

SECTION 23 09 00 – ELECTRIC CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The General provisions of the Contract, including General, Supplementary and Special Conditions, the Owner's policy concerning the Executive Order Compliance and Division 1 - General Requirements, apply to work specified in this section. Subcontractor must familiarize himself with the terms of the above documents.

1.2 QUALITY ASSURANCE

- A. Refer to paragraph "Acceptable Manufacturers" for acceptable pre-qualified temperature control sub-contractors for the work specified in this section.
- B. Installers Qualifications: Firms specializing and experienced in electric control system installations for not less than 5 years.
- C. Codes and Standards:
 - 1. Electrical Standards: Provide electrical products (line voltage) which have been tested, listed and labeled by UL and comply with NEMA standards.
 - 2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric control systems.
 - 3. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
 - 4. NEMA EMC1 - Energy Management Systems Definitions.
 - 5. ASME MC85.1 - Terminology for Automatic Control.
 - 6. NEMA ICS1 - Industrial Control and Systems.
 - 7. UL Compliance: Provide control system listed under UL 916 for Control of Mechanical Systems and Temperature Regulating Systems.
 - 8. NFPA Compliance: Comply with NFPA 70 "National Electrical Code."

1.3 DESCRIPTION OF WORK

- A. Provide all controls and instrumentation work necessary for the construction of the project as indicated on the Drawings and specified herein. Such work includes, but is not limited to the following:
 - 1. The system of electronic temperature controls utilizing microprocessor-based digital controllers shall include all controlled equipment as shown on drawings, herein specified, and as shown on point list.
 - 2. Provide control and interface panels and all necessary transducers, EPU's, relays, switches and other devices for the complete control system as specified herein.
- B. The work included under this section of the specifications and drawings includes the complete installation of an electronic temperature control system utilizing digital controllers.

- C. The point list identifies those points that are to be addressed by the digital controller and incorporated into the new electronic, stand-alone temperature control system.
- D. The system of automatic temperature control shall be furnished and installed as required for proper control of the HVAC equipment and shall include the furnishing and installation of all equipment materials and labor necessary for or reasonably incidental to the complete control system, and if shown but not specified or if specified but not shown shall be provided as though delineated in both specifications and drawings.
- E. The contractor is to furnish and install a complete temperature control system including all necessary hardware and all operating and applications software necessary to perform the control sequences of operation as called for in this specification.
- F. The contractor is to obtain and pay for all necessary construction permits and licenses.
- G. The Drawings and Specifications are not intended to show all details. The Contractor is to secure satisfactory information before submitting the proposal and include in the proposal a sum sufficient to cover all items of labor and material required for the complete installation of the devices and systems described.
- H. All work performed under this Section of the Specification shall comply with all codes, laws and governing bodies. If the Drawings and/or Specifications are in conflict with governing codes, the Contractor shall submit a proposal with appropriate modifications to the project to meet code restrictions. If this Specification and associated drawings exceeds governing code requirements, this Specification shall govern.
- I. The Contractor shall execute his work in such a manner as to minimize down time and prevent delays in the scheduled completion date.

1.4 COORDINATED WORK

- A. This Contractor shall cooperate with other contractors performing work on this project as necessary to achieve a complete neatly fitted installation for each condition. To that end, each contractor shall consult the drawings and specifications for all trades to determine nature and extent of others' work.
- B. It shall be the duty of the Contractor to work in cooperation with the owner and other contractors and so arranging his work that the entire project will be delivered complete in the best possible condition by the scheduled completion date.

1.5 CLEAN-UP

- A. This Contractor shall maintain the premises in an orderly fashion at all times during the construction period. He shall remove all cartons, containers, crates, etc., as soon as their contents have been removed and he shall also remove all debris, caused by his work daily. All cartons, debris, etc., shall be removed from the site and premises at the sole expense of the Contractor.
- B. At the completion of the work, the Contractor shall clean all of his work, equipment, etc., free from dust, etc., and leave the work in good housekeeping fashion in a manner acceptable to the Owner.

1.6 SUBMITTALS

A. Shop Drawings: Provide shop drawings for both the hardware and applications software to be utilized in the temperature control system. The following is a minimum submittal requirement:

1. Hardware:

- a. Include a complete bill of material of equipment used indicating quantity, manufacturer and model number and other relevant technical data.
- b. Include manufacturer's description and technical data, such as, performance curves, product specification sheets and installation/maintenance instructions for the items listed and other items relevant but not listed below:

- 1) Digital Controller
- 2) D/A and A/D Converters
- 3) Power Supply
- 4) Sensors
- 5) Batteries
- 6) Relays/Switches
- 7) Control Panels
- 8) Flow Switches

- c. Provide complete coded interconnection wiring diagrams for each electrically operated piece of equipment. Show all termination and wiring numbers.
- d. Provide schematic wiring diagrams for each control panel. Show all terminations and wiring numbers.
- e. Provide schematic wiring diagrams for all field sensors and controllers.

2. Software:

- a. Provide a complete description of the applications programming language and instructions on how to program and reprogram any portion of the system.
- b. Provide programming flow diagrams of the applications software.
- c. Include a complete description of the operation of the temperature control system including sequences of operation.
- d. Provide line-by-line applications software utilized to accomplish the control strategies called for in this specification.
- e. Provide the control loop algorithms/calculations proposed.
- f. Provide a digital controller point list including both inputs and outputs indicating I/O point number, the controlled device associated with the I/O point and the location of the I/O device.
- g. Provide other documentation not listed above if deemed necessary by the Owner or Engineer to enable understanding of the applications software and algorithms proposed for proper functioning of the control system.

3. General:

- a. No construction may begin until shop drawings are approved by the Engineer for conformity with the plan and specification design intent.
- b. Quantities of items submitted will not be reviewed by the Engineer, and is the responsibility of the Contractor.
- c. When manufacturers cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project will be highlighted or clearly indicated by other means.

- d. Provide to the Engineer any additional information or data which the Engineer deems necessary to determine compliance with these specifications or which he deems valuable to the Owner in documenting the system to be installed.
- B. Construction Record Documents: At the completion of the work, the Contractor shall submit three (3) revised signed and certified sets of documents as construction record documents. Construction record documents should include significant departures from the Contractor's originally approved documents or the Engineer's documents.
1. Construction record documents to be submitted are those listed under shop drawings pertaining to both hardware and software.
 2. Construction record documents for software also requires that the Contractor supply to the Owner the project software in storage on written/paper form and on floppy disc.
- C. Operating and Maintenance (O&M) Manuals: Four (4) O&M manuals shall be submitted for approval and shall include the following, at a minimum, bound in four (4) ring hardback binders after system acceptance.
1. Names, addresses and telephone numbers of Contractors installing equipment and systems and the service representative for the system.
 2. Shop drawing hardware and software submittals as well as construction record documentation if not duplication of shop drawing submittals.
 3. Complete descriptions on the maintenance of all system components including sensors, controllers, actuators, etc. The descriptions shall include inspection, periodic preventative maintenance suggestions, system/component failure and diagnosis and the procedure for repair or replacement of defective components.
 4. Definitions of terms utilized where applicable and necessary for complete Owner understanding of the installed system.

1.7 START-UP/TESTING

- A. Prior to testing and verifying proper system operation, the Contractor shall furnish the Owner and Engineer, for acceptance, two (2) copies each of the start-up/testing procedure proposed. The Owner and Engineer must approve the check-out procedure prior to start-up/testing.
- B. Submittal of the start-up/testing procedure must be submitted one (1) calendar month prior to the projected construction completion date.
- C. After the procedure is approved and after installation is complete and systems are ready to be placed in regular service, the Contractor shall notify the Owner of this fact in writing.
- D. On the start-up date, the Contractor will have on-site qualified field technicians to place the system in operation, making such tests, adjustments and changes as may be found necessary to insure successful operation of the equipment and systems.
- E. The Contractor is to test and verify proper operation for each control loop.
- F. Each control loop check will verify that the digital controller, watch dog circuit, automatic/manual switch, fail-safe control and electric interlocks are operating as intended to accomplish the control strategy.
- G. Sensor calibrating/operation will be tested to verify that they are operating and within the performance parameters established in this specification.

- H. Each input and output shall be checked to verify that correct terminations/designations of I/O are in place.
- I. Communications to the digital controller shall be tested and verified that it is in working order.
 - 1. On-site communications to the digital controller will be tested as well as on-site communications to the controller.
- J. Proper operation of all on-site operator interface hardware shall be tested to verify proper operation.
- K. Downloading of applications programs will be tested both from on-site and off-site locations to verify proper operation of downloading procedure.
- L. Reports/trend logs will be retrieved to verify proper operation/format.
- M. All tests will be documented by the Contractor and certified verifying that the tests have been performed and that all deficiencies have been corrected.
 - 1. All testing must be performed and all deficiencies corrected to the Owners satisfaction.
- N. At the end of the start-up/testing, if equipment and systems are operating satisfactory to the Owner and Engineer, the Owner shall sign certificate certifying that the systems operation has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of guaranty.

1.8 GUARANTY

- A. The control systems specified shall be guaranteed free from defects, workmanship and material under conditions for a period of fifteen (15) months after acceptance by the Owner. Any equipment herein described proven to be defective in workmanship or material during guarantee period shall be adjusted, repaired or replaced at no charge to the Owner.
- B. During the guarantee period, software updates/digital controller improvements, i.e., microprocessor chip changes, shall be provided to the Owner at no charge. Written authorization by the Owner must, however, be granted prior to the software or digital controller hardware updates.

1.9 TRAINING

- A. Within one (1) week after the temperature control systems has been accepted by the Owner, the Contractor will provide a minimum of four (4) hours of training at the site of the Installation for Owner designated personnel on the operation and maintenance of the system installed. Training sessions shall be limited to four hours per day and two days per week.
- B. The Instructor(s) shall be competent and have full knowledge of the system installed and will provide training specifically oriented to the Owner's installed system.
- C. The training shall utilize the operating and maintenance manual provided for the system as the reference manual and the training will include, at a minimum, the following:
 - 1. Description of the overall control system configuration and physical layout indicating location of all sensors and controlled devices.

2. Description of the control strategies being utilized at the installation.
 3. Description of all the key hardware components utilized in the system.
 4. Instructions on how to communicate with (command and monitor) the systems digital controller.
 5. Description of the programming instructions required to use the system.
 6. Description of the requirements to retrieve alarm and trend log formats and how to react to alarm conditions.
 7. Description of diagnostic trouble-shooting techniques for the entire system.
- D. One (1) month after the initial training program is conducted, a second training session shall be held at the site of the installation. This session shall be a minimum of four (4) hours in length, and will be held to refresh the Owner's designated operating personnel in the items listed under paragraph C above. This session will also provide the Owner designated operating personnel an opportunity to question the instructor after some experience with the system has been gained.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide electric control system of one of the following:
1. Johnson Controls Metasys System.
 2. Siebe Controls.
- B. Substitutions: Bidder desiring approval of material or equipment not specified may submit request for approval under provisions of section 23 01 00. Submittals shall include the following in addition to section 23 01 00 requirements:
1. Written description of system proposed.
 2. Block diagram of complete system architecture as applicable to this project. Include all communications trunks along with their associated communication rates.
 3. Hardware and performance specifications for each system component.
 4. Complete description of local area network including hardware requirements and performance data.
 5. A list of no less than five projects similar in size and types of systems being controlled which are on-line and in full operation.
 6. Resumes of the project manager, applications engineering staff, and electronics technicians proposed for project. Include training, expertise, and work history. Provide phone numbers for service calls along with proposed response time for on-line and on-site service.

2.2 GENERAL

- A. The function of this section is to establish a minimum quality of hardware to be provided, a minimum quality of installation and to establish equipment or equipment configurations to be utilized for standardization.
- B. All work installed by the temperature control contractor shall be done in a neat and workmanlike manner as determined by the Owner, and acceptable standards for this type of work.

- C. The temperature control contractor will provide hardware as specified to meet all system performance requirements. Should hardware be required to meet the specified system performance which is not specified herein, the contractor shall follow procedures established in the General Conditions.
- D. Where two (2) or more units of the same class of equipment are required, these units shall be products of a single manufacturer; however, the component parts of the system need not be the products of a single manufacturer.
- E. The digital controller system materials and installation will be addressed in three sections:
 - 1. System Controller.
 - 2. Field Equipment.
 - 3. Wiring.

2.3 ARCHITECTURE

- A. Diagram shown on the drawings shows the major hardware components which will form the digital control system. This diagram is included for clarification purposes only and is not intended to dictate a specific control system configuration.
- B. The following terms, when used in this section, will be as defined here.
 - 1. Digital Controller: A microprocessor-based controller supplied by an approved manufacturer. The term digital controller will be used to designate a package of equipment as supplied by the manufacturer.
 - 2. System Controller: A digital controller plus associated equipment. The term system controller will be used to designate a specific group of equipment which will be supplied either as part of the digital controller package or supplied independently to meet the system controller specification.
 - 3. Field Equipment: Equipment through which the system controller will interface with the facilities environmental, mechanical, and electrical systems.

2.4 BAS NETWORKS

- A. Wide Area Network:
 - 1. Under this project a Web Browser based wide area network controller shall be installed in Boettcher Hall. The web based controller shall be a Johnson Controls Metasys NAE 55 controller and shall communicate with all other metasys controllers on campus and to a wide area network. Provide controller with BACnet MS/TP communications trunk, N2 communications trunk, and a Lonworks communications trunk.
 - 2. The Building Automation System (BAS) hardware and software must communicate with the existing BAS throughout including Legacy type Controllers. Communication shall include exchanging full data between all buildings on the network. Alarms, historical trending, and changes of value shall be E-mailed or faxed via the Intranet/Internet. Historical trending and changes of value shall display 1-8 points on a single graph.
 - 3. The new system naming schemes shall be consistent with current naming schemes throughout.
 - 4. The Intranet connection must be Ethernet with TCP/IP Addresses for each panel (controller). Interface existing products via BACnet and provide gateway to Legacy controllers. The BAS through the wide area network shall display, monitor, edit, modify and command all points/objects on all controllers in all buildings on the network. The

BAS shall provide immediate access to all points/objects in each building. The new BAS must facilitate a graphical interface.

5. The new BAS shall provide password protection consistent with the owners wide area network.
6. The new graphics must be compatible with and able to transfer to the Web Browser Software.
7. Modems or telephone connections shall not be permitted.

B. Architecture:

1. The network architecture shall consist of no more than 2 levels. A high level local area network (LAN) shall support Supervisory DDC controllers and BAS operator workstations and a low level LAN shall support unitary DDC controllers.
2. The network shall be modular and have the inherent ability to be expanded and modified without having to remove and replace existing equipment.
3. The high level LAN and low level LAN communication shall be transparent to the BAS operator. All I/O points residing on either LAN shall be global and be shared between both LANs.
4. Design the BAS to eliminate dependence upon any single device for alarm reporting and control execution. Each controller shall operate independently by performing it's own control alarm management and historical data collection.

C. General:

1. Provide separate and dedicated networks for BAS use only. Do not use a network that shares or serves other building systems.
2. Communication between the high level and low level LANs shall be through DDC controllers that are connected to both LANs.
3. Communication throughout the BAS shall use an open protocol. Provide protocol(s) and associated documentation to the Owner for future use by competitors to develop a communication interface with the BAS.
 - a. If the BAS trade will not disclose information, all networks, controllers and communication within the BAS, shall support and comply with ASHRAE 135 (BACnet) to provide interoperability with a multiple vendor and multiple protocol system(s). Demonstrate compliance of this requirement.
 - b. The Building Automation System (BAS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BAS shall not be limited to only use of open communication protocol standards, but be able to also integrate a wide variety of third-party devices and applications via existing vendor protocols and through the latest software standards.
4. Avoid the use of repeaters to amplify electronic signals. With Architect/Engineer approval, limited use is acceptable only on the high level LANs, and only if there is no other options.

D. High Level LAN:

1. Use an industry standard IEEE 802 protocol with commonly available, multiple source network equipment and products.
2. Data transfer and communication shall operate at a speed of at least 2.5 mega bits per second.
3. Ethernet is the preferred network, however, other technologies will be considered. If the Owner has standardized on another type of LAN for office automation, use that type for the BAS.
4. Provide for a combined total of at least 50 Supervisory DDC controllers and BAS operator workstations.
5. Provide for multiple user communications and multiple session activity.
6. BAS operator workstations and Supervisory DDC controllers shall reside on the high level LAN, with communications directly between controllers, directly between workstations, and between controllers and workstations, on a peer to peer basis.

7. Use supervisory DDC controllers, for control of the following primary systems and equipment:
 - a. Chilled Water Systems.
 - b. Heating Hot Water Systems.
 - c. Air-handling units and roof-top units over 20 tons.

- E. Low Level LAN:
 1. Limit the use of the low level LAN to data transfer and communication between unitary DDC controllers.
 2. Data transfer and communication shall operate at a speed of at least 76,000 bits per second.
 3. Limit the use of unitary DDC controllers to the following HVAC equipment:
 - a. Variable Air Volume Units.
 - b. Power Ventilators.
 - c. Booster Coils.
 4. Connect VAV unit DDC controllers to the same DDC controller serving the VAV units' respective air-handling system.

- F. BAS Operator Interfaces:
 1. Access:
 - a. Access to the BAS networks, through a computer workstation, or notebook computer shall not limit the BAS operator to availability of data.
 - b. The hardware configuration of the BAS networks shall be transparent to the BAS operator when accessing data.
 - c. If not already provided as a part of the BAS design, provide an easily accessible, properly protected and labeled high level LAN communication port in each mechanical equipment room. The communication port shall provide for connection of either a computer workstation or a notebook computer.
 2. Computer Workstations:
 - a. Connect workstations to the high level LAN through a communications port directly on the LAN or through a communications port on a DDC Controller.
 - b. Workstations shall be able to communicate with any device connected to either the high level or low level LANs.
 3. Notebook Computers:
 - a. Connect notebook computers to the high level LAN through a communications port directly on the LAN or through a communication port on a DDC Controller.
 - b. Connect notebook computers to the low level LAN through a communication port on a unitary DDC Controller.
 - c. Notebook computers shall be able to communicate with any device connected to either the high level or low level LANs, regardless of the location of the physical connection to the BAS.
 - d. The notebook computer shall provide monitoring, programming, scheduling, setpoint adjustments and reporting capabilities of I/O connected anywhere in the BAS. Provide dynamic graphic displays on notebook computers that are identical to the workstations.

2.5 SYSTEM CONTROLLER

A. General:

1. The temperature control contractor will supply a system controller which is capable of meeting or exceeding the performance requirements as specified under this section.
2. The temperature control contractor will supply a sufficient number of system controllers to meet the input/output capacity requirements and shall supply a sufficient number of system controllers such that none is overloaded from a control standpoint.

- a. Overloaded is defined as a condition where the system controller cannot update all input values, calculate control outputs and execute all control within five (5) seconds.
3. Supply a dedicated 120 volt/1 phase, 20 amp circuit to power the system controller. Provide a service disconnect at the system controller. Provide surge protection for the power circuit.
 4. The system controller shall be enclosed in a rigid enclosure, with baked enamel finish, hinged access door and keyed latch. Digital controllers meeting this criteria may be directly mounted.
 5. When the digital controller qualifies for direct mounting, remaining components to complete the system controller shall be mounted in the field interface panel.
 6. When the digital controller is to be mounted in a contractor supplied enclosure, all components classified under system controller shall be mounted in a common enclosure.
 7. The system controller shall be labeled using one inch plastic engraved tags. Every component forming the system controller shall be labeled using 1/2 inch plastic embossed tags. Every termination within the system controller shall be labeled with mechanically fabricated or mechanically printed letters, numbers, etc., which exactly corresponds to as-built drawings.
- B. Enclosure:
1. The contractor supplied enclosure shall be of rigid construction with baked enamel finish, NEMA Type 1, have a hinged door with keyed lock. The enclosure shall be sized for twenty (20) percent spare mounting space. The lock shall be keyed consistent with the field interface panels.
- C. Digital Controller:
1. The digital controller shall be supplied by a pre-approved manufacturer and shall be of the designation, model or type listed.
 2. These units shall be the latest version available including the most updated software and hardware offered by the manufacturers and shall include:
 - a. Supervisory DDC Control Unit.
 - b. Unitary DDC Controllers - all VAV terminal units, air handling units, hot water system, chilled water system, etc..
 - c. IBM PS/2 software:
 - 1) Standard machine third party interface
 - 2) Graphic programming language
 3. Supervisory DDC controller through which all other digital controllers communicate shall maintain full communication to all other controllers and the network monitoring terminal at all times.
 4. Supervisory DDC Control Unit: A 16 bit microprocessor based controller providing a multitasking/multi-user operating system. The complete software library for this project shall reside in the ROM memory of the controller. All programming including applications programs, defined functions, and point database shall be protected from loss due to power failure with non-volatile memory. Modifications to the software database shall be accomplished while the controller is on-line. Controllers shall utilize true floating point arithmetic capabilities. Units with input/output capabilities may be utilized as an Unitary DDC Controller in addition to its network supervision requirements. Units shall have a built-in keypad/terminal or shall be provided with a portable terminal for program modification. All units shall be UL listed under UL 916 for control of mechanical systems and temperature regulating systems.

5. Unitary DDC Controller: An Unitary DDC Controller shall be a 16 bit microprocessor based standalone DDC controller capable of monitoring and controlling all input and output points of a specific system. An Unitary DDC Controller shall be capable of performing its specified control responsibilities independently of other controllers in the network. Each Unitary DDC Controller shall have sufficient memory to support its own operating system and data base and shall directly interface to a portable service terminal. All programming including application programs, defined functions, and point database shall be protected from loss due to power failure with non-volatile memory. Multiple Unitary DDC Controllers shall not be used to control a single system unless they communicate through a true Peer-Peer communications protocol in which loss of communication between them and the Supervisory DDC controller does not cause loss of communication between Unitary DDC Controllers. The minimum communication rate between Unitary DDC Controllers and Supervisory DDC controllers shall be 9600 Baud.
6. Processor Speed: The minimum acceptable processor speed for direct digital controllers shall be as follows:
 - a. Supervisory DDC Controllers - 8MHz.
 - b. Unitary DDC Controllers - 5MHz.
7. Input/Output Electrical Protection:
 - a. All analog inputs/outputs and digital inputs and outputs shall be protected at minimum to withstand 120 volts AC continuously without damage to the digital controller.
 - b. This includes any input/output supplied whether or not it will be utilized in meeting this specification.
8. Field Input/Output:
 - a. Provide, at minimum, digital input, digital output, analog input, and analog output point capacity as follows:
 - 1) Basic requirements: Per input/output summary.
 - 2) Spare capacity: 1 from each block of eight.
9. Memory:
 - a. The microprocessor-based digital controllers shall contain both random access memory (RAM) and read only memory (ROM). All the operating programs (systems' monitor) for the digital controller shall be ROM or PROM, i.e., memory resident operating system. Application software programs and strategies to accomplish the desired sequence of operation and other requirements shall be random access memory (RAM) resident. Bulk storage devices such as disks, tapes, etc., shall not be allowed/used in an interactive "on-line" mode.
10. Provide a sufficient memory capacity for all applications programs specified in this Section plus 100 percent future growth.
11. Communications Section:
 - a. Supervisory DDC controllers shall communicate with each other and the network monitoring terminal through a Local Area Network.
 - b. Supervisory DDC controller shall have a serial or parallel communication port for printer alarm reporting which shall be EIA RS232C or RS422 compatible.

D. Digital Controller Power Supply:

1. When this power supply may create problem heat for the digital controller, it may be mounted in the field interface panel or separately in it's own enclosure.

E. Battery Backup:

1. Provide battery backup to the memory and real time clock such that a loss of house service power of up to 24 hours will not cause any program loss or loss of the time. The battery shall be rechargeable and automatically be recharged after a power outage.
2. Provide circuitry to eliminate erratic operation due to low battery charge, sensing battery performance to execute an orderly shutdown before the electronic minimum operating point is reached.
3. Upon restoration of power, the system controller will automatically resume its operating functions.

F. System Integrity Checks:

1. The digital controller will have circuitry to continuously check for system integrity. This will include such items as hardware/software checks and watch dog timers. Should the digital controller fail any of these integrity checks, all controller outputs will go to a failsafe value.

2.6 FIELD EQUIPMENT

A. General:

1. All field interface devices, where practical, will be mounted in the field interface panel. All other field interface devices will be mounted at the point of field interface in a separate enclosure suitable for the location. When the manufacturer provides an enclosure/packaging of the device or sensor which protects the device from dust, moisture, conceals integral wiring and moving parts, this enclosure will be acceptable.
2. Every field interface device and every field termination will be labeled using words, letters or numbers with permanent mechanically fabricated or printed tags exactly corresponding to as-built drawings.

B. Field Interface Panel:

1. General:
 - a. Mounted within the field interface panel will be power supplies for sensors, interfacing relays and contactors, output point logic override for safety pneumatic to electric transducers, output status indication, etc.
 - b. Where shown on the plans, the field interface panel will be firmly attached to a permanent wall or it shall be freestanding.
2. Enclosure:
 - a. Supply an enclosure of all steel construction with baked enamel finish, NEMA, Type 1 rated with a hinged type door and keyed lock or equivalent rigid construction. The enclosure shall be sized for twenty (20) percent spare mounting space.
3. Terminations:

- a. All wiring to and from the field interface panel will be to screw type terminals. Analog or communications wiring may use the field interface panel as a raceway without terminating.
 - b. All wiring within the field interface panel will be run in plastic wiring duct to give a neat and workmanlike appearance.
4. Output Status:
- a. Every output shall have a visual indication of it's status. Binary outputs will use a light emitting diode (LED). Electrical analog outputs will use either a voltmeter or ammeter.
 - b. All output status indication will be amounted in a common location within the field interface panel on a sub-panel. Provide sufficient room for all used and all spare outputs. Each output will be properly labeled.
5. Pulse Width Modulation to Continuous Analog Output:
- a. Where called for, provide equipment to convert a binary output from pulse width modulation to a continuous analog signal. Binary to electric will be through the use of a stepping motor potentiometer arrangement.
- C. Analog Inputs:
- 1. The temperature control contractor shall provide equipment for analog sensing as indicated in the point list. This will include the sensor, signal conditioning equipment and wiring.
 - 2. Sensors and signal conditioning equipment provided shall be of the type which are universally accepted in the industry, can easily be second sourced and could be utilized with the majority of Digital Controller manufacturer's equipment.
 - 3. Transducers may be supplied as an integral unit with the field sensor, mounted separately from the sensor, in a field interface panel or be packaged as part of the Digital Controller providing specified sensing accuracy is achieved. All transducers shall be calibrateable.
 - 4. Transduced analog signals shall be of one of the following forms: 4-20 MA, 0-5V, or 0-10V. Frequency modulated signals will not be allowed.
 - a. Exception: Direct thermister input to the Digital Controller for A to D conversion and software linearization will be acceptable.
 - 5. Sensor and transducer selection shall be appropriate for the duty and mounting location including but not limited to the following items:
 - a. The sensor/transducer will be appropriately packaged for the location.
 - 1) Architectural housing for space wall mounting.
 - 2) Weatherproof/sunshield housing for outside mounting.
 - 3) Thermal well housing for water applications.
 - 4) Dust and physical protective housing for duct mounting.
 - b. The sensor/transducer will be appropriately selected to withstand ambient conditions.
 - 1) Moisture or condensation where it is a factor.
 - 2) Vibration from ductwork, equipment, etc.

- 3) Reasonably expected transient conditions such as temperatures, pressures, humidities, etc., outside the normal sensing range.
- c. The sensor/transducer will be appropriately selected to most closely match the expected sensing range.
 - d. The system shall maintain the specified end-to-end accuracy throughout the warranty period from sensor to Digital Controller read-out.
 - e. Temperature Sensors: Temperature sensors will be by the use of thermistors or RTD's. Thermocouples or solid state temperature sensors will not be allowed.
 - f. Space temperature applications with a range of 50 to 120 degrees F. within plus or minus 0.5 degrees F. Sensor shall have built-in setpoint potentiometer.
 - g. Duct temperature applications with a range of 25 to 130 degrees F within plus or minus 0.5 degrees F. Averaging type temperature sensors shall utilize a resistance sensing element incorporated in a copper capillary of 20 feet.
 - h. Outside air temperature applications with a range of minus 20 to plus 100 degrees F within plus or minus 1.0 degrees F. Sensor shall be available for outdoor or duct mounting.
 - i. Water temperature applications with a range of 30 to 100 degrees F. within plus or minus 0.5 degrees F; the range of 100 to 250 degrees F within plus or minus 1.0 degrees F; and applications for the purpose of performing BTU calculations using differential temperatures to within plus or minus 0.15 degrees F.
 - j. Pressure Sensors: Differential pressure sensor shall vary the output voltage with a change in differential pressure. The sensor shall be connected to the remote controller by means of a three-wire unshielded cable.
 - 1) Space Static Pressure: Pressure sensor shall have a range of .1 inches WC with an accuracy of plus or minus .5 percent of range.
 - 2) Duct Static Pressure: Pressure sensor shall have a range suitable for the specific application with an accuracy of plus or minus 1 percent of range. Differential pressure sensors used in laboratory exhaust applications shall be constructed of type 316L stainless steel and shall be UL listed under UL 913 Class 1, Division 1 standards.

D. Analog Outputs:

1. The temperature control contractor shall provide equipment for analog outputs as indicated in the point list. This will include digital to analog conversion and wiring to the controlled device. When required, the analog output signal must be fed back as an analog input. When hardware feedback is not required, the output will be software estimated.
2. All controlled devices which are to be modulated are to receive analog signals of one of the following forms: 4-20 MA, 0-5V, or 0-10 volt.
3. Digital to analog converters shall be packaged as part of the digital controller and have a minimum resolution of 8 bits plus sign for 256 levels of control.
4. Alternate Method #1: The following method of conversion of a pulsed digital output to an analog signal may be employed.
 - a. Electric: Pulsed motor/potentiometer rated for a minimum of 5 million operations and be able to respond to input impulses of less than .2 second duration.
5. Alternate Method #2: The following method of conversion of a pulsed digital output to an analog signal may be employed.

- a. Electric: The actuated device may be directly controlled from the digital controller provided that the digital controller in conjunction with the controlled device can give a minimum of 50 levels of control.

- 1) This method of control cannot be used when analog feedback is required.

E. Digital Inputs:

- 1. The temperature control contractor shall provide equipment for digital inputs as indicated in the point list.
- 2. All digital inputs will be electrically isolated from the digital controller either by optical isolation or relays.
 - a. When relays are used, transient suppression shall be placed across the relay contacts.
- 3. All digital inputs will be provided by dry contacts single pole double throw. The contacts will be wired normally open or normally closed as required.
- 4. Pulse Accumulation: For pulse accumulation, provide a buffered input port which will totalize pulses between interrogations. The pulse accumulator shall accept rates up to ten (10) pulses per second.
- 5. Pressure Switches: Pressure switches shall have a repetitive accuracy of plus or minus one (1) percent of their operating range and shall withstand up to 150 percent of rated pressure. Sensors shall be diaphragm or bourdon tube. Switch actuation shall be adjustable over the operating pressure range. Switch shall have a snap-action SPDT contact rated for the application. Switch contacts shall be wiping contacts and shall have adjustable differential setting. Differential pressure switches shall be Dwyer 1630 Series with Operating ranges between 0.05 to 12 inches, W.C.
- 6. Control Relays: Control relay contacts shall be rated for the application, with SPDT contacts, enclosed in a dustproof enclosure. Relays shall have silver cadmium contact with a minimum life span rating of one million operations.

F. Digital Outputs:

- 1. The temperature control contractor shall provide equipment for digital outputs as indicated in the point list.
- 2. All digital outputs will be electrically isolated from the digital controller either by optical isolation or relays.
 - a. When relays are used, transient suppression shall be placed across the coils.
- 3. All digital outputs will be provided by dry contacts single pole double throw. The contacts will be wired normally open or normally closed as required.
- 4. Equipment Start/Stop: Equipment on/off control shall use either momentary relays or magnetic latching relays as appropriate for the equipment control starter.

G. Controlled Devices:

- 1. Control Valves: Provide factory-fabricated electrical control valves of type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature rating of piping system. Except as otherwise indicated, provide valves which mate and match material of connecting piping. Equip control valves with control valve motors, and with proper shutoff ratings for each individual application.

- a. Water Service Valves: Equal percentage characteristics with range of 50 to 1, and maximum full flow pressure drop of 5 PSIG.
 - b. Valve Trim and Stems: Polished stainless steel.
 - c. Packing: Spring-loaded Teflon, self-adjusting.
 - d. Terminal Unit Control Valves: Provide control valves for control of terminal units including, but not necessarily limited to, convectors, finned tube radiation, and fancoil units that are of integral motor type. Provide modulating type valves.
2. Dampers: Provide automatic control dampers as indicated, with damper frames not less than formed 13 ga galvanized steel. Maximum damper section size shall be 48"x72" with larger damper installed in sections with appropriate jack shafting. Provide mounting holes for enclosed duct mounting. Provide damper blades not less than formed 16 ga galvanized steel, with maximum blade width of 8". Equip dampers with motors, with proper rating for each application.
- a. Secure blades to 1/2" diameter zinc-plated axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Provide blade bearings of nylon and provide thrust bearings at each end of every blade. Construct blade linkage hardware of zinc-plated steel and brass. Submit leakage and flow characteristic, plus size schedule for controlled dampers.
 - b. Operating Temperature Range: From -20°F to 200°F.
 - c. For standard applications, provide parallel or opposed blade design. For proportional or modulating control applications, provide opposed blade design. For mixing applications, provide parallel blade design. Dampers shall be designed to operate in systems having velocities up to 3,000 FPM and shall have stainless steel seals along top, bottom and sides of frame and butyl rubber seals along each blade. Dampers shall be rated for leakage at less than 10 cfm/sq. ft. of damper area, at differential pressure of 4" w.g. when damper is being held by a torque of 5.0 inch-pounds.
3. Dampers and Valve Motors: Size each motor to operate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified.
- a. Provide permanent split-capacitor or shaded pole type motors with gear trains completely oil-immersed and sealed. Equip spring-return motors, where indicated on drawings or in operational sequence, with integral spiralspring mechanism. Furnish entire spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - b. Motors for outdoor locations shall be completely weatherproof, and capable of normal operation at -20°F.
 - c. Actuators may be of the push-pull or rotating type for either modulating or two-positioning control. Actuators shall stroke by a rotating motion of an overload-proof synchronous motor. Control voltage shall be either 24V AC or 0-20V DC as required by the application.

H. Thermostats:

1. Low-Temperature Protection Thermostats: Provide low-temperature protection thermostats of manual-reset type, with sensing elements 20'-0" in length. Provide thermostat designed to operate in response to coldest 1'-0" length of sensing element, regardless of temperature at other parts of element. Support element properly to cover entire duct width. Provide separate thermostats for each 25 sq. ft. of coil face area or fraction thereof.

- I. Smoke Detectors:
 - 1. Duct Mounted Smoke Detectors: Duct Mounted Smoke Detectors are provided as work of Division 26.
- J. Contactors, Relays, and Switches:
 - 1. Electric Contactors: Provide contactors for operating or limit- control of electric heating loads which are UL-listed for 100,000 cycles of resistive loads. Equip with replaceable molded coils and replaceable silver cadmium oxide contacts. Coat core laminations with heat-resistant inorganic firm to reduce core losses. Provide line and load terminals on contactors with higher-than-35-amp rating, or provide one-piece formed-and-welded pressure type. Provide screw-type contactors for 35-amp-or-lower rating. Equip field-mounted contactors with suitable steel enclosures; and provide open-type mounting for those installed in factory- fabricated panels.
 - 2. Water Flow Switches: Provide water flow switches of stainless steel or bronze paddle types. Where flow switches are used in chilled water application, provide vapor-proof type to prevent condensation of electrical switch. Provide pressure-flow switches of bellows actuated mercury type or snap-acting type, with appropriate scale range and differential adjustment for service indicated.
 - 3. Flow switches shall be of the paddle type equipped with SPOT contacts to establish proof of flow. Flow switches shall be of the vapor proof type similar to a McDonnell Miller FSS-V.

2.7 WIRING

- A. All devices in the digital temperature control panel or remote shall be final connected under this Section.
- B. Wire:
 - 1. General:
 - a. All power wiring, class 1, 2 or 3 wiring and communications wiring required for satisfactory installation and operations of all equipment required on this project for the section of work specified under temperature control shall be supplied and installed by the Temperature Control Contractor (TCC).
Exception: When specifically specified to be provided by another trade.
All wiring shall be installed in accordance to wiring specifications found in Division 26 and those found in this section.
Note: Should any discrepancy be found between wiring specifications in this Division 23 and Division 26, wiring requirements of Division 23 will prevail for work specified in Division 23.
 - b. All wiring shall be installed in accordance with all applicable electrical codes and shall comply with equipment manufacturer's recommendations.
Exception: When specifically specified materials or installation methods exceed applicable electrical codes and equipment manufacturer's recommendations.
 - c. The TCC shall be responsible for all required permits for his work.
 - 2. Raceway System:

- a. All wiring shall be installed in a complete conduit raceway system of a minimum trade size of 1/2 inch. Conduit shall be installed continuous from terminal to terminal and shall be mechanically and electrically connected. The entire system shall be grounded.
 - b. Conduits passing from the building exterior to interior or passing between conditioned and non-conditioned spaces shall be sealed to prevent condensation in the conduit.
 - c. Conduits crossing building-expansion joints shall be provided with expansion fittings and flexible grounded bonds by-passing the fittings to insure ground continuity.
3. Wire and Cable
- a. All wire shall be copper and meet the minimum wire size and insulation class listed.

Wire Class	Min. Wire Size	Min. Insulation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge	600 Volt
Class Two	18 Gauge Stranded	300 Volt
Class Three	18 Gauge Stranded	300 Volt
Communications	Per Manufacturer	Per Manufacturer
 - b. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit. Power and Class One may not be run together with Class Two and Three or communications.
 - c. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per NEC.
 - d. All sensor wiring shall have a 100 percent grounded shield.
 - e. All sensor wiring shall use crimped or soldered connections. Wire nuts are not allowed.
 - f. Conduit, in finished areas, shall be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction.
 Exception: Metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.
 Note: Finished areas include offices, hallways, restrooms, etc.
 - g. Conduit, in non-finished areas where possible, shall be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exposed conduit shall run parallel to or at right angles to the building structure.
 Note: Non-finished areas include equipment rooms; such as HVAC equipment, telephone equipment, batteries, work shops, janitorial closets, etc.
 - h. Identify all control/signal wires with labeling tape using either words, letters or numbers that can be exactly cross-referenced with as-built drawings.
 - i. Pull spare control cables as noted on drawings.

PART 3 - EXECUTION

3.1 GENERAL

- A. The temperature control contractor will supply an approved digital controller complete with all required hardware and software to meet the minimum requirements specified for each of the four areas of performance.
 - 1. Building system control.
 - 2. Alarming/monitoring.
 - 3. Operator interface.
 - 4. Data collection and formatting.

- B. In meeting these performance specifications, the temperature control contractor will provide a total system of a configuration.
 - 1. Compatible with good industry practice.
 - 2. Composed of components meeting minimum hardware quality specified.
 - 3. Compatible with specified system architecture.

3.2 BUILDING SYSTEM CONTROL

- A. Hardware:
 - 1. Provide all hardware required to meet the control strategies and performance described in this section.
 - 2. Provide control inputs and outputs as checked and noted, and as shown on the input/output summary forms. These include:
 - a. 1 form for the central chiller plant.
 - b. 1 form for the central boiler plant.
 - c. 1 form for each air handling unit.
 - d. 1 form for all miscellaneous equipment.
 - 3. For each input point, provide required field hardware of the type described in this specification and interface to the system controller.
 - 4. For each output, provide a controlled device as required and as described in this specification to allow for proper control of the point.
 - 5. Upon detection of a digital controller failure, outputs will default to a failsafe value.
 - 6. Each output loop will consist of the following:
 - a. Primary Controller: An approved digital controller including all software to meet system performance requirements.
 - b. Watch'Dog Circuit Decision: A means of detecting digital controller failure.
 - c. Failsafe: The default control output when a control loop component fails or power is lost. The concept of failsafe shall be followed through each component of the control loop.
 - d. Automatic/Manual Circuit Decision: A means whereby automatic control can be overridden by operating personnel.
 - 1) Provide an automatic/manual switch for each digital output.
 - e. Output Indication: Each digital output of the system controller will have visual status of the control level to the operator through the use of a light source. Each analog output of the system controller will have visual status of the control level to the operator through the use of meters or gauges.

- f. Electrical Interlocks for all control - Safety type interlocks. Including but not limited to smoke control, fire shutdown, freeze thermostats, safety included by equipment manufacturer, etc.
- g. Controlled Device: Field equipment required for proper control of an output point.
- h. Primary Feedback: Control feedback specifically to the digital controller and listed in the input/output summary.

B. Building Temperature Control Software:

1. General:

- a. Provide all software required to meet the control strategies and performance described in this section.
- b. All software shall be turned over to the Owner complete and ready for operation. All operator entered parameters shall be entered as shown. When not indicated, submit a written request for values to the engineer.
- c. The format that is used to present the software requirements is only a means of conveying the required information as simply and concise as possible. Software need only meet the performance requirements.
- d. Applications software may be contractor generated or factory generated and may be stored in RAM or ROM type memory. Factory or contractor generated software shall be such that contractor or owner can modify programmed sequences with knowledge of the appropriate password. When factory supplied programs are supplied in ROM which do not meet or exceed these specifications, they will be abandoned and new programs will need to be written and supplied by the contractor.
- e. Use, at minimum, all of the program inputs specified for each application program. Where the specified program inputs are not available, provide a "default" value to replace the missing input, thus maintaining the integrity of the algorithm used.
- f. Where operator parameters are required, they shall need to only be entered once. They shall be easily examined with a simple command and easily modified using a simple command.

2. Control Equation:

- a. The digital controller output response will be generated by a software-based control equation in which any combination of inputs, user entered parameters, or the outputs of other software-based control equation can serve as input variables.

C. All control outputs will be of one of the following forms:

- 1. Two State Control: Will be used when that which is to be controlled (in a closed loop control this is what we are sensing for feedback) is only to be in one of two states. The output of the system controller will either be a maximum value or zero.
Example: Exhaust Fan
Desired Fan Status On-Off (Digital)
Possible Fan Status On-Off (Digital)
Control Signal Two State
- 2. Proportional Plus Integral Control: Will be used when that which is to be controlled (in a closed loop control this is what we are sensing for feedback) can be at any value from zero to maximum and the controlled device can be at any position or output value from zero to maximum. The output of the system controller will be proportional to the control loop input plus a constant times the summation of the control error between the setpoint and actual, over a time period.
Example: Heating Valve

Desired Output 0-100% (Analog)
Possible Output 0-100% (Analog)
Control Signal PI

3. Pulse Width Modulation: Will be used when that which is to be controlled (in a closed loop control this is what we are sensing for feedback) can be any value from zero to maximum but the controlled device can only be a zero or maximum value. The output of the system controller will be at maximum for a percentage of some cycle time. This percentage will be proportional to the control loop input plus a constant times the summation of the control error between the setpoint and actual over time. Include minimum on and off times when rapid equipment cycling could be detrimental to equipment.

Example: Single State Electric Heat
Desired Output 0-100% (Analog)
Possible Output On-Off (Digital)
Control Signal PWM

3.3 MONITOR/ALARM-INPUT/OUTPUT

- A. The temperature control contractor will provide both the hardware and software required to monitor points listed in the input/output summary.
- B. Provide software as described in this section completely programmed such that when turned over to the Owner, all alarming functions will be available to the Owner without additional programming.
- C. Upon the input of a simple command, the operator will be able to examine the status or value of any input/output. All analog values examined will be in correct engineering units and all binary inputs/outputs will be indicated as open/closed, on/off, low/high, etc.
- D. Each analog input point will be assigned maximum and minimum operating or expected value. When the sensed variable exceeds the assigned operating range, an alarm will be generated.
- E. The commanded state of each binary output will be compared to the actual state. If these are not the same, an alarm will be generated. Time delays will be provided as required to prevent false alarms.
- F. Alarms shall be classified as either critical or informational.
- G. Critical alarms will output in the following manner.
 1. The digital controller will dial out to a designated phone number after being acknowledged by a terminal. A printed alarm message will be sent to the designated terminal giving time, date, location and alarm description. This message shall consist of up to fifty (50) characters.
 2. A similar alarm message to that sent off site will appear on the local access terminal.
 3. A binary output will energize a light and horn located at the field interface panel. A silence switch shall be provided for the horn. The alarm will only be manually reset. If reset and the silence switch is on, the horn will be activated until the silence switch is returned to its normal position.
- H. Both critical and information alarms will be stored in memory and will be available through an operator command.

3.4 OPERATOR INTERFACE

A. General

1. The temperature control contractor will provide both the hardware and software required to provide ease of use to the operator.
2. Provide software as described in this section completely programmed such that when turned over to the Owner, all functions will be available to the Owner without additional programming.

B. English Language:

1. All data which will be output for the benefit of the operator or which will be input by the operator will be comprised of standard ASCII characters.
2. Numerical values shall be followed by appropriate units; such as: °F, °C, PSI, etc.

C. Password:

1. A minimum of three (3) levels of access to the system software shall be provided. Level One will allow review of all operating parameters and all inputs and outputs. Level Two will allow modification of any user entered parameter plus all access granted to level One. Level three will allow the user to perform any programming function plus all access granted to Levels one and two.

D. On-Line Programming:

1. The user will be able to generate new software while the digital controller is performing control functions.

3.5 DATA COLLECTION AND FORMATTING

A. The temperature control contractor will provide both the hardware and software required to provide operator logs.

B. Provide software as described in this section completely programmed such that when turned over to the Owner, these logs will be available to the Owner without additional programming.

1. Point Summary: Will print out every currently programmed point showing:
 - a. The descriptive name.
 - b. Current analog value or current digital state.
2. Trend Log: Set up a trend log for every input and output point to record, at minimum, the last thirty (30) values. Time intervals shall initially all be set at two (2) minutes; however, they may be user changeable up to one (1) hour.
3. Alarm Log: Set up an alarm log which will print the last thirty (30) alarms giving time, date, description and location.
4. Daily Report: Set up a software program which will be able to initiate any alarm log, trend log, or point summary on a time programmed weekly basis. Allow for up to four (4) reports per day. Preceded report with time and date.

3.6 CONTROL STRATEGY

- A. The program or software that will initiate the remote enunciation through network communications to communicate with the remote terminal until the alarm report is received and/or acknowledged automatically by the remote terminal. During this communication activity, other temperature control functions and activities of the Supervisory DDC controller shall not be affected and shall continue to function and operate on a real time basis. Additionally, all or any current and/or pending alarm condition(s) detected and sensed, shall not affect the current and/or programmed activities of the Supervisory DDC controller with regards to other control, monitoring and/or alarm functions. The Supervisory DDC controller shall continue to execute and/or implement all software and programs loaded into it irrespective of whether an alarm condition(s) is detected, or whether the Supervisory DDC controller is trying to automatically communicate with a remote terminal. The computer will continue to communicate and report until the report or data has been received by the remote terminal.
- B. It will be the responsibility of the temperature control contractor to provide the following:
 - 1. Temperature control programs to accomplish the desired sequence of operation as indicated. These computer programs shall be provided to the Architect/Engineer for approval with the hardware submittals. The responsibility will remain with the temperature control contractor to modify the program to accomplish the desired sequence of operation.
 - 2. The new digital temperature control panel shall be:
 - a. Completely user programmable and setpoints alterable; user programmable to mean allowing the user to completely alter and/or change operating strategies, program and/or software algorithms, operating programs and setpoints.
- C. The temperature control contractor shall provide the programs or software necessary to implement all sequence of operations, methods, alarm programs, etc., needed in this project.

3.7 APPLICATION PROGRAMS: PROVIDE SOFTWARE TO ACCOMPLISH THE FOLLOWING

- A. Perform all functions specified in the I/O summary tables by use of the appropriate application programs.
 - 1. Program Inputs: Use all of the program inputs specified for each application program to calculate the specified program output(s). Where the specific program inputs are not available (no status indication called for in the I/O summary table), provide a "default" value to place the missing input, thus maintaining the integrity of the algorithm used.
 - 2. Analog Commands:
 - a. Setpoint Adjustment: using an AO or DO in conjunction with an AI signal from the sensed media, achieve changes in operating setpoints via electric transducers actuators.
 - b. Position Adjustment: Provide position adjustment as specified by using an AO or DO in conjunction with an AI signal from a controlled device to close the control loop.
 - 3. Analog Monitoring: The system shall measure all analog values specified in the I/O summary tables including calculated analog points, and shall express analog values in proper engineering units with sign.
 - 4. Data Environment Restart: Provide a DE restart program based on detection of power failure. Upon restoration of power to the DE, restart all equipment and restore all loads to the state at time of power failure or to the state as commanded by time programs or other

- overriding programs. Provide appropriate time delays to prevent demand surges or overload trips.
5. Failure Mode: Provide a "watch-dog" timer function for detection of failures. Upon detection of system failure, force all outputs to a predetermined state, consistent with the control device interfacing with the DE.
 6. Device Operation: All control devices connected to the system shall have memory resident constraints checked before each command or CPA is issued to insure that no equipment damage will result from improper operation.
 7. Time Programs: Time programs shall automatically be initiated based on pre-established time schedules for those items specified. Provide capacity to control on/off and event initiation times for each day of the week (Monday through Sunday). Provide an additional time program(s) for holidays. To eliminate power surges, the system shall enter an adjustable time delay between consecutive start commands generated by the time program for electrical loads over 20 horsepower or 50 kw.
 8. Event Programs: Event programs shall be manually or automatically initiated based on events, either hardware or software derived.
 9. Scheduled Start/Stop Program: Provide software to start and stop equipment based on the time of day and day of week including holidays. The program shall monitor the controlled equipment status to verify that the start and stop command has been carried out (and provide the system with an alarm when the equipment does not start or stop, fails, or is locally started or stopped). The schedule start/stop program shall operate in conjunction and be coordinated with optimum start/stop, day/night setback, ventilation/recirculation and lighting control programs. The software requirements are:
 - a. Program Inputs:
 - 1) Day of week.
 - 2) Time of day.
 - 3) Summer or winter operation.
 - 4) Equipment constraints.
 - b. Program Outputs:
 - 1) Start signal.
 - 2) Stop signal.
 10. Supply and exhaust fans
 - a. Optimum start/stop program inputs:
 - 1) Time of the day (occupied or not occupied).
 - 2) Day of the week.
 - 3) Summer or winter.
 - 4) Space temperature(s).
 - 5) Space temperature setpoints (min & max).
 - 6) Outside air temperature.
 - b. Provide software to start and stop separately the supply and exhaust fans based on the time of the day and day of the week including holidays if the engineer determined to be applicable. The program shall continuously monitor the controlled equipment to verify that the start and/or stop commands have been carried out. The start/stop program shall operate in conjunction and be coordinate with the ventilation/recirculation, cooling, heating, refrigeration, etc. programs.
 - c. Program outputs:

- 1) Start signal.
 - 2) Stop signal.
11. Day/Night Setback Program: Provide software to reduce the heating space temperature setpoint or raise the cooling space temperature setpoint during unoccupied hours. The program shall close outside air dampers when the equipment operates during the unoccupied periods. The day/night setback program shall be operated in conjunction and coordinated with the scheduled start/stop and optimum start/stop programs. The software requirements are:
 - a. Program Inputs:
 - 1) Day of week.
 - 2) Time of day.
 - 3) Summer or winter operation.
 - 4) Space temperature.
 - 5) Minimum space temperature during unoccupied periods.
 - 6) Maximum space temperature during unoccupied periods.
 - b. Program outputs:
 - 1) Day/night control signal.
 - 2) Open/Close OA damper control signal.
12. Economizer Program: Provide software to reduce the HVAC system cooling requirements when the outside air dry-bulb temperature is less than the return air dry-bulb temperature. When the outside air dry-bulb temperature is greater than the return air dry-bulb temperature the outside air dampers, return air dampers, and relief air dampers shall be positioned to provide minimum required outside air. When the outside air dry-bulb temperature is below a changeover temperature of 58°F, the outside air, return air and exhaust air dampers are positioned to maintain the required mixed air temperature. The software requirements are:
 - a. Program Inputs:
 - 1) Changeover dry bulb temperature.
 - 2) Outside air dry bulb temperature.
 - 3) Return air dry bulb temperature.
 - b. Program outputs:
 - 1) Automatic - minimum outside air damper analog control signal.
13. Ventilation and Recirculation Program: Provide software to reduce the HVAC system thermal load during warm-up or cool-down cycles prior to occupancy of the building. The outside air damper shall remain closed for warm-up and cool-down cycles occurring during unoccupied periods. During building occupied periods the outside air, return and relief dampers shall be under local loop control. During summer operation, when the outside air temperature is cooler than the space temperature, the outside air temperature is warmer than space temperature the outside air and exhaust air dampers shall open and the fans shall be energized. During winter operation, when the outside air and exhaust air dampers shall open and the fans shall be energized. The program shall operate in conjunction and be coordinated with scheduled start/stop and optimum start/stop programs prior to building occupancy. The software requirements are:

- a. Program Inputs:
 - 1) Day of week.
 - 2) Time of day.
 - 3) Summer or winter operation.
 - 4) Occupancy schedules.
 - 5) Outside air dry bulb temperature.
 - b. Program Outputs:
 - 1) Automatic-close damper analog control signal.
14. Outside, exhaust and return air damper control - for constant volume systems in equipment buildings.
- a. Program inputs:
 - 1) Outside air temperature.
 - 2) Return air temperature.
 - 3) Mixed air temperature.
 - 4) Discharge air temperature.
 - 5) Summer or winter (change over temp.)
 - 6) Mixed air temperature setpoint.
 - 7) Discharge air temperature setpoint.
 - b. Outside air temperature of 55°F and below the dampers will modulate and positioned, using PI strategy, to maintain the desired mixed air temperature setpoint. Cooling requirement will be from outside air alone. The mixed air setpoint will be calculated setpoint as resetted by return air temperature.
 - c. Outside air temperature above 55°F the dampers will now be under the control of the discharge air temperature setpoint, and will be positioned and modulated using PI strategy to provide the required discharge air temperature. If outside air alone cannot provide the required discharge air temperature setpoint, refrigeration will be started to augment the cooling requirements. At this time, the outside air and the exhaust air dampers will remain open until the outside air enthalpy exceeds the return enthalpy or indicated by other conditions to close, where upon the dampers will close to minimum position.
 - d. The dampers (exhaust/outside) will remain close if the fans are off.
 - e. The stages of refrigeration will be energized one at a time to meet the required discharge air temperature setpoint.
 - f. All sensor points and setpoint will be continuously monitored by the controller and will update itself automatically.
 - g. The programs controlling, the other pieces of equipment will be made consistent with the program.
 - h. Program outputs.
 - 1) Modulating or pulse width signal using PI strategy to exhaust, outside and return dampers.
 - 2) Minimum damper position signal.
 - 3) Call for refrigeration signal.
15. Systems Reports: The system shall be capable of outputting reports through its own communications channel to a compatible terminal directly connected to its communications port and to a remotely located compatible ASCII terminal, i.e. Teletype 43 keyboard/CRT/printer, either singly or in combination or Texas Instruments "Silent

700" printer/keyboard combination through telephone automatic dial-up capability. This reporting capability shall be upon operator request from the direct connected or remotely located compatible terminal, or when triggered by pre-programmed events or times as described in the various sequence of operations. All reports from the system whether activated automatically or in response to an operator request from a remote compatible ASCII terminal shall be preceded by an approved identification scheme followed by the text of report. As a minimum, these reports shall consist of the following:

- a. Every 3-hour readings of all input and output points in the system during occupied times only. The initial 3-hour time span between all input and output points scans shall be fully changeable/alterable to other time spans by software or program modification. The readings shall be whatever sensed conditions, i.e. temperatures, on/off status, humidity, enthalpy, refrigeration, etc., at each respective points identified in the system. All reporting shall be done automatically without operator assistance. If during the time of reporting the remote terminal is communicating with other temperature control systems homing into the same terminal, the temperature control system shall initiate a pre-programmed sequence to keep on calling/communicating until the information/report is transmitted and receipt acknowledged by the remote terminal.
- b. History Report: Upon operator request from a remote compatible ASCII terminal or keyboard, provide a record of the following:
 - 1) Highest and lowest sensed value from all points over the operating time of the temperature control system.
- c. Input/Output Reports: Print the value or state of a specified input and/or output and/or group of inputs and/or outputs in standard engineering units as may be applicable. The particular input and/or output shall be fully identified in the report.
- d. Alarm Reports: Print an english language - based message(s) indicating the occurrence of pre-programmed alarm condition(s). The message(s) shall be fully changeable and/or alterable by software modifications in its entirety. Each alarm message shall consist of a minimum of 50 ASCII characters.
- e. Error Report: Print a historical record of errors encountered in running the required self-test diagnostics and a record of power interruptions.
- f. Over-ride Reports: Print a listing of those inputs and outputs that are currently overridden. The listing shall contain overrides due to use of the output hand-off-auto switches as well as overrides initiated via the operators terminal.
- g. Trace: Print a record of the operation of given control sequence.
- h. System Integrity Tests: The unit shall continuously perform discrete tests to verify the performance of its CPU and memory (both RAM and ROM). These tests shall be performed in background and shall determine whether a fault has occurred. These shall include:
 - 1) Performance checks on the CPU.
 - 2) Correctness of data/programs stored in ROM.
 - 3) Correctness of application programs stored in RAM.
- i. ROM Check: This background test shall validate check sums maintained for each 2K of ROM. If an error is detected, it shall be logged.
- j. RAM Integrity Checks: As each drum control decision is processed, it shall be checked to insure data validity before execution of a control decision. If an error is detected, the condition shall be logged and the line exempted from further processing.

END OF SECTION 23 09 00