Jack pin/pair configuration shall be T568A per \-EIA 568A-\. Outlets shall be unkeyed. Faceplates shall be provided and shall be impact resistant plastic, single gang. Mounting plates shall be provided for system furniture and shall match the furniture system in color.

e. Patch panels shall consist of eight-position modular jacks arranged in rows or columns on wall mounted frames. Cable terminations shall be insulation displacement (IDC) type. Patch panel components shall meet or exceed the requirements of \-EIA 568A-\ for Category 5 connecting hardware. Jack pin/pair configuration shall be T568A per \-EIA 568A-\. Jacks shall be unkeyed.

f. Patch cords shall be cable assemblies consisting of flexible, twisted pair stranded wire with eight-position plugs at each end. Patch cords shall meet the requirements of \-EIA 568A-\ for Category 5. Cable shall be label verified. Cable jacket shall be factory marked at regular intervals indicating the verifying organization and performance level. Patch cords shall be wired straight through such that pin numbers are identical at each end and shall be paired to match T568A patch panel jack wiring per \-EIA 568 A-\. Patch cords shall be unkeyed. Patch cords shall be factory assembled.

2.10.7.2 Bridges

Bridges shall provide communication between local area networks segments as shown. Bridges shall support protocols utilized in the local area networks. The bridge shall include interface equipment to support data rates shown, but no less than 14,400 bps. Bridges with multiple communication lines shall be modular, expandable

to a minimum of 16 ports. Each port shall have LED indicators for monitoring network status. The bridge shall be self-configuring and protocol transparent.

2.10.7.3 Hubs

Network hubs shall provide communication between network devices using 10 BASE T 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.

2.10.8 Security Callback Modem

The security callback modem shall be a stand-alone modem with a security feature to call back the originating number after receiving a call. The modem shall be programmable to set callback telephone numbers. It shall operate at speeds up to 56k bps full duplex on circuits in the asynchronous mode. The modem shall have error detection, auto answer/auto dial, call progress detection, and the appropriate security safeguards, including passwording, to allow for call back of predefined numbers associated with each password, after receiving a call.

2.10.9 Uninterruptible Power Supply (UPS)

A self contained UPS suitable for installation and operation at the operator workstation, shall be provided and sized to provide a minimum of 10 minutes of operation of the OWS equipment. Equipment connected to the UPS shall not be affected in any manner by a power outage of a duration less than the rated capacity of the UPS. 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. Provide USB connection with software for automatic shutdown of data applications. The UPS shall be as specified in SECTION \=16610=\, UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM ABOVE 15 kVa CAPACITY.

2.11 OWS SOFTWARE

The OWS software shall support all specified functions, plus expansion to a minimum of 50,000 points, complete with their point database. The OWS shall be online at all times and shall perform all required functions as specified.

2.11.1 Operating System

The operating system shall perform the following functions:

a. Support operation with multiple tasks for each user.

b. Support operation and management of all peripheral devices.

c. Provide file management functions for disk I/O, including creation and deletion of files, copying of files, a directory of all files including size and location of each, sequential and random ordered records.

d. Provide printer spooling.

e. Support for the specified LAN interface.

2.11.2 Real Time Clock Synchronization

The system shall synchronize each real time clock within one second and at least once per day automatically, without operator intervention and without requiring system shutdown. An operator shall be able to initiate time synchronization manually. The system shall initiate a real-time clock sync from a national clock standard once per day to obtain the correct time and date.

2.11.3 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 the UMCS database by the Contractor.

2.11.4 Report Generator

Software shall be provided with commands to generate and format reports for displaying, printing, and storing on disks. Reports shall be stored by type, date, and time. The destination of each report shall be selectable by the operator. Reports shall use database values and parameters, values calculated using the real time static database; with the reports subsequently stored on disks.. Reports shall be spooled allowing the printing of one report to be complete before the printing of another report commences. Database parameters used in reports shall be assignable by the operator. Dynamic operation of the system shall not be interrupted to generate a report. The report generation mode, either periodic, automatic or request, shall be operator assignable. The report shall contain the time and date when the sample was taken, and the time and date when the report was printed. Software shall be provided to format and store on a removable diskette all data, trends, profiles, reports and logs specified herein in a defined, standard format such as ASCII text or Data Interchange Format (DIF) for export and further processing by other computer systems. Data transfer function shall be accessible by operator command from any workstation, subject to password.

2.11.4.1 Periodic Automatic Report Modes

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.

2.11.4.2 Request Report Mode

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

2.11.4.3 Creation of Reports

a. Status Report: The system shall include software to produce reports on the current status of any equipment or parameters in the database, including:

(1) An individual equipment item sensor or control device.

(2) A list of equipment, sensors, or control devices, by category, such as building, unit, FEP, or I/O point database parameter.

b. Correlated Alarm Reports: The software shall provide for generating a report to include parameters dependent on a specific alarm in order to obtain detailed diagnostics of the I/O point database when an alarm condition occurs. The software shall include:

(1) Identification of the initiating alarm.

(2) Identification of correlated dependent parameters.

(3) Automatic reporting of current status of each dependent parameter when an alarm condition is detected in the initiating point. Provision shall be made for 64 initiating alarms each having up to 32 dependent parameters.

c. Profile Reports: The software shall provide for generating profile reports by sampling and storing defined parameters on an operator assignable and selectable time interval basis such as an interval of 15 minutes for a period of 1 month and shall include:

(1) Power consumption (value vs time).

(2) Power demand (value vs time).

(3) Analog (value vs time).

(4) Two variable (point) profiles.

(5) Equipment subsystem profiles (value vs value or value vs time). Sixty-four profile reports shall be provided each with 1000 samples of up to 8 parameters.

2.11.5 Standard Reports

The following standard reports shall be provided:

2.11.5.1 Electrical Power Utilization Report: An electrical power utilization summary, operator selectable for substations, meters, or transducers, individual meters and transducers, any group of meters and transducers, and all meters for an operator selected time period. The report shall include the voltage, current, power factor, electrical demand, electrical power consumption, reactive power (Kvar) for each substation, facility, system or equipment as selected by the operator. The report shall be automatically printed at the end of each summary period and shall include:

(a) Total period consumption.

(b) Demand interval peak for the period, with time of occurrence.

(c) Power consumption (kWh) over each demand interval.

(d) Average (kW) demand during the 5 to 60 minute user definable interval containing the installation's peak demand.

(e) Time-of-use peak, semi-peak, off-peak, or baseline total kWh consumption.

(f) Reactive power during each demand interval.

(g) Power factor during each demand interval.

(h) OA temperature and r.h. taken at the maximum and minimum of OA temperature of the report period with the time and dates of occurrence. At the installation's peak demand interval, the OA temperature and r.h. shall also be recorded.

(i) Calculated heating and cooling degree days to an operator selected base.

2.11.5.2 Electrical Peak Demand Prediction Report: A report based on the demand limiting program. The report shall include:

(a) Target.

(b) Actual peak and predicted peak for each demand interval for that day.

(c) Predicted demand for the next demand interval.

2.11.5.3 Energy Utilization Report: An energy utilization summary, operator selectable, for a point, unit, building, area, installation, and the entire UMCS. The report shall include:

(a) Beginning and ending dates and times.

(b) Total energy usage for the current and previous day.

(c) Total energy usage for the current and previous month.

(d) Maximum rate of consumption for the current and previous day.

(e) Maximum rate of consumption for the current and previous month.

(f) OA temperature high, low, and average.

(g) OA r.h. or dew point high, low, and average.

(h) Calculated degree days.

(i) OA Temperature and r.h. taken at the maximum and minimum of OA temperature with the time and dates of occurrence. At the installation's peak demand interval, the OA temperature and r.h. shall also be recorded.

2.11.5.4 Equipment Electrical Consumption Report: An equipment electrical consumption report shall be provided for monitoring the electrical parameters and energy consumption from equipment instrumented or metered. Report shall obtain data for equipment, facility, system, substation metered for power and associated electrical parameters. Report shall be correlated to equipment, systems, facility or substation. Report shall monitor the power consumption (kWh), power factor, reactive power (kvar), current, voltage, and instantaneous demand (kW) of each device and provide high and low level alarm points. Report shall also totalize and report system, facility, substation and equipment energy consumption and other electrical parameters at operator selectable intervals. Report shall provide data for the following intervals as a minimum:

(a) Minutes (operator selectable from 0-60).

(b) Hourly.

(c) Daily.

(d) Weekly.

(e) Monthly.

(f) Yearly.

Reports shall include the starting and ending time of the reporting interval. Longer reporting intervals shall be accumulated by totalizing the results of shorter intervals.

2.11.5.5 Alarm Report: Outstanding alarms by building or unit, including time of occurrence.

2.11.5.6 Lockout Report: Points disabled, including time disabled, and identification of operator disabling the point.

2.11.5.7 Analog Limit Report: An analog limit and differential summary selectable to allow a single point, analog points within a unit, analog points within a building, and analog points for the project. Displays and logs shall still indicate the current value of these points even though alarming has been suppressed. The report shall include:

(a) Point analog value.

(b) Engineering units.

(c) High limit.

(d) Low limit.

(e) High reasonableness limit.

(f) Low reasonableness limit.

(g) High limit differential.

(h) Low limit differential.

(i) Analog value change differentials.

2.11.5.8 Run Time Reports: A report totalizing the accumulated run time of individual pieces of equipment. The operator shall be able to select the following subsets of equipment:

(a) Individual equipment items without status feedback.

(b) Individual equipment items with analog or digital status feedback.

(c) Equipment type, such as air handling units.

(d) Specific equipment sizes by types, such as all motors over \^15 kilowatt.^\ \~20 hp.~\

(e) Equipment by physical grouping. The system shall maintain statistics on a number of equipment items equal to the number of digital inputs and outputs. Run time shall be totaled up to 9999 hours. Reports shall be generated on equipment which has reached the target run time specified in the database. The software will provide for manual and automatic reset, operator selectable and settable for each individual run time totalized, reset to zero upon generation of the report, as necessary.

2.11.5.9 Cooling Tower Profiles: A cooling tower profile for each cooling tower as shown, including:

(a) Total daily and monthly on-time (each fan).

(b) Number of on and off transitions (each fan).

(c) Maximum and minimum daily condenser water temperature and the time of occurrence.

(d) Maximum and minimum daily condenser water temperatures for the current month.

2.11.5.10 Chiller Utilization Report: A report of the operation of each chiller as shown on a daily and monthly basis, including:

(a) Daily run-time in each one of at least 10 discrete loading levels.

(b) Daily run-time average for the above discrete loading levels.

(c) Total on-time for each level for the current month.

(d) Monthly average energy use in Mjoules, kWh or btuh for total on-time at each level.

2.11.5.11 Optimum Start-Stop Report: A list of all systems and buildings not meeting occupancy temperature requirements within plus or minus 20 minutes of the designated occupancy time and those systems and buildings meeting the occupancy temperature earlier than 20 minutes prior to the designated occupancy time, printed daily or upon request. The report shall include:

(a) System and building identification.

(b) Building occupancy schedule.

(c) Actual start or stop time.

(d) Calculated start-stop time.

(e) OA and space temperature at fixed start-stop time and at actual beginning or end of occupancy.

(f) OA temperature at beginning or end of occupancy.

(g) Target space temperature C.

2.11.5.12 Out-Of-Service Report: A report to list out-of-service devices in each OWS, each DTS circuit, and each FEP.

2.11.5.13 Static Database Reports: A listing of the values of fixed parameters and constraints defining the characteristics of the system and the connected equipment. Provide operator commands to list the entire static database or to list an operator selected building, unit, point, or FEP. Each value shall be listed with appropriate units in English.

2.11.5.14 Real-Time Database Reports: A list of the values of dynamic variables including all AIs, DIs, and calculated points. These data shall be sampled concurrently, including year, month, day, hour, and minute on the report. Operator commands shall allow for listing the entire real-time database or an operator selected installation, building, unit, point, or FEP. Each value listed shall be identified in English.

2.11.5.15 Communication Network Circuit Report: A listing of all communication circuits from each OWS to each NC; and from each NC to its Unitary Controllers and Universal Programmable Controllers. The report shall include for each communication circuit:

(a) Operator selected number (1-99) of retransmission attempts.

(b) Total number of transmissions attempted (0-64,000).

(c) Present consecutive retries (in progress) (1-99).

(d) Total number of retries (cumulative to 32,000).

2.11.5.16 Network Security Callback Modem Log: A listing of all incoming and outgoing calls from each Network Security Callback Modem at all locations in the UMCS.

2.11.5.17 Significant Events Report: The significant events report shall include system events in chronological order. The size of the report shall be user definable and shall be stored at a universally retrievable system location, accessible from any workstation. The report shall have a user selectable/definable query, and the report shall include event times and descriptions for all items queried. All queries shall be based on the following:

(a) Time.

(b) Date.

(c) Point name or acronym.

(d) Control operations.

(e) Status report.

(f) System failures.

(g) Control failures.

(h) Data transmission failures.

(i) User login and transactions.

(j) Time schedules.

(k) Point types.

2.11.5.18 Energy Savings Report: An energy savings summary, operator selectable for a point, unit, building, area, installation, of the entire UMCS. The report shall use on the rating or capacity of each controlled point using a formula based on each application program and the time each program is in effect. The basis of the energy savings report shall be the calculations and methods described in the \-NFESC ESA RELEASE 8-\. The report shall include the types of systems and equipment described in the Energy Saving Analysis program.

2.11.6 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.

2.11.7 Workstation Software

****
NOTE: Control schematics will be shown on the drawings in order to support this paragraph. Additionally, include any required graphics such as floor plans, and one line diagrams. Where floor plans are already shown on the drawings, a listing of those to be included as graphics will be developed and included on the drawings. Provide a list of custom symbols and any required graphics which are to be automatically initiated by any condition the UMCS can detect such as an alarm.
****

Each workstation shall be provided with operator interface operating system software as follows:

2.11.7.1 Windowing System: Each workstation shall be provided with a windowing system software package with communication and programming capabilities. The windowing system shall also include a user application multiple window management program to organize the graphic display and shall conform to graphic display hierarchy shown.

2.11.7.2 Graphical User Interface: Each workstation shall be provided with an graphical user interface. The graphical user interface shall include a set of desktop utilities as listed below.

(a) File management.

(b) Shell tool.

(c) Calculator.

(d) Text editor.

(e) Icon editor.

2.11.7.3 Display Information: The Workstation shall display information necessary to support all requirements specified, including:

(a) Operator commands.

(b) Alarm notification.

(c) Reports.

(d) System graphics as specified and as shown, incorporating real time data.

(e) Curve plotting.

(f) Units of measure (e.g., ft, lb, psig, cm)

2.11.7.4 System Graphics Implementation: System graphics displays shall be hierarchial displays which integrate real time data into the display. System graphics shall reflect actual system configuration and points required for the sequence including system wide data such as outside air temperature and humidity. Each system schematic shall be included as a separate display keyed to the building in which it is installed. Displays of all systems and points shown shall be included. Different colors textures, and use of inverted video shall be used for various components and real time data. Colors and textures shall be uniform on all displays. Data associated with a display shall be updated within 10 seconds of the digital status change or the analog change in excess of the analog change differential. When a point is in alarm, the representation for that point shall be distinctly distinguishable until acknowledged, and shall change to indicate acknowledgement until the alarm condition no longer exists. Floor plans shall display equipment zones, associated systems and points. All points shall have correct units, associated with the points, displayed. Zones with space temperature exceeding alarm limits shall be color-filled on the floor plan with red in a distinguishable texture for exceeding the high limit and with blue in a distinctly different texture for exceeding the low limit Colors shall be used to allow rapid recognition and ease of interaction. Any real time data which is not current, due to FEP communications failure, FEP failure, or point out of service, shall be highlighted or flagged. Each display shall clearly distinguish between the following types of information:

(a) Real-time updated data.

(b) User-entered data.

(c) Bad or out-of-scan data.

(d) Disabled controls (control inhibited).

(e) Disabled sensors (reporting inhibited).

(f) Devices in alarm (unacknowledged).

(g) Out-of-limits data.

2.11.7.5 Display Editor: The display editor shall enable the user to create, modify, and delete displays. The primary use shall be for adding and modifying one-line diagrams, status displays, system summaries, and system directories, as Network Controllers/Unitary Controllers/Universal Programmable Controllers and new points, data, and other necessary changes are made. 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. The basic functions shall include:

(a) Create a new graphic.

(b) Modify a portion of a graphic.

(c) Delete a graphic.

(d) Call up a graphic.

(e) Cancel the display of a graphic.

(f) Assign conditions which automatically initiate the display.

(g) Overlay alphanumerics and graphics.

(h) Save new, modified, or existing graphics as new graphics.

(i) Integrate real-time data with the display.

(j) Define the background color.

(k) Define the foreground color.

(l) Locate the symbols.

(m) Position and edit alphanumeric descriptors.

(n) Establish connecting lines.

(o) Establish sources of latest data and location of readouts.

(p) Display analog values as specified.

(q) Cursor control (up, down, right, left).

(r) Create and display alphanumeric displays.

(s) Create and display reports.

(t) Define and create symbols. In constructing the static or fixed background portion of a single-page or multi-page display where the basic formats and dynamic field locations are identical in the different pages, the user shall not be required to repetitively enter the same information for each page.

2.11.7.6 Charting: The workstation shall allow the user to display data as:

(a) Trend Charts: The system shall support the presentation of data with time on the X-axis (horizontal) and amplitude on the Y-axis (vertical). A minimum of 360 15-minute divisions of 24 1-hour divisions, and 31 1-day divisions shall be displayed on the X-axis. A minimum of 10 equal divisions, in engineering units, shall be displayed on the Y-axis. The start and end date/time shall be user definable on the hour starting at midnight. The system shall display trends in a real time mode.

(b) Bar Chart: The system shall support presentation of data in bar chart form with a minimum of 360 15-minute divisions and 31 1-day divisions to be displayed on the X-axis.

2.11.7.7 System Menus and Displays: The user shall be able to call up the following displays by multiple character entry, dedicated function key, 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 Network Controllers, Unitary Controllers, and Universal Programmable Controllers).

(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)

2.11.8 System Graphics Symbols

The system graphics software shall include a library of the symbols listed, plus 100% expansion. Symbols shall conform to \-ASHRAE-81930-\ where applicable. The software shall allow the operator to create, modify, delete, call-up, list, and store display symbols. A library of callable display symbols shall be furnished, including:

a. Pump: Right hand (RH), Left hand (LH), Upflow (U), Downflow (D).

b. Valve, Two-Way: Horizontal (H), Vertical (V).

c. Valve, Three-Way: H, V.

d. Flow Element: H, V.

e. Temperature Sensor: H, V.

f. Pressure Sensor: H, V.

g. Humidity Sensor: H, V.

h. Air Handling Unit, Single Deck.

i. Air Handling Unit, Double Deck.

j. Fan: r.h., IH, U, D.

k. Chiller.

l. Boiler.

m. Air Compressor.

n. Vertical Piping and Ductwork.

o. Horizontal Piping and Ductwork.

p. Unit Heater.

q. Pressure Reducing Valve: H, V.

r. Damper: H, V.

s. Electric Meter.

t. Limit Switch: H, V.

u. Flow Switch: H, V.

v. Temperature Switch: H, V.

w. Pressure Switch.

x. Coil: H, V.

y. Solenoid Valve: H, V.

z. Filter: H, V.

aa. Condensing Unit.

bb. Cooling Tower.

cc. Custom symbols as shown.

2.11.9 Hard-Copy Screen Request

Each workstation 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. Printer output format shall be an exact image of its corresponding display on the monitor. The hard-copy output shall be selectable to the workstation printer or to any network printer.

2.11.10 Alarms

The software shall notify an operator of the occurrence of an alarm condition. The UMCS alarm history shall be stored on disk and shall be recallable by the operator using the report generator. Alarm messages shall take precedence over reports, and reports shall take precedence over logging of operator actions. A minimum of the most recent 25 system alarms shall be directly available at each workstation. Alarms shall be displayed in chronological order with the oldest unacknowledged alarm displayed first. Operator acknowledgment of one alarm shall not be considered as acknowledgment of any other alarm nor shall it inhibit reporting of subsequent alarms. Each alarm shall be assignable to any one or any combination of workstations by time of day and day of week. Additionally, the alarms shall be logged at the operator workstation. Alarm acknowledgment at any given workstation shall not constitute acknowledgment for any other workstation in the system. Alarm data to be displayed and stored shall include:

a. Identification of alarm.

b. Date and time to the nearest second of occurrence.

c. Device or sensor type.

d. Limit exceeded (if analog).

e. Engineering units.

f. Current value or status.

g. Alarm class.

h. Alarm messages.

2.11.11 Digital Alarms Definition

Digital alarms are those conditions indicated by switching contacts in the connected equipment as specified and shown. These alarms shall be subject to immediate reporting, within the alarm response time, at the operator workstation regardless of other considerations such as the overall time constant associated with a controlled system or process.

2.11.12 Analog Alarms Definition

Analog alarms are those high or low conditions calculated from a measured analog parameter in the database as specified and shown. These alarms shall be subject to immediate reporting, within the alarm response time, at the operator workstation, regardless of other considerations such as the overall time constant associated with a controlled system or process. The FEPs analog readings shall be compared to predefined high and low limits, and alarmed via uplink to the operator workstation 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. High and low alarm limits shall be stored in the operator workstation and FEP databases. Operator-requested analog displays, reports, and summaries shall flag each analog point in alarm. Each high and low limit shall have an associated unique limit differential specifying the amount by which a variable must return into the proper operating range before being annunciated as a return-to-normal-state. Limits and differentials shall be enterable on-line by the operator in units of the measured variable, without interruption or loss of monitoring of the point concerned. 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. The system shall automatically suppress control functions and analog alarm reporting associated with a digital point when that digital point is turned off or reset.

2.11.13 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. The system shall provide for 100 secondary messages with a field of 25 lines of 60 characters each.

2.11.14 Alarm Classes

Classes of alarms which will be identified for each item, include:

a. Class 1 (Critical): Display, print, and audible alarm at occurrence and at return-to-normal. Acknowledgment by the operator shall be required at occurrence and at return-to-normal.

b. Class 2 (Informational): Display, print, and audible alarm at occurrence and at return-to-normal. No acknowledgment is required unless otherwise shown.

2.11.15 Pop-up Note Function

A pop-up note function shall be included with each workstation, 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.

2.11.16 Control Sequence Programming

The system shall include a programming function which shall be used to create all control sequences utilized in NCs and UPCs. This function shall reside in the Workstations to create, modify, and test software for FEP resident programs. The control sequence 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 FEP. The programming function shall include elements for mathematical, logical, timing, setpoint, display and input/output functions 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 real-time 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 function shall provide for the following:

a. Creation, modification, and testing of programs. Modular application software, control sequences, and PID control loops and database information shall be used in the development of programs.

b. Editing FEP source code.

c. Conversion of source programs into executable object code.

c. Saving and retrieving source and executable object code.

d. Using the portable computer for loading files directly into the FEP.

f. Uploading of existing FEP programming and database information and downloading of FEP programming and database information.

2.11.17 Command Software

The system shall accept English language operator commands for defining and selecting points, parameters, graphics, report generation, and all other functions associated with operation. The operator commands shall be usable from workstation keyboards with individual operator passwords as specified.

2.11.17.1 Command Input: Operator's commands shall be 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 in full words and acronyms for all required information, identifying acceptable command formats. The operator's response shall be a word, phrase, or acronym including parameters where required.

2.11.17.2 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. The system shall explain to the operator why the command cannot be executed. Conditions for which operator error assist messages shall be generated include:

(a) The command used is incorrect or incomplete.

(b) The operator is restricted from using that command.

(c) The command addresses a disabled or out of service point.

(d) The command addresses a point which does not exist.

(e) The command would violate constraints.

2.11.17.3 Operator's Commands: The operator's commands shall provide the means for entry of control and monitoring commands, and for retrieval of information. Processing of operator commands shall commence within 5 seconds of entry, with some form of acknowledgment provided at that time. The operator’s commands shall perform tasks, including:

(a) Request a display of any digital, analog, or accumulator point, or any group of related points.

(b) Startup and shutdown of selected systems or devices.

(c) Initiate reports.

(d) Modify time and event scheduling.

(e) Modify analog limits.

(f) Adjust setpoints.

(g) Adjust control loop gain constant.

(h) Adjust control loop integral constant.

(i) Select manual or automatic control modes.

(j) Enable and disable individual points at individual FEPs.

(k) Enable and disable individual FEPs.

(l) Define points.

(m) Generate and format reports.

2.11.17.4 Level of Addressing: Six levels of addressing for identification shall be provided, for example:

(a) Point - the individual sensor or control device within a unit.

(b) Unit - the unit that a point is associated with, such as an AHU.

(c) Building Subsection – floor, wing, penthouse, mech room.

(d) Building - the building that a point is located in or near.

(e) Area - the area that a building is located in or near.

(f) Facility - Installation included in the UMCS.

2.11.17.5 Access Control: A minimum of 256 passwords shall be usable with the UMCS software. The system shall display the operator's names or initials on the monitor. The system shall print the operator's name or initials, action, date, and time on the printer at log-on and log-off. The password shall not be displayed or printed. The system shall maintain a file logging all activity of the system. This file shall maintain, as a minimum, a record of all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications. The activity log shall be maintained at the operation workstation. The system shall automatically provide a mechanism for archiving the log files for long term record storage. Each password shall be definable and assignable for the following:

(a) Commands usable.

(b) Access to operating system.

(c) Access to command software.

(d) Access to applications software.

(e) Individual points which are to be accessed.

(f) Access for alarm assignments.

(g) Access to workstations.

(h) Access to groups of points.

2.11.18 FEP and DTS Circuit Alarms

The system shall supervise each FEP, I/O function and DTS circuit for alarm reporting, including:

a. FEP not responding.

b. FEP responding (return to normal).

c. NC to OWS DTS circuit high error rate.

d. NC to Unitary Controller/Universal Programmable Controller DTS circuit high error rate.

e. FEP intrusion alarm.

f. FEP offline.

g. FEP online.

h. FEP failure (self-diagnostics).

i. Point not responding to command.

j. Point change of state without command.

2.11.19 Trending

Any analog or calculated point shall be operator assignable to the trend program. A minimum of 100 points shall be sampled at individually assigned intervals at each workstation, selectable between one minute and 24 hours. Program shall write a disk file after each point is trended for 100 intervals. The sample intervals shall be able to be defined, modified, or deleted online. The system shall automatically store the accumulated trend data to a 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.

2.11.20 OWS Database

The OWS database shall be stored on disk. The static database shall be downloadable as required to FEPs in the system.

2.11.20.1 Real Time Database

The real time database includes those variables which change with time or conditions including all DIs, AIs, PAs, and virtual (logic) points. It may reside in the FEPs only, or additionally at the OWS computer.

2.11.20.2 Real Time Database Update

The real time database shall be updated from the field, allowing the operator to select update times from 10 minutes to 24 hours, in increments of one minute.

2.11.20.3 Static Database

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

2.11.20.4 Static Database Update

A copy of each FEP's static database shall be updated automatically once per day, or upon demand from the OWS database.

2.11.20.5 Workstation Access to Real Time Data

Any workstation shall have access to the real time data. Display of data shall commence within 15 seconds.

2.11.21 Historical Data Storage and Retrieval

A historical data storage and retrieval function shall be provided at the operator workstation to collect and store real-time data from all workstations. This function shall be a general purpose data storage and retrieval function 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, for short-term analysis, and then output the data to the DVD and CD-ROM disk drives for long-term retention. The operator shall also be able to selectively recall short-term data stored on hard disk for presentation on workstation displays in a tabular trend report format. Retrieval and printing of the contents of

any selected historical data file shall be available to any workstation using the supplied data retrieval and report generation program. The report generation program shall decode and format the data. The output of the report generation program shall be capable of being shown on workstation, printed in a report, or stored. Each hard disk file shall be self-defining to allow data elements to be identified and accessed even if changes, additions and deletions have occurred in the real-time database.

2.11.22 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. The Contractor shall provide 128 different sets of engineering unit conversions. Each engineering conversion unit shall include range, span, and conversion equation.

2.11.23 Analog Totalization

Any analog or calculated point shall be operator assignable to the totalization program. Analog values shall be totalized within a given time period. This 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, building, or entire area. 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.

2.11.23.1 Energy Totalization

The program shall totalize energy from various sources. The inputs, such as kWh, \^liters^\ \~gallons~\ of fuel, \^cubic meters^\ \~cubic feet~\ of natural gas, shall be maintained by the system on daily, monthly and annual basis. The data shall be used by other programs and for report generation.

2.11.23.2 Electrical Energy Totalization

Data from the various meters and instrumentation shall be used to collect energy utilization, power factor, voltage and current inputs. The program shall calculate instantaneous power (kW) and reactive power (kvar) and totalize energy consumption (kWh) based on the combination of current, voltage, and power factor inputs provided. The energy usage calculated shall be totalized for an adjustable time period. The time period shall be defined uniquely for each type of parameter to be totalized. The system shall allow the operator to define or modify time periods online. Input and calculated data for each facility, mechanical systems, groups of facilities determined by operator, shall be collected by the system, and used to maintain records and to generate reports.

2.11.23.3 Natural Gas and Fuel Oil Energy Totalization

The system shall calculate the heat energy in to \^Joule,^\ \~Btu,~\ for each energy source consumed by the mechanical systems specified, totalize the calculated \^Joules,^\ \~Btus,~\ the instantaneous rate in \^Joule,^\ \~Btu,~\ and store the data on disk. The \^Joules^\ \~Btus~\ calculated shall be totalized for an adjustable time period. The time period shall be defined uniquely for each \^Joule^\ \~Btu~\ totalization. The system shall allow the operator to define or modify time periods online.

2.11.24 Prediction Software

Prediction software shall be provided having the following characteristics:

a. The prediction software shall perform an extrapolation into the future based on a time series using a minimum of six analog values equally spaced on the time axis.

b. The prediction software shall perform a least squares or parabolic curve fit to obtain an extrapolation into the future.

2.11.25 Electrical Power Demand Limiting

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NOTE: Include in the settings table on the drawings necessary load shed data required to implement the demand limiting program. Demand limiting calculations will be directly correlatable to this family of load shed schedules.
****

The UMCS shall monitor and limit the electrical demand at individual installations using a demand minimization program and a time of day demand limiting program. The demand minimization program shall be activated manually by an operator who will be advised when a utility wide peak is expected, as well as the duration of the peak period. The time of day demand limiting program shall be active at all times in accordance with the re-established seasonal schedules and peak demand limits. The time of day demand limiting program shall use installation electric utility meters and predict an electrical peak demand. When the predicted demand exceeds a preset value, the demand limiting programs shall change equipment operating set points and shed loads on a pre-scheduled step basis to reduce the connected load before the actual electrical demand peak exceeds the target peak demand value.
Examples of electrical power demand limitings are:

2.11.25.1 Standard Demand Limiting Steps-Summer

The electrical power demand limiting program shall assign standard demand limiting steps for HVAC equipment as follows:

a. Split System Air Conditioning Units and Heat Pumps:

Step 1: Reset space temperature upwards (if available).

Step 2: Turn off compressor.

Step 3: Turn off system.

b. Variable Air Volume Air Handling Units:

Step 1: Reset air handling cooling discharge air temperature upward.

Step 2: Minimize air handling unit air flow.

Step 3: Shut off system, including return and exhaust fans.

c. Constant Volume Air Handling Units:

Step 1: Reset air handling cooling discharge air temperature or reset space temperature upwards as shown.

Step 2: Stop chilled water flow to coil.

Step 3: Shut off system, including return and exhaust fans.

d. Heating and Ventilating Units: Shut off system, including return and exhaust fans.

e. Variable Air Volume Terminal Boxes:

Step 1: Reset box discharge cooling air temperature upwards.

Step 2: Minimize air flow.

f. Constant Volume Terminal Boxes: Reset box discharge cooling air temperature upwards.

g. Chillers:

Step 1: Reset chilled water discharge temperature upwards.

Step 2: Limit capacity.

Step 3: Shut off system (including auxiliaries).

2.11.25.2 Standard Demand Limiting Steps-Winter

The time of day demand limiting program shall assign standard demand limiting steps for HVAC equipment as follows:

a. Split System Air Conditioning Units and Heat Pumps:

Step 1: Reset space temperature lower if heating, or reset space temperature higher if cooling.

Step 2: Turn off compressor.

b. Variable Air Volume Air Handling Units:

Step 1: Reset discharge air temperature lower if heating, or reset discharge air temperature higher if cooling.

Step 2: Minimize air handling unit air flow.

c. Constant Volume Air Handling Units:

Step 1: Reset discharge air temperature lower if heating, or reset discharge air temperature higher if cooling .

Step 2: Stop chilled water flow to coil.

d. Heating and Ventilating Units:

Step 1: Reset air handling discharge air temperature lower.

Step 2: Shut off system, including return and exhaust fans.

e. Variable Air Volume Terminal Boxes:

Step 1: Reset box discharge air temperature lower if heating, or reset discharge air temperature higher if cooling.

Step 2: Minimize air flow.

f. Constant Volume Terminal Boxes:

Step 1: Reset box discharge air temperature lower if heating, or reset temperature higher if cooling.

g. Chillers:

Step 1: Reset chilled water discharge temperature higher.
Step 2: Limit capacity.

2.11.25.3 Time-of-Day Demand Limiting Program

The program shall continuously monitor power demand, and with prediction software, calculate a predicted power demand. When the predicted power demand exceeds a preset peak demand value (target), the program shall select and shut off loads on a pre-scheduled priority basis to reduce the connected load before the actual peak exceeds the target. The OWS shall serve to coordinate the actions of the FEPs. The time of day demand limiting program shall shed (turn off) equipment and change equipment operating setpoints at selected locations based on electrical demand. The time-of-day program shall permit a minimum of six summer interval and six winter interval individually definable demand periods in 24 hours for each location. The program shall provide separate time of day demand periods for each weekday, weekends and holidays. The program shall provide for separate peak demand targets for each utility billing cycle and each time-of-day demand interval at each location. This program shall utilize the sliding window method for shedding and changing operating setpoints to prevent exceeding an electrical power demand limit peak value (target). The peak demand value shall be calculated at a minimum of 1-minute intervals.

a. Priority Levels: The time-of-day demand limiting program shall provide five equipment operating steps, 3 summer and 2 winter. Equipment and setpoints in the lowest priority steps shall be shed or reset before loads in the next higher priority step. Loads shed or reset in the higher priority steps shall be restored before loads in lower priority steps.

b. Program Inputs:

(1) Day of week/holiday.

(2) Time-of-day.

(3) Equipment operating and setpoint status.

(4) Equipment constraints.

(5) Maximum temperature override setpoint during occupied periods (cooling season) per individual control point.

(6) Minimum temperature override setpoint during occupied periods (heating season) per individual control point.

(7) Electrical power sliding window demand limit peak value (target) for each individual billing cycle and each time-of-day demand period for each location.

(8) FEP equipment and setpoint lists for each step and each time of day demand period, summer and winter.

(9) Beginning and ending dates of winter and summer billing periods.

(10) Beginning and ending times for each time of day period.

(11) Length of sliding window interval.

(12) Total demand.

(13) Operating setpoint (current).

(14) Beginning and ending dates for each billing cycle.

c. Program Outputs

Step 1: Activation signal.

Step 2: Activation signal.

Step 3: Activation signal (Summer only).

Step 3: Deactivation signal (Summer only).

Step 2: Deactivation signal.

Step 1: Deactivation signal.

2.11.26 LAN Software

A network operating system shall be supplied as part of the LAN software. 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 access control to the workstations. Operators shall be able to perform all specified functions, given the proper passwords, including database definition/modification, graphic creation/modification, and trending.

2.12 STARTUP

2.12.1 Recovery From Power Failure

When a power failure occurs at the workstation or FEP, the system shall automatically start upon restoration of power and the programs shall be restarted in a manner to assure an orderly resumption.

2.12.2 FEP Restart

An FEP restart program based on detection of power failure at each FEP shall be provided. Upon restoration of power to the FEP, the FEP shall restart equipment, and restore loads to the state at time of power failure, or to the state as commanded by time programs or other overriding programs. Start time delays between successive commands to prevent demand surges or overload trips shall be provided.

2.13 DATA COMMUNICATION REQUIREMENTS

UMCS data communications shall support the specified functions and UMCS configuration shown.

2.13.1 OWS/FEP

The OWS shall be able to initiate an upload or download of FEP data and programs.

2.13.2 OWS Network Access via Bridge

Workstation not directly connected to a remote LAN shall be able to communicate with the remote LANs using bridges as specified and shown.

2.13.3 Workstation Network Access via Network Security Call Back Modem

Workstation not directly connected to a LAN shall be able to communicate with remote LAN using the workstation modems and remote LAN security call back modems. All incoming calls shall be logged with time, day, date, duration and caller's identification. All callback connections shall be logged with time day, date, duration and caller's identity.

2.13.4 Workstation Modem Communication

Workstation shall be able to communicate with other computer systems using a modem and dial-up circuit. Workstation shall be able to initiate upload or download of data files, however, the workstation shall not be able to answer any incoming calls (for system security reasons).

2.14 DTS

The contractor shall provide DTS between Operator Workstation and NC as specified for LAN installation. The Contractor shall provide DTS between the NC and FEPs as specified in Section \=16768=\ FIBER OPTIC DATA TRANSMISSION SYSTEM and Section \=16792=\ WIRELINE DATA TRANSMISSION SYSTEM.

2.15 EXTRAORDINARY SUPPLIES

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

a. CD write-able disks	50 each
b. DVD write-able Disks	25 each
c. Diskettes \^89 mm^\ \~3-1/2 inch~\	10 boxes of 10 each
d. Laser Printer Toner Cartridges	5 each
e. Color Printer Ink Cartridges	10 per color
f. Dot Matrix Printer Ribbons	10 each
g. Color Printer Paper	10 boxes
h. Alarm Printer Fanfold Paper	10 boxes

2.16 FACTORY TEST

2.16.1 Factory Test Setup

The Contractor shall 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. Model numbers of equipment demonstrated shall be identical to those to be delivered to the site. Original copies of data produced during the factory test, including results of each demonstration procedure, shall be delivered to the Government at the conclusion of the test, prior to Government approval of the factory

test. The report shall be arranged so that commands, responses, and data acquired are correlated to allow logical interpretation of the data. Surge testing need not be conducted if the Contractor can provide acceptable documented proof that such testing has been satisfactorily demonstrated to the Government with identical surge protection applied. The factory test setup shall include the following:

a. OWS Equipment as specified.

b. Workstations as specified.

c. One NC per DTS type, but not less than two NCs.

d. One Unitary Controller and Universal Programmable Controller of each type used in the proposed system, but not less than two Unitary Controllers, and one Universal Programmable Controller.

e. Test Set.

f. Portable computers for each FEP type as specified.

g. Sufficient I/O functions to demonstrate the I/O capability and system normal operation.

h. Communications circuits of each type and speed to be utilized in the proposed system including bridges, modems, encoder/decoders, transceivers, and repeaters as specified.

i. Surge protection equipment for power, communications, I/O functions, and networks.

j. Software required for proper operation of the proposed system including application programs and sequences of operation.

2.16.2 Factory Test Procedures Package

The Contractor shall deliver the approved factory test procedures package to the Government prior to or concurrent with written notification of the scheduled factory test. The package shall also include the following:

a. Factory test equipment block diagram.

b. Hardware descriptions.

c. Software descriptions.

d. Operator commands.

e. I/O functions with failure modes for test database points.

f. Required passwords for each operator access level.

g. Description of each type of digital and analog point in the test database.

h. List of test equipment.

i. Surge protection circuit diagrams.

j. Inputs required for each application program (I/O point values and status) and corresponding expected results of each set of input values.

k. Default values for the application program inputs not implemented or provided for in the contract documents for the application programs to be tested.

PART 3 EXECUTION

3.1 INSTALLATION REQUIREMENTS

3.1.1 Installation

The Contractor shall install system components and appurtenances in accordance with the manufacturer's instructions and shall provide necessary interconnections, services, and adjustments required for a complete and operable system. Instrumentation and communication equipment and cable grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation. The Contractor shall adjust or replace all devices not conforming to the required accuracies, except those which are factory set and sealed. These factory sealed devices shall be replaced (not adjusted). Wiring in exposed areas, including low voltage wiring, shall be installed in metallic raceways or EMT conduit as specified in SECTION \=16415=\ ELECTRICAL WORK, INTERIOR. Wiring in air plenum areas installed without conduit shall be plenum-rated per \-NFPA 70-\. The existing controls shall remain in operation until the new UMCS panels are ready for cutover. The Contractor shall schedule and arrange the cutover of the new panels to cause the least disruption to the Government. This cutover activity shall be fully coordinated with the Government, and written permission shall be obtained by the Contractor before beginning this work.

3.1.1.1 Isolation, Penetrations of Buildings and Clearance from Equipment

The UMCS shall be completely installed and ready for operation, as specified and shown. 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 \=07270=\ FIRESTOPPING. The UMCS installation shall provide clearance for control-system maintenance by maintaining access space between coils, access space to mixed-air plenums, and other access space required to calibrate, remove, repair, or replace control-system devices. The control-system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.1.2 Device Mounting

Devices mounted in or on piping or ductwork, on building surfaces, in mechanical/electrical spaces, or in occupied space ceilings shall be installed in accordance with manufacturers' recommendations and as shown. Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified. Any deviations shall be documented by the Contractor 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 meters.^\ \~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 one \^pascal^\ \~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.

3.1.2 Existing Conditions Report

The Contractor shall perform a field survey, including testing and inspection of existing equipment and local control loops to be connected to the UMCS, and furnish a report documenting the current status. The Contractor shall verify the operability of all control dampers and valves for all equipment to be operated by the UMCS, and shall identify all inoperable/damaged dampers and valves in the report. For those items considered nonfunctional, the Contractor shall provide (with the report) specification sheets, or written functional requirements to support the findings and the estimated costs to correct the deficiencies. As part of the report, the Contractor shall define the scheduled need date for connection to existing equipment. The Contractor shall make written requests and obtain Government approval prior to disconnecting any controls and obtaining equipment downtime. Existing control loops which are not to be replaced with new UMCS controls shall be inspected, calibrated, and adjusted as necessary to place them in proper operation and to accomplish the required operating sequences as a part of the complete UMCS. Such work shall proceed only after receiving Government approval of these requests. If a local control loop or any device fails after the Contractor has commenced work on that loop or device, the Contractor shall diagnose the failure and perform necessary corrections to the Contractor's equipment and work. The Contractor shall be held responsible for repair costs due to Contractor negligence or abuse of Government equipment.

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NOTE: Designer is to delete if not required by the user.
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3.1.3 Air and Hydronic System Status Report and Balancing

The Contractor shall, as a part of his initial survey for existing conditions report, evaluate and record the air and hydronic flows of the HVAC systems as well as the setpoints of existing instrumentation. A written report, including the field data collected related to air and hydronic system flows, pressures, and temperatures shall be presented to the Government. During replacement of existing control loops with DDC, these flows, pressures, and temperatures shall be maintained if they do not conflict with the requirements of the sequences of operation, ranges and temperature setpoints shown. If such setpoints or conditions cannot be achieved, a written report shall be immediately furnished to the Government prior to further work on the specific HVAC equipment or system. The report shall explain the problem, the recommended solutions to correct the problem, the cost of work involved and time needed to complete the work. After written approval of the report, the Contractor shall resume work on the specific equipment or system.

3.1.4 System Requirements

The Contractor shall use the diagrams, database tables, and operating sequences in conjunction with other specified requirements to identify the hardware and software required.

3.1.5 Utility Metering

Metering and equipment shown shall be interfaced to the UMCS. Utility outages must be carefully coordinated and may be restricted to other than normal working hours or weekends. Contractor shall not interfere with building operations at any time other than scheduled outages.

3.1.6 Instrumentation and Control Diagrams

Framed, non-fading half-size drawings in laminated plastic shall be provided for equipment furnished and for interfaces to existing 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 diagrams and posted beside the diagrams. Proposed diagrams, instructions, and other sheets shall be submitted prior to posting. The instructions shall be posted before PVT begins.

3.1.7 Sequences of Operation

The Contractor shall study the operation and sequence of existing controls, as a part of his existing conditions report, and note any deviations from the described sequences of operation on the contract drawings. The Contractor shall make necessary adjustments to make the equipment operate in an optimum manner, and shall fully document any required changes made. The Contractor shall coordinate the installation of all new equipment to insure continued operation of those items which are to remain.

3.2 INSTALLATION OF EQUIPMENT

The Contractor shall install equipment as specified, as shown and as required in the manufacturer's instructions for a complete and fully operational UMCS.

3.2.1 FEP

FEPs shall be installed in place of existing automatic temperature control panels and other control and monitoring equipment where they exist. Existing equipment not reused as part of the UMCS shall be removed and disposed as directed by the Government. Existing wiring, conduit and tubing that is not reused shall be removed.

3.2.2 Temperature Instrument Installation

3.2.2.1 RTD

When the RTD is installed in pipe or is susceptible to corrosion or vibration, the 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 OA 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 in a manner to allow easy replacement.

3.2.2.2 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.

3.2.2.3 Low Temperature Protection Thermostats

For each \^1.8 square meter^\ \~20 square feet~\ of coil face area, or fraction thereof, a thermostat responding to the lowest \^1 meter^\ \~1 foot~\ length shall be provided to sense the temperature at the location shown. The thermostat sensing element shall be installed in a serpentine pattern.

3.2.2.4 Averaging Temperature Sensing Elements

Sensing elements shall have a total element minimum length equal to \^305 linear mm per square mm^\ \~1 linear foot per square foot~\ of duct cross-sectional area.

3.2.2.5 Thermometers and Temperature Sensing Elements

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

3.2.2.6 Thermocouples

Thermocouples in flues shall be installed in protective tubes or installed 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.

3.2.2.7 Instrument Shelters

Instrument shelters shall be installed in the location shown with the bottom \^1 meter^\ \~4 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.

3.2.3 Relative Humidity Instrument

The relative humidity r.h. sensors shall have air guards when installed in air flows of more than 15 meters per second across the sensor element.

3.2.4 Room Instrument Mounting

Room instruments shall be installed in place of existing space thermostats and humidistats. Existing devices shall be removed and shall become the property of the Government. Where new instruments are required or room instruments are to be relocated, as shown, new room instruments shall be mounted so that their sensing elements are \^1.5 meters^\ \~5 feet~\ above the finished floor unless otherwise shown. Where new room instruments do not completely cover the existing installation, or a room instrument is not installed in the space of a removed device, or the existing wall finish is damaged during construction work of this project, the Contractor shall patch, repair and paint as necessary to match the existing wall finish.

3.2.5 Air Flow Measuring Device at Supply and Return Fans

Probes shall be mounted in fan inlets as shown. In cases where double width double inlet fans are used, air flow probes shall be installed at each inlet. Probes shall be installed in accordance with the probe manufacturer's recommended practices. For double width double inlet installations, where one air flow probe assembly is used on each fan inlet, each like sensing line (static with static, total with total) shall be "tee" connected to produce one resultant signal line for each type of signal input to the flow controller. In instances where vortex dampers are utilized, Contractor shall install cone adapter assembly recommended by probe manufacturer. Plastic tubing shall not be used to connect probes due to turbulent air flows. Where existing air flow measurement stations are reused as part of the UMCS, the Contractor shall inspect, clean, and calibrate existing equipment to insure accurate measurements.

3.2.6 Pressure Instruments

3.2.6.1 Pressure Sensors
Pressure sensors (all types) installed on liquid lines shall have drains. Pressure sensors installed on steam lines shall have drains and siphons. Pressure sensors shall have valves for isolation, venting, and taps for calibration. Pressure sensors shall be verified by calibration. Differential pressure sensors shall have nulling valves.

3.2.6.2 Pressure Switches

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

Pressure switches (all types) installed on liquid lines shall have drains. Pressure switches installed on steam lines shall have drains and siphons. Pressure switches shall have valves for isolation, venting, and taps for calibration. Pressure switches shall be adjusted to the proper setpoint, and shall be verified by calibration. Differential pressure switches shall have nulling valves. Switch contact ratings and duty shall be selected for the application.

3.2.6.3 Duct Static-Pressure Sensing Elements and Transmitters

The duct static-pressure sensing element (tap or pitot tube) shall be located approximately two-thirds of the distance from the supply fan to the end of the duct with the greatest pressure drop. Transmitter shall be located at the nearest accessible point of calibration. Taps shall be provided for transmitter calibration.

3.2.6.4 Control Devices Installed in Piping and Liquid Systems

Gauges and sensors in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock.

3.2.7 Flow Instruments

3.2.7.1 Flowmeters

Flowmeters shall be installed in accordance with \-ASME-18-\.

3.2.7.2 Orifice Plates

Orifice plates shall be located in horizontal pipe runs for liquid flow measurement, and in vertical pipe runs unless otherwise shown for steam flow measurement. For liquid measurement, the orifice plate flanges shall be installed so that the pressure taps are in the horizontal plane with the centerline of the pipe. 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 steam pipe measurement in horizontal pipe runs, eccentric orifice plate flanges shall be installed so that the pressure taps are 45 degrees below, or in the horizontal plane with the centerline of the pipe. Orifice plates shall be installed for ease of accessibility for periodic maintenance. The differential pressure sensors shall be as close to the orifice plates as possible. For gas measurement the required differential pressure transmitter shall be physically installed above the orifice taps. For steam, the required differential pressure transmitter shall be installed a minimum of \^203 mm^\ \`8 inches~\ below the taps. For liquid, the differential pressure transmitter shall be installed below the orifice taps.

3.2.7.3 Flow Nozzles

Flow nozzles shall be installed in horizontal pipe runs with flanges 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. The differential pressure sensors shall be installed as close to the flow nozzle as possible.

3.2.7.4 Venturi Tubes

Venturi tubes shall be installed in horizontal pipe runs for liquid flow measurement, and in vertical pipe runs for steam flow measurement. Venturi tubes shall be installed so that the pressure tap is in the horizontal plane

with the centerline of the pipe. Venturi tubes shall be installed for ease of accessibility for periodic maintenance.

3.2.7.5 Insertion 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 exists.

3.2.7.6 Insertion Turbine Meters

Turbine meters shall be installed without interruption to service. The Contractor shall 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 as recommended by the manufacturer.

3.2.7.7 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.

3.2.7.8 Positive Displacement Flow Meters

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

3.2.7.9 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.

3.2.7.10 Paddle Flowmeter

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

3.2.7.11 Ultrasonic Flowmeter

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

3.2.7.12 Flow Switches

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

3.2.8 Level Instruments

3.2.8.1 Liquid Level Switches

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.

3.2.8.2 Mercury Float Switches

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

3.2.8.3 Liquid Level Sensors

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

3.2.9 Electric Power Devices

3.2.9.1 Potential and Current Transformers

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

3.2.9.2 Watthour and Demand Meters

The Contractor shall install watthour, demand meters, and transducers in new enclosures unless otherwise shown.

3.2.9.3 Transducers

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

3.2.9.4 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 kilowatts.^\ \~5 hp.~\ Applications over \^4 kilowatts^\ \~5 hp~\ shall use a current transducer.

3.2.10 Position Sensors

3.2.10.1 End (Limit) Switch

Limit switch type and mounting shall be properly suited for the application to provide reliable switch operation. Switches shall be positioned to reliably sense the required position.

3.2.10.2 Damper End Switches

Damper end switches and mountings shall be properly suited for the application to provide reliable operation.

3.2.10.3 Potentiometers and Associated Transducers
Potentiometer type and mounting shall be properly suited for the application to provide reliable operation. Transducers shall be matched to the potentiometers type and range to provide a compatible 4 to 20 mA signal to the FEP.

3.2.11 Output Devices

All output devices (transducers, relays, or other devices) not an integral part of the FEP shall be mounted in an enclosure mounted adjacent to the FEP, unless otherwise shown.

3.2.11.1 Relays and Contactors

The Contractor shall install relays and contactors in new enclosures. H-O-A switches and override switches shall be installed so that UMCS controls function through the automatic position and other controls work through the hand position. Safety and fire or life safety interlocks shall function through both hand and automatic switch positions.

3.2.11.2 EP Valve

The Contractor shall install EPs in new enclosures adjacent to the controlling FEP.

3.2.11.3 Controllers

The Contractor shall install controllers in new enclosures.

3.2.11.4 IP Transducer

The Contractor shall install IP transducers in new enclosures adjacent to the controlling FEP.

3.2.12 Miscellaneous Instruments

Miscellaneous instruments shall be installed in accordance with the manufacturer's inspections and as shown.

3.2.13 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.

3.2.14 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. The Contractor shall 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.

3.2.15 Fire Alarm Interface

The UMCS shall interface with the existing fire alarm system where shown, through the use of fire alarm control relays. These relays shall be provided and installed within \^meter^\ \~3 feet~\ of the existing interface point. The UMCS Contractor shall arrange the control system to accomplish the required control sequences as described in response to activation of these fire alarm relays or of local smoke detectors. Wiring of fire alarm control relays and final device testing and adjustment required for proper operation of the final device in response to fire alarm control relays shall be provided as part of the UMCS construction. Fire alarm and smoke control sequences shall operate completely independently of the UMCS and shall not rely on any UMCS logic or FEP components to accomplish the specified actions.

3.2.16 Safeties

All existing safeties shall remain in operation. The Contractor shall coordinate the installation of all new equipment to ensure correct operation of all safeties, in accordance with codes and regulations in effect at the time the work is accomplished.

3.2.17 Wire and Cable Installation

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NOTE: Secure and classified areas should meet requirements of NACSIM 5203 and DIAM 50-3 for cable distribution and wiring.
****

System components and appurtenances shall be installed in accordance with \-NFPA 70-\, manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with \-EIA 606-\. Penetrations in fire-rated construction shall be firestopped in accordance with Section \=07270=\ FIRESTOPPING. Conduits, outlets and raceways shall be installed in accordance with Section \=16415=\ ELECTRICAL WORK, INTERIOR. Wiring shall be installed in accordance with \-EIA 568-\ and as specified in Section \=16415=\ ELECTRICAL WORK, INTERIOR. Wiring, and terminal blocks and outlets shall be marked in accordance with \-EIA 606-\. Cables shall not be installed in the same cable tray, utility pole compartment, or floor trench compartment with ac power cables. Cables not installed in conduit or wireways shall be properly secured and neat in appearance.

3.2.17.1 Horizontal Distribution Cable

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NOTE: Decrease suspension distance for bundled cable. One or two cables can be suspended at 1.5 meters (5 foot) intervals. Delete last two sentences if there are no raised floors.
****

The rated cable pulling tension shall not be exceeded. Cable shall not be stressed such that twisting, stretching or kinking occurs. Cable shall not be spliced. Fiber optic cables shall be installed in either conduit or through type cable trays to prevent microbending losses. Copper cable not in a wireway shall be suspended a minimum of \^[200] [_____] mm^\ \~[18] [_____] inches~\ above ceilings by cable supports no greater than \^[1.5] [_____] m^\ \~[60] [_____] inches~\ apart. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of \^300 mm (12 inches)^\ \~12 inches~\ shall be maintained when such placement cannot be avoided. Cables shall be terminated; no cable shall contain unterminated elements. Minimum bending radius shall not be exceeded during installation or once installed. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered. In raised floor areas, cable shall be installed after the flooring system has been installed. Cable \^[1.8] [_____] meters^\ \~[6] [_____] feet~\ long shall be neatly coiled not less than \^[300] [_____] mm^\ \~[12] [_____] inches~\ in diameter below each feed point in raised floor areas.

3.2.17.2 Riser and Backbone Cable

Vertical cable support intervals shall be in accordance with manufacturer's recommendations. Cable bend radius shall not be less than ten times the outside diameter of the cable during installation and once installed. Maximum tensile strength rating of the cable shall not be exceeded. Cable shall not be spliced.

3.2.17.3 Telecommunication Outlets

a. Faceplates: As a minimum each jack shall be labeled as to its function and a unique number to identify cable link.

b. Cables: Unshielded twisted pair and fiber optic cables shall have a minimum of \^150 mm^\ \~6 inches~\ of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturers bend radius for each type of cable shall not be exceeded.

c. Special Cable Tagging Requirements: Cables installed inside buildings shall be tagged at \^3 meters^\ \~10 foot~\ intervals prior to installation.

d. Pull Cords: Pull cords shall be installed in all conduit serving telecommunications outlets which do not initially have fiber optic cable installed.

e. Terminal Blocks: Terminal blocks shall be mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Industry standard wire routing guides shall be utilized.

3.2.17.4 Unshielded Twisted Pair Patch Panels

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NOTE: Panel and cable density will determine the port and panel quantity in each rack.
****

Patch panels shall be mounted in equipment racks with sufficient modular jacks to accommodate the installed cable plant plus 10 percent spares. Cable guides shall be provided above, below and between each panel.

3.2.17.5 Fiber Optic Patch Panels

Patch panels shall be mounted in equipment racks with sufficient ports to accommodate the installed cable plant plus 10 percent spares. A slack loop of fiber shall be provided within each panel. Loop shall be [\^[900] [_____] mm^\ \~[3] [_____] feet~\ in length.] [provided as recommended by the manufacturer]. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

3.2.17.6 Equipment Racks

Open frame equipment racks shall be bolted to the [floor] [floor slab]. Cable guides shall be bolted or screwed to racks. Racks shall be installed level. Ganged racks shall be bolted together. Ganged rack cabinets shall have adjacent side panels removed. Wall mounted racks shall be secured to the mounting surfaces to prevent fully loaded racks from separating from the mounting surface.

3.2.17.7 Rack Mounted Equipment

Equipment to be rack mounted shall be securely fastened to racks by means of the manufacturers recommended fasteners.

3.2.18 Termination

Cables and conductors shall sweep into termination areas; cables and conductors shall not bend at right angles. Manufacturer's minimum bending radius shall not be exceeded. When there are multiple system type drops to individual workstations, relative position for each system shall be maintained on each system termination block or patch panel.

3.2.18.1 Unshielded Twisted Pair Cable

Each pair shall be terminated on appropriate outlets, terminal blocks or patch panels. No cable shall be unterminated or contain unterminated elements. Pairs shall remain twisted together to within the proper distance from the termination as specified in \-EIA TSB 40-A-\. Conductors shall not be damaged when removing insulation. Wire insulation shall not be damaged when removing outer jacket.

3.2.18.2 Shielded Twisted Pair Cables

Each cable shall be terminated on panel-mounted connectors. Cables shall be grounded at patch panels using manufacturer's recommended methods. Shield braid shall be continuous to connector braid terminator. Wire insulation shall not be damaged when removing shield.

3.2.18.3 Coaxial Cable

Home run type station cables shall be terminated at each end. Backbone cables shall be terminated with appropriate connectors or end-of-line terminators as required. Loop-type cable systems shall be terminated with appropriate drop connectors and terminators as required. Backbone cable shield conductor shall be grounded to communications ground at only one point and shall not make electrical contact with ground anywhere else.

3.2.18.4 Fiber Optic Cable

Each fiber shall have connectors installed. The pull strength between the connector and the attached fiber shall not be less than \^[11.3] [_____] kg.^\ \~[25] [_____] pounds.~\ The mated pair loss, without rotational optimization, shall not exceed [1.0] [_____] db. Fiber optic connectors shall be installed per \-EIA 568-\.

3.2.19 Grounding

Signal distribution system ground shall be installed in the telecommunications entrance facility and in each telecommunications closet in accordance with \-EIA 607-\ and Section \=16415=\ ELECTRICAL WORK, INTERIOR. Equipment racks shall be connected to the electrical safety ground.

3.3 SOFTWARE INSTALLATION

The Contractor shall load software required for an operational UMCS, including databases (for points specified and shown), operational parameters, and system, command, and application programs. The Contractor shall 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.

3.4 SITE TESTING

The Contractor shall 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 each phase of 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 PVT shall not be run during scheduled seasonal off-periods of heating and cooling systems. Testing shall be performed in accordance with approved test procedures developed using \-MIL-STD 2203-\, as a technical and format requirement. The Test Procedures shall cover actual equipment and functions specified fro the project. Additional test procedures for any operational modes or equipment which are not specifically addressed in the MIL-STD shall be prepared by the Contractor, using the same methodology and format as is required by the MIL-STD.

3.4.1 Testing, Adjusting and Commissioning

After the Contractor has received written approval of the Group I data package and 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, the Contractor shall test, adjust, and commission each control loop and system and shall verify proper operation of each item in the sequences of operation, including hardware and software. The Contractor shall 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. Ground rods installed by the Contractor shall be tested as specified in \-IEEE Std 142-\. The Contractor shall calibrate each instrumentation device connected to the UMCS 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. The Contractor shall check each control point within the UMCS control network by making a comparison between the control command at the Workstation and field-controlled device. The Contractor shall

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. The Contractor shall verify operation of systems in the specified failure modes upon UMCS network failure or loss of power, and verify that systems return to UMCS control automatically upon a resumption of UMCS network operation or return of power. The Contractor shall 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.

3.4.2 PVT

The Contractor shall demonstrate that the completed UMCS complies with the contract requirements. Using approved test procedures, based on using \-MIL-STD 2203-\ as a technical and format requirement, all physical and functional requirements of the project including communication requirements shall be demonstrated and shown. The Contractor shall demonstrate that each system operates as required in the sequence of operation. The PVT as specified shall not be started until after receipt by the Contractor of written permission by the Government, based on the Contractor's 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, the Contractor shall deliver test reports and other documentation as specified to the Government.

3.4.3 Endurance Test

The Contractor shall use the endurance test as specified to demonstrate the specified overall system reliability requirement of the completed system. The endurance test shall be conducted in phases as specified. 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. The Contractor shall provide an operator to man the system 8 hours per day during daytime operations, including weekends and holidays, during Phase I and Phase III 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, the Contractor shall commence an assessment period as described for Phase II. Upon successful completion of the endurance test, the Contractor shall deliver test reports and other documentation as specified to the Government prior to acceptance of the system.

3.4.3.1 Phase I (Testing)

The test shall be conducted 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized by the Government in writing. If the system experiences no failures during the Phase I test, the Contractor may proceed directly to Phase III testing after receipt by the Contractor of written permission from the Government.

3.4.3.2 Phase II (Assessment)

After the conclusion of Phase I, the Contractor shall 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, the Contractor shall 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, the Contractor shall demonstrate that failures have been corrected by performing appropriate

portions of the performance verification test. Based on the Contractor's report and the test review meeting, the Government will determine the restart point, and may require that the Phase I test be totally or partially rerun. The Contractor shall 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. If the retest is completed without any failures, the Contractor may proceed directly to Phase III testing after receipt by the Contractor of written permission from the Government.

3.4.3.3 Phase III (Testing)

The test shall be conducted 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized by the Government in writing.

3.4.3.4 Phase IV (Assessment)

After the conclusion of Phase III, the Contractor shall 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, if any deficiencies appeared during Phase III. After delivering the written report, the Contractor shall 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, the Contractor shall demonstrate that failures have been corrected by performing appropriate portions of the performance verification test. Based on the Contractor's report and test review meeting, the Government may require that the Phase III test be totally or partially rerun. The Contractor shall 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 IV assessment shall be repeated as if Phase III had just been completed.

3.4.3.5 Exclusions

The Contractor will not be held responsible for failures resulting from the following:

a. An 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 UMCS performed as specified.

b. Failure of a Government furnished communications link, provided that the FEP 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.

c. Failure of existing Government owned equipment, provided that the failure was not due to Contractor furnished equipment, installation, or software.

3.4.4 Opposite Season Test

During the warranty period, but not later than 6 months from completion of the endurance test, the Contractor shall conduct a 10 day opposite season test using \-MIL-STD 2203-\ as a technical and format guide to demonstrate that the UMCS functions properly during the opposite climatic season such as summer or winter. Test reports and other documentation as specified shall be delivered to the Government. The Contractor shall conduct specified training at this time.

3.5 TESTING WIRE AND CABLE

Materials and documentation to be furnished under this specification are subject to inspections and tests. All components shall be terminated prior to testing. Equipment and systems will not be accepted until the required inspections and tests have been made, demonstrating that the signal distribution system conforms to the specified requirements, and that the required equipment, systems, and documentation have been provided.

3.5.1 Unshielded Twisted Pair Tests

All metallic cable parts shall be tested for proper identification and continuity. All opens, shorts, crosses, grounds, and reversals shall be corrected. Correct color coding and termination of each pair shall be verified in the communications closet and at the outlet. Horizontal wiring shall be tested from and including the termination device in the communications closet to and including the modular jack in each room. Backbone wiring shall be tested end-to-end, including termination devices, from terminal block to terminal block, in the respective communications closets. These test shall be completed and all errors corrected before any other tests are started.

3.5.2 Category 3 and Category 5 Circuits

[Twenty five percent of the installed Category 3 circuits, selected on a random basis,] [and] [All Category 5 circuits] shall be tested using a test set that meets the Class II accuracy requirements of \-EIA TSB 67-\ (Draft) standard. Testing shall use the Basic Link Test procedure of \-EIA TSB 67-\. If more than 5 percent of the Category 3 circuits tested fail, then all Category 3 circuits shall be tested. Cables which contain failed circuits shall be replaced and retested to verify the standard is met.

3.5.3 Shielded Twisted Pair

Wiring configuration shall be tested for continuity, opens, shorts, swaps and correct pin configuration; dc resistance both pair-to-pair and wire-to-shield shall be verified. Cable lengths shall be verified. Near end crosstalk shall be tested from 722 kHz to 300 MHz. Ground potential difference between wiring closets, ground path resistance shall be tested per \-IBM GA27-3361-07-\.

3.5.4 Coaxial Cable

Cable shall be tested for continuity, shorts, and opens. Characteristics impedance shall be verified over the range of intended operation. Cable length shall be verified. Cable shall be sweep tested for attenuating over the range of intended operation.

3.5.5 Fiber Optic Cable

Unless stated otherwise, tests shall be performed from both ends of each circuit. Connectors shall be visually inspected for scratches, pits, or chips and shall be reterminated if any of these conditions exist. Each circuit leg and complete circuit shall be tested for insertion loss at [850 and 1300] [1310 and 1550] [_____] nm using a light source similar to that used for the intended communications equipment. High-resolution optical time domain reflectometer (OTDR) test shall be performed from one end of each fiber. Scale of the OTDR trace shall be such that the entire circuit appears over a minimum of 80 percent of the X-axis.

3.6 RELIABILITY CALCULATION

This exponential calculation depends on the test duration and assumes that the Mean Time Between Failures (MTBF) does not change after each repair; and that the probability of failure is constant throughout the useful life of the component regardless of how many failures the system has experienced. This calculation does not account for effects of aging.

3.6.1 Definition of Reliability

System reliability is calculated in terms of overall MTBF where the component reliability furnished by vendors is already expressed as MTBF. The mathematical combination of the component MTBF values is defined as the system reliability, R(t); the probability that the system will perform its function during a given time period under specified conditions. In this calculation, each component reliability is determined; the component reliabilities are combined as dictated by the system configuration; and the overall MTBF is computed as follows:

R(t) = e(-t/MTBF); where:

MTBF = mean time between failure

t = duration of test period

e = base of natural logarithms

When t/MTBF is less than 0.1, the reliability can be approximated as follows:

R(t) = 1 - (t/MTBF)

A specific reliability value can be interpreted by noting that a value of R(t) greater than 1/e (which equals 0.37) indicates that the MTBF value is greater than the test duration.

3.6.2 Series and Parallel Components

Components are in series if failure of one component causes a system failure. Reliability of components in series is a product of the individual reliabilities:
R = 1 - (r1)(r2)(r3). . .(rn)

If components in a system are redundant (parallel), reliability is computed as follows:

R = 1 - { (1-r1)(1-r2). . . (1-rn)}

If a system has parallel components, an equivalent series reliability is computed for each set of parallel components. The reliability of the system is then computed as the product of series and equivalent series reliabilities.

3.6.3 Calculation Procedure

The Contractor shall prepare a table showing the following data:

a. Name and quantity of each component.

b. Identify each component as series or parallel. (For example, if there are 2 printers, the failure of 1 will not cause a system failure).

c. MTBF for each component.

d. Single unit reliability: R = e(-t/MTBF), where t = 1,000 hour test period.

e. Total Component Reliability (TCR) where TCR = Rn, and n = number of components. For parallel components, TCR = 1 - (1-R)n, where n = number of components.

f. Cumulative Reliability (CUMR) is the product of total component reliability; for example:

CUMR 4 = (TCR1) (TCR2) (TCR3) (TCR4) = (CUMR3) (TCR4)

g. Cumulative MTBF = -1,000/LN (CUMR); where LN (CUMR) is the natural logarithm of (CUMR).

As an example: CUM.MTBF = -1,000/LN (CUMR4)

3.6.4 Sample Calculations

MTBF is not calculated for sensors and controls. I/O functions are part of the FEP. Any I/O failure not attributable to sensors and controls constitutes an FEP failure and is thus reflected in the FEP MTBF. MTBF for other components are based on the lowest values provided by vendors. The MTBF of a Workstation is assumed to be 16,000 hours. The numbers of components for the UMCS configuration are as follows:

Workstation	2
Network LAN Equipment - one of each	1
Network Security Call Back Modem	1
Network Controller	1
Unitary Controller	2
Universal Programmable Controller	2
I/O Functions	90

-- End of Section --