SECTION 15971 - DIRECT DIGITAL CONTROL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

Edit paragraphs A & B for each project as applicable.

A. The Contractor shall become aware of the Method of Procedure requirements outlined in Division 1. Change orders will not be considered for time associated with Method of Procedure requirements.

B. General: The Control System Contractor shall provide a complete new modified control system using new control devices to replace existing devices to operate as specified. The contractor shall inspect the existing conditions prior to submitting a proposal. The existing temperature control system control devices, dampers, operators, wiring, conduit, air piping, valves, etc. not being modified and which are no longer utilized, shall be removed, and not abandoned in place.

1. All temperature control devices to be removed shall be returned to the Owner in good condition.

C. The Control Contractor will be responsible for all installation, programming, commissioning, testing and performance verification.

D. The Controls Contractor will be responsible for providing all devices required for a complete operating control system.

E. It shall be a digital, distributed microprocessor-based system with a pneumatic and electronic interface, where required. The Control System for this project will be referred to as a Building Automation System (BAS).

F. Total quantity and type of control points shall consist of specifications, drawings and as required to complete the sequence of operation as specified. Additional points shall be provided as required to meet all sequence of operation functions, safeties and data base. The drawings and Specifications are not intended to show all details necessary to make the system complete and operable.

G. The Control Contractor shall be responsible for all phases of software design, all equipment, installation and warranty for the BAS. The Control Contractor shall be responsible for supplying and installing all necessary control devices for completing the BAS.

H. The system shall include all control device, valves, interlocks, field devices, hardware, software, automatic dampers, piping, fittings, wire, conduit, etc., as specified and required and connected so as to perform all functions and operate according to the specified sequences.

*** Edit paragraph below for applicable projects.***

I. The Contractor shall leave operable existing controls in operation until the BAS is tested and proven operative. At that point, and with concurrence from the Owner and the Engineer, the Contractor shall be responsible for removing existing controls that are no longer necessary. Start-up of the BAS system, and any installation work that requires the interruption of the normal operation of any piece of equipment, shall be scheduled with the Owner. If the

interruption of the normal operation of any piece of equipment during normal working hours is unacceptable to the Owner, then it shall be scheduled during after hours (night or weekend).

~~1.~~ ~~The premium labor costs associated with off hour work shall be included as part of the contract. Change orders for off hour work will not be considered.~~

J. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner or Architect/Engineer in writing. Unless approved otherwise, all products (including firmware revisions) used in this installation shall have been used in at least twelve (12) projects prior to this installation. The previous sites may be located anywhere in the U.S.A. This requirement is not intended to restrict the Contractor to the use of any outdated equipment. Therefore, all products used in this installation shall also be currently under manufacture and have available, for at least ten years after completion of the contract, a complete line of spare parts. If the above requirements are mutually exclusive, the Contractor shall include a specific statement to this effect in the Bid.

K. Refer to other Division 15 sections for installation of instrument wells, valve bodies and dampers in mechanical systems.

L. Provide electrical work as required, complying with requirements of Division 16 sections including, but not limited to raceways, wires, cables, electrical identification, supporting devices and electrical connections for equipment. Work includes, but is not limited to, the following:

1. Interlock and control wiring between field-installed controls, indicating devices and unit control panels.

2. The Contractor shall be responsible for all additional electrical and other costs involved to accommodate the temperature control system panel, motors and electrical devices requiring power which differs from the power requirements shown on the electrical drawings.

*** Verify with Electrical Consultant & Architect location of Coordination Table.***

3. Refer to Division 1/16 for mechanical/electrical coordination.

M. Control Contractor shall furnish & identify location requirements for all necessary control devices which may be installed by others including the following, but not limited to:

1. Automatic control valves.
2. Flow switches.
3. Outside, return and exhaust air dampers for the supply fan/return fan systems.
4. Modulating dampers.
5. Required wells for insertion thermostats and/or temperature sensing wells.
6. Pressure Sensors.

Use the following paragraph for applicable projects.

N. Each Temperature Control Contractor shall include Section 15764 laboratory room pressure and fume hood controls as a part of Section 15970. Each Temperature Control Contractor shall submit separate bid cost for each of the manufacturers listed in Section 15764. Each T.C.C. is responsible for coordinating all labor and materials with suppliers and contractors prior to submitting bids.

1.2 QUALITY ASSURANCE:

A. Contractors Qualifications: Firms regularly engaged in installation and commissioning and servicing of digital control equipment, of types and sizes required, whose firm has been in business in similar service for not less than 5 years.

B. All work of this Section shall be fully “Year 2000 Compliant”. (See Section 15010). All date related data shall use four digit dates. “Windowing” of dates is specifically prohibited.

C. Only those manufacturers specified are allowed to bid temperature controls. All bidders shall make available, upon the Owner's request, open book unit pricing of all materials and labor.

D. The system shall be installed by competent mechanics, regularly employed by the Temperature Control Contractor.

E. All bidders must have installed and completed at least two (2) direct digital temperature control jobs of similar design, size and scope using the same equipment as specified.

F. All bidders must have a local office in the area of the project site.

G. All bidders must have capabilities of doing component level repairs on all systems, including electronic systems.

H. No Field Devices shall be multiplexed to a single I/O point unless specified. Each control or sensing point shall be terminated at a unique location on the BAS panel, Slave or Dedicated Controller and be associated with a unique software point on the BAS.

I. Codes and Standards:

1. All equipment and the installation shall comply with the requirements of all applicable local and national codes including but not limited to the currently enforced edition of the Uniform Building Code, Uniform Fire Code, Uniform Electrical Code, and all applicable codes of the National Fire Protection Association including the National Electrical Code.

2. Electrical Standards: Provide electrical products, which have been tested, listed and labeled by UL and comply with NEMA standards.

3. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric control systems.

4. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

J. All bidders must have a minimum of one person dedicated to software generation. This person shall be located in an office local to the project site.

K. The equipment and software proposed by the supplier shall be currently in manufacture. No custom products shall be allowed unless required by the Specification. All products shall be supported by the manufacturer for a minimum of 5 years including spare parts, board repairs and software revisions.

L. The Temperature Control Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each

contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others work.

M. It will be the responsibility of the Contractor to work in cooperation with the Owner and with all other contractors and employees rendering such assistance and so arrange his work such that the entire project will be delivered complete in the best possible condition and in the shortest time.

1.3 PROPRIETARY INFORMATION:

A. Project Documentation: All custom software, programs, code, databases, graphic files and drawings (whether hard copy or CADD based files) prepared for this system shall be the exclusive property of the Owner and shall not be reproduced or distributed without prior written permission from the Owner.

B. The use or reference to AT&T / Owner any of its subsidiaries or any of the facility automation projects shall not be used by the Manufacturer or Contractor in any promotional media, including advertisements, sale brochures, annual reports and client references or endorsements, without prior written permission from the Owner. The Owner reserves the right to restrict or refuse access to any or all of its facilities.

1.4 SUBMITTALS:

A. Submit in accordance with Division 1 and 15 submittal requirements.

B. In addition to the requirements set forth in paragraph A above, the following shall be included in the shop drawing submittals including, but not limited to:

1. Product Data: Submit manufacturer's technical product data sheets for each control device furnished, each data sheet shall be labeled indicating its control drawing descriptor and include the following:

   a. indicating dimensions;
   b. capacities;
   c. performance characteristics;
   d. electrical characteristics;
   e. finishes of materials;
   f. commissioning, installation instructions and start-up instructions.

2. Valve, damper and well and tap schedule showing size, configuration, capacity and location of all equipment.

3. Control system drawings containing pertinent data to provide a functional operating system and a sequence of operation.
4. Detailed wiring diagrams.

5. A floor plan of each area with a detailed new conduit/wiring layout shall be included. The plan shall indicate all conduit locations within ±2' of actual installed location. All walls, doors and temperature control devices shall be accurately shown.

6. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and all control devices. Identify all control points with labeling.

7. Label each control device with setpoint or adjustable range of control. Provide a bill of materials with manufacturer's part number.

8. Indicate all required point to point electrical wiring. Clearly differentiate between portions of wiring that are existing and portions to be field-installed.

9. Provide details of faces of control panels, including controls, instruments, and labeling.

10. Include verbal description of sequence of operation and reference each device described by schematic symbol used.

11. Provide a detailed listing of all software program code written for each system.

12. Provide a point list with database input information to include a point name, address, base and span, action and other required information.

13. Provide a detailed test plan and procedure for each HVAC system and for each type of terminal unit control including valves. The test plans shall fully define reporting methods, procedure, equipment utilized, milestones for the tests, identifying the simulation programs, and personnel. The test procedures shall be developed from the test plans and shall consist of instructions for test execution and evaluation. A test report form shall be developed for each point and sequence of operation. Commissioning procedures shall be provided for each HVAC system and for each type of terminal unit control system. The procedure shall include setpoint, prop. band, integral, derivative, mode constraints input, output settings, tuning procedures., etc.

C. Submit manufacturer's installation instructions.

D. Submittal data and shop drawings shall be prepared and submitted in the following formats:

1. All drawings prepared for the project shall be developed using the Autocad CADD program, most current version, (or a CADD package capable of producing AutoCadd "DXF" compatible format files).
2. All submittals data shall be the same size for any group of information and shall be in a three screw and post binder. (NO EXCEPTIONS). All the information shall be indexed and tabbed with reference to the specific section of these specifications.

3. The format for different groups of submittal information are as follows:

   a. Control drawings, building plans (including complete floor plans), schematics and system configurations shall be CADD prepared drawing, bound and indexed. Drawings that cannot represent the total information on an individual ANSI size B (11" x 17") drawing, i.e. a building plan, shall be noted with appropriate match lines, cross references and key plans.

   b. Technical data, sequence of operations, material list, point lists, program listings, I/O schedules, operator's and programmer's manuals, etc. shall be type written, original product data sheets or CADD prepared drawings, ANSI size A or ANSI size B.

4. Upon completion of the project and acceptance of systems the contractor shall provide to the Owner one set of hard copy as-built shop drawings and diskettes.

E. Shop drawings shall include riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typicals will be allowed where appropriate.

F. When the Architect/Engineer requires, the Contractor will resubmit with the corrected or additional submittal data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully reviewed.

G. Contractor agrees that shop drawing submittals processed by the Architect/Engineer are not change orders, that the purpose of shop drawing submittals by the Contractor is to demonstrate to the Architect/Engineer that the Contractor understands the design concept, that he demonstrates his understanding by indicating which equipment and material he intends to furnish and install, and by detailing the fabrication and installation methods he intends to use. The Contractor shall be responsible for space requirements, configuration, performance, changes in bases, supports, structural members and openings in structure, and other apparatus that may be affected by their use.

H. Contractor further agrees that if deviations, discrepancies, or conflicts between shop drawing submittals and the contract documents in the form of design drawings and specifications are discovered either prior to or after shop drawing submittals are processed by the Architect/Engineer, the design drawings and specifications shall control and shall be followed. If alternates do not meet these requirements, it shall be this Contractor's responsibility to remove them and install material originally specified, at no cost to the Owner.

1.5 DELIVERY, STORAGE AND HANDLING:

A. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent any equipment damage, and to eliminate all dirt and moisture from equipment. Store all equipment and materials inside and protected from weather.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND CONTRACTORS:

A. Subject to compliance with requirements, install one of the following systems:

1. Johnson Controls
2. Honeywell

2.2 GENERAL PRODUCTS DESCRIPTION:

A. The Building Automation System (BAS) shall be capable of integrating multiple building function including equipment supervision and control, alarm management, energy management, and historical data collection and archiving. All products and materials installed shall be suitable for the intended application requirements including but not limited to:

1. Accuracy
2. Rangeability
3. Temperature and pressure ranges
4. Shut-off pressures
5. Differential pressures
6. Repeatability
7. Materials of construction suitable with the environment and/or media in which they are in contact with
8. Code compliance
9. Velocities.

B. The BAS shall consist of the following:

1. Standalone DDC panels
2. Standalone application specific controllers (ASCs)
3. Portable Operator's Terminals
4. Personal Computer Operator Workstations
5. High Speed Communication Network (LAN)

The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone DDC panels, and operator devices.

C. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

D. Standalone DDC panels shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC panel or combination of panels on the network without dependence upon a central processing device. Standalone DDC panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

E. Shared points will not be allowed.

F. BAS shall allow third party software to operate on personal computer workstation without any degradation to the controls operating normally.

2.3 NETWORKING/COMMUNICATIONS:

The design of the BAS shall network operator workstations and Standalone DDC panels as shown on the attached system configuration drawing. Inherent in the system's design shall be the ability to expand or modify the network either via the local area network, or auto-dial telephone line modem connections, or via a combination on the two networking schemes.

A. Local Area Network

1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.

2. Dynamic Data Access: All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

   a. Access to system data shall not be restricted by the hardware configuration of the BAS. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.

3. General Network Design: Network design shall include the following provisions:

   a. High speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. The minimum baud rate shall be 1 Megabaud.

b. Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.

c. Detection and accommodation of single or multiple failures of either workstations, DDC panels, or the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

d. Message and alarm buffering to prevent information from being lost.

e. Error detection, correction, and retransmission to guarantee data integrity.

f. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

g. Commonly available, multiple sourced, networking components and protocols shall be used to allow the BAS to coexist with other networking applications such as office automation. MAP, ETHERNET, IBM Token Ring and ARCNET are acceptable technologies.

h. Use of industry standard IEEE 802.x protocol. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading.

i. Synchronization of the realtime clocks in all DDC panels shall be provided.

B. Dial-Up Communications: Auto-dial/auto-answer communications shall be provided to allow standalone DDC panels to communicate with remote operator stations on an intermittent basis via telephone lines.

1. Dial-Up Standalone DDC Panels: Auto-Dial panels shall automatically place calls to workstations to report critical alarms, or to upload trend and historical information for archiving.

a. Standalone DDC panels shall analyze and prioritize all alarms to minimize the initiation of calls. Non-critical alarms shall be buffered in memory and reported as a group of alarms, or until an operator manually requests an upload of all alarms.

b. The auto-dial program shall include provisions for handling busy signals, "no answers," and incomplete data transfers. Default devices shall be called when communications cannot be established with primary devices.

2. Dial-Up Workstations: Operators at dial-up workstations shall be able to perform all control functions, all report functions, and all database generation and modification functions as described for workstations connected via the local area network. Routines shall be provided to automatically answer calls, and either file or display information sent from remote DDC panels. The fact that communication is taking place with remote control systems over telephone lines shall be completely transparent to an operator.

a. An operator shall be able to access remote buildings by selection of any facility by its logical name. The PC Dial-UP program shall maintain a user-definable

cross-reference of buildings and associated telephone numbers, so the user shall not be required to remember or manually dial telephone numbers.

b. A PC workstation may serve as an operator device on a local area network, as well as a dial-up workstation for multiple auto-dial DDC panels or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with local area network activity, nor shall local area network activity keep the workstation from handling incoming calls.

3. Modem Characteristics; Dial-up communications shall make use of Hayes compatible 9600 baud modems and voice grade telephone lines. Each standalone DDC panel may have its own modem, or a group of Standalone DDC panels may share a modem.

2.4 STANDALONE DDC PANELS:

A. General: Standalone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each standalone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and the attached point list.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases including:

1. Control Processes
2. Energy Management Applications
3. Alarm Management
4. Historical/Trend Data for all points
5. Maintenance Support Applications
6. Custom Processes
7. Operator I/O
8. Dial-Up Communications
9. Manual Override Monitoring

C. Point Types: Each DDC panel shall support the following types of point inputs and outputs:

1. Digital Inputs for status/alarm contacts
2. Digital Outputs for on/off equipment control
3. Analog Inputs for temperature, pressure, humidity, flow and position measurements
4. Analog Outputs for valve and damper position control, and capacity control of primary equipment
5. Pulse inputs for pulsed contact monitoring

D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors and actuators.

The system architecture shall support a minimum capacity of [%] for all types of DDC panels, and all point types included in the initial installation.

E. Serial Communication Ports: Standalone DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or portable DDC panel Operator's Terminals. Standalone DC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.

F. Hardware Override Switches: The operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, onboard hand/off/auto operator override switches for analog control type points. These override switches shall be operable whether the panel is powered or not.

G. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.

H. Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

I. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel, and shall not require the connection of an operator I/O device.

J. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with the latest IEEE Standard 587.

1. Provide ISLATROL active tracking filters or equal, which provides both high and low voltage transients, non-linear characteristics, capable of instantaneously responding to spikes or transients without degradation to the filter or its performance. Power protection device shall be UL listed and have a reliability in excess of 100,000 hours of mean time between failures.

2. Signal wiring shall not be installed in same conduit as high voltage wiring.

K. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all standalone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

Should DDC panel memory be lost for any reason, the user shall have the capability of reloading the DDC panel via the local area network, via the local RS-232C port., or via telephone line dial-in.

2.5 SYSTEM SOFTWARE FEATURES:

A. General

1. All necessary software to form a complete operating system as described in this specification shall be provided.

2. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description

1. Pre-Tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms.

a. Two Position Control
b. Proportional Control
c. Proportional plus Integral Control
d. Proportional, Integral, plus Derivative Control
e. Automatic Control Loop Tuning

2. Equipment Cycling Protection; Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.

3. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

4. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

C. Energy Management Applications: DDC panels shall have the ability to perform any or all of the following energy management routines.

- Time of Day Scheduling
- Calendar Based Scheduling
- Holiday Scheduling
- Temporary Schedule Overrides
- Optimal Start
- Optimal Stop
- Night Setback Control
- Enthalpy Switchover (Economizer)
- Peak Demand Limiting
- Temperature Compensated Load Rolling
- Fan Speed/CFM Control
- Heating/Cooling Interlock
- Cold Deck Reset
- Hot Deck Reset
- Hot Water Reset
- Chilled Water Reset
- Condenser Water Reset
- Chiller Sequencing

All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Execution portion of this specification.

D. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:
   a. Any system-measured point data or status
   b. Any calculated data
   c. Any results from other processes
   d. User-Defined Constants
   e. Arithmetic functions (+, -, *, /, square root, exp, etc.)
   f. Boolean logic operators (and, or, exclusive or, etc.)
   g. On-delay/Off-delay/One-shot timers.

2. Process Triggers: Custom processes may be triggered based on any combination of the following:

   a. Time interval
   b. Time of day
   c. Date other processes
   d. Time programming
   e. Events (e.g., point alarms)

3. Dynamic Data Access: A single process shall be able to incorporate measured or calculated data from any and all other DDC panels on the local area network.

   In addition, a single process shall be able to issue commands to points in any and all other DDC panels on the local area network.

4. Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote device such as a printer or pager.

5. Custom Process Documentation: The custom control programming feature shall be self-documenting. All interrelationships defined by this feature shall be documented via graphical flowcharts and English language descriptors.

E. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

1. Point Change Report Description: All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.

2. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Each DDC panel shall automatically inhibit the reporting of selected alarms during system

shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

3. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PCs used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

4. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.

   Each standalone DDC panel shall be capable of storing a library of a least 250 Alarm Messages. Each message may be assignable to any number of points in the panel.

5. Auto-Dial Alarm Management: In Dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

F. Historical Data and Trend Analysis: A variety of Historical Data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.

1. Continuous Point Histories: Standalone DDC panels shall store Point History Files for all analog and binary inputs and outputs.

   The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be store for the past 24 hours to allow the user to immediately analyze equipment performance and all problem related events for the past day. Point History files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commands for each point.

2. Control Loop Performance Trends: Standalone DDC panels shall also provide high resolution sampling capability with an operator-adjustable resolution of 10-300 seconds in one second increments for verification of control loop performance.

3. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of one minute to two hours, in one-minute intervals, shall be provided. Each standalone DDC panel shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 500 data samples.

4. Data Storage and Archiving: Trend data shall be stored at the Standalone DDC panels, and uploaded to hard disk storage when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file form for use in 3rd Party person computer applications.

G. Runtime Totalization: Standalone DDC panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification.

1. The Totalization routine shall have a sampling resolution of one minute or less.

2. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.

H. Analog/Pulse Totalization: Standalone DDC panels shall automatically sample, calculate, and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons, etc.).

2. The Totalization routine shall have a sampling resolution of one minute or less.

3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

I. Event Totalization: Standalone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.6 APPLICATION OF SPECIFIC CONTROLLERS - HVAC APPLICATIONS:

A. Each Standalone DDC Controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a Standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Points shall not be shared between controllers.

C. Each ASC shall have sufficient memory to support its own operating system and data base including:

1. Control Processes
2. Energy Management Applications
3. Operator I/O (Portable Service Terminal)

D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation, or any PC or portable operator's terminal connected to any DDC panel in the network.

E. Application Specific Controllers shall directly support the temporary use of a portable service terminal. The capabilities of the portable service terminal shall include, but not be limited to, the following:

1. Display temperatures
2. Display status
3. Display setpoints
4. Display control parameters
5. Override binary output control
6. Override analog setpoints
7. Modification of gain and offset constants

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller..

2.7 AHU CONTROLLERS:

A. AHU Controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in the Execution portion of this specification, and for future expansion.

1. Large Air Handling Units

a. Mixed Air-Single Path
b. Mixed Air-Dual Path
c. 100% Single Path
d. 100% Dual Path

B. AHU Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.

C. AHU Controllers shall have a library of control routines and program logic to perform the sequence operation as specified in the Execution portion of this specification.

D. Occupancy-Based Standby/Comfort Mode Control: Each AHU Controller shall have a provision for occupancy sensing overrides. Based upon the contract status of either a manual wall switch or an occupancy sensing device, the AHU Controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

E. Continuous Zone Temperature Histories: Each AHU Controller shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

F. Alarm Management: Each AHU Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

2.8 OPERATOR INTERFACE:

A. Basic Interface Description:

1. Command Entry/Menu Selection Process: Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu

selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

2. Graphical and Text-Based Displays: At the option of the user, Operator Workstations shall provide consistent graphical or text-based displays of all system point and applications data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.

3. Multiple, Concurrent Displays: The Operator Interface shall provide the ability to simultaneously view several different types of system displays in overlapping windows to speed building analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze the system performance. If the interface is unable to display several different types of displays at the same time, the BAS Contractor shall provide at least two operator stations.

4. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display, and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password.

    a. Passwords shall be exactly the same for all operator devices, including portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all DDC panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for DDC panels individually.

    b. A minimum of five levels of access shall be supported:

        1) Level 1 = Data Access and Display
        2) Level 2 = Level 1 + Operator Overrides
        3) Level 3 = level 2 + Database Modification
        4) Level 4 = Level 3 + Database Generation
        5) Level 5 = Level 4 + Password Add/Modification

    c. A minimum of 50 passwords shall be supported at each DDC panel.

    d. Operators will be able to perform only those commands available for their respective passwords. menu selections displayed at any operator device, including portable or panel mounted devices, and shall be limited to only those items defined for the access level of the password used to log-on.

    e. User-definable, automatic log-off timers from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

5. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:

    a. Start-up or shutdown selected equipment
    b. Adjust setpoints
    c. Add/Modify/Delete time programming
    d. Enable/Disable process execution
    e. Lock/Unlock alarm reporting for each point
    f. Enable/Disable Totalization for each point

g. Enable/Disable Trending for each point
h. Override PID loop setpoints
i. Enter temporary override schedules
j. Define Holiday Schedules
k. Change time/date
l. Enter/Modify analog alarm limits
m. Enter/Modify analog warning limits
n. View limits
o. Enable/Disable demand limiting for each meter
p. Enable/Disable duty cycle for each load.

6. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:

a. A general listing of all points in the network
b. List of all points currently in alarm
c. List of all off-line points
d. List all points currently in override status
e. List of all disabled points
f. List all points currently locked out
g. List of all items defined in "Follow-Up" file
h. List all weekly Schedules
i. List all Holiday Programming
j. List of limits and deadbands

Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

B. Dynamic Color Graphic Displays: Color graphic floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, and hot water boiler systems, shall be provided as specified in the Execution portion of this specification to optimize system performance analysis and speed alarm recognition.

1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.

2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.

3. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
4. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.

a. The BAS Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (i.e. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (i.e. constant volume-terminal reheat, VAV, etc.) and electrical symbols.

b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawings program to allow the user to perform the following:

1) Define symbols
2) Position and size symbols
3) Define background screens
4) Define connecting lines and curves
5) Locate, orient, and size descriptive text
6) Define and display colors for all elements
7) Establish correlation between symbols or text and associated system points or other displays.

c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aid the operator in the analysis of the facility.

To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC panels, including application specific controllers used for DDC unitary or VAV terminal unit control.

C. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the Operator. System definition and modification procedures shall not interface with normal system operation and control.

1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

a. Add/Delete/Modify Standalone DDC Panels
b. Add/Delete/Modify Operator Workstations
c. Add/Delete/Modify Application Specific Controllers
d. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants
e. Add/Delete/Modify alarm reporting definition for each point.
f. Add/Delete/Modify control loops
g. Add/Delete/Modify energy management applications
h. Add/Delete/Modify time and calendar-based programming
i. Add/Delete/Modify Totalization for every point
j. Add/Delete/Modify Historical Data Trending for every point
k. Add/Delete/Modify custom control processes
l. Add/Delete/Modify any and all graphic displays, symbols, and cross-references to point data
m. Add/Delete/Modify dial-up telecommunication definition
n. Add/Delete/Modify all operator passwords
o. Add/Delete/Modify Alarm Messages

2. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications and control sequences shall be performed through fill-in-the-blank templates and graphical programming approach.

Graphical programming shall allow the user to define the software configuration of DDC control logic for HVAC system control sequences, fan interlocks, pump interlocks, PID control loops, and other control relationships through the creation of graphical logic flow diagrams.

a. Graphical Programming: Control sequences are created by using a mouse input device to draw interconnecting (comparisons and mathematical calculations), and outputs of a control sequence. As a minimum, graphic symbols shall be used to represent:

1) Process Inputs, such as temperature, humidity, or pressure values, status, time, date, or any other measured or calculated system data.
2) Mathematical Process Operators, such as addition, subtraction, multiplication, or greater than, equal to, less than, etc.
3) Logical Process Operators such as AND, OR, Exclusive OR, NOT, etc.
4) Time Delays
5) Process Control Outputs such as start/stop control points, analog adjust points, etc.
6) Process Calculation Outputs
7) Text file Outputs and Advisories

b. Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single DDC panel, but shall be able to allow the development of all other DDC panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

c. Sequencing, Testing, and Simulation: A software tool shall be provided, which allows a user to simulate control sequence execution to test strategies before they are actually applied to mechanical systems. Users shall be able to enter hypothetical input data, and verify desired control response and calculation results via graphical displays and hardcopy printouts.

3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data. control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

4. Database Save/Restore/Back-Up: Back-up copies of all standalone DDC panel databases shall be stored in at least one personal computer operator workstation.

5. Continuous supervision of the integrity of all DDC panel databases shall be provided. In the event that any DDC panel on the network experiences a loss of its data base for any reason, the system shall automatically download a new copy of the respective database to restore proper operation. Database back-up/Download shall occur over the local area network without operator intervention. Users shall also have the ability to manually execute downloads of any or all portions of a DDC panel's database.

D. A portable laptop computer shall be provided to the Owner upon completion of the project. The laptop computer shall include all necessary hardware and software to allow remote access of the complete BAS on or off the site via a modem phone line communication connection.

The laptop computer shall be configured to monitor, access, and make adjustments to the system and operate the same as the computer workstation described above.

The laptop computer shall have the following minimum configuration:

1. NEC Versa
2. Intel P5-133 mHZ

3. 16mB RAM
4. 12.1" Active color display
5. Local Video Bus with accelerator
6. PCMCIA Slots (2) Type II / (1) Type III ports: Parallel, Serial, CRT, PS/2 Keyboard mouse
7. Lithium Ion battery
8. 1 GB hard drive
9. 3.5" 1.44 mB floppy disk drive
10. Battery charger
11. 1 spare battery
12. MS-DOS 6.2 or higher
13. MS Windows '95
14. Integral Track Mouse
15. Targus Universal Case
16. Built-in 28.8 K bps Fax/Modem
17. MS Office '97 Professional
18. 155 V plug-in adapter power supply

E. Standalone DDC panel Local or Portable Operator's Terminals: Each DDC panel shall be capable of supporting an operator's terminal for local command entry, instantaneous and historical data display, and program additions and modifications.

1. There shall be a provision for both permanently mounting the standalone DDC panel Operator Terminal, or using it as a portable handheld unit.

2. The DDC panel Operator Terminal shall simultaneously display a minimum of 6 points with full English identification to allow an operator to view single c\screen dynamic displays depicting entire mechanical systems.

3. The operator functions provided by the DDC panel Operator Terminal shall include, but not be limited to, the following:

   a. Start and stop Points
   b. Modify Setpoints
   c. Modify PID Loop Setpoints
   d. Override PID Control
   e. Change Time/Date
   f. Add/Modify Start/Stop Weekly Scheduling
   g. Add/Modify Setpoint Weekly Scheduling
   h. Enter Temporary Override Schedules
   i. Define Holiday Schedules
   j. View Analog Limits
   k. Enter/ Modify Analog Warning Limits
   l. Enter/ Modify Analog Alarm Limits
   m. Enter/ Modify Analog Differentials
   n. View Point History Files

4. The DDC panel Operator Terminal shall provide access to all real or calculated points in the controller to which it is connected, or any other controller in the network. This capability shall not be restricted to a subset of predefined "global points", but shall provide totally open exchange of data between the operator terminal and any DDC panel in the network.

5. Operator access at all DDC panel operator Terminals shall be identical to each other, as well as identical to the PC or Laptop Operator Workstations. Any password changes shall automatically be downloaded to all controllers on the network.

6. The DDC panel operator terminal shall provide English language prompting to eliminate the need for the user to remember command formats or point names. Prompting shall be provided consistent with a user's password clearance and the types of points being displayed, to eliminate the possibility of operator error.

7. A multi-function touchpad shall be provided for point and command selection, as well as parameter entry. To minimize the possibility of operator error, the DDC panel Operator Terminal shall change and limit touchpad functions based upon an operator's password clearance, the function being performed, and types of points being displayed. Screen displays shall clearly indicate only valid touchpad functions.

8. Context-Sensitive Help: On-line, interactive user's "Help" manuals and tutorials shall be provided. Based upon operator request, the "help" function shall provide general system operating instructions, and specific descriptions of commands available in the currently displayed menus.

9. Identification for all real or calculated points shall be consistent for all network devices. The same English language names used at PC workstations shall be used to access points at the DDC panel Operator's Terminal to eliminate cross-reference or look-up tables.

10. In addition to instantaneous summaries, the DDC panel Operator's Terminal shall allow a user to view a Point History file for system points. Point History files shall provide a record of value of analog points over the last 24 hours, at 30-minute intervals, or a record of the last ten status changes for binary type points.

2.9 MATERIALS AND EQUIPMENT:

A. General: The Contractor shall provide control products in the sizes and capacities indicated. The existing control system shall remain and be reused as is. Additional controllers, sensors, and devices which are required to make a complete control system shall be the responsibility of the controls contractor.

Select type of damper for each project.

B. Dampers shall be constructed of a minimum of 13 gauge galvanized steel frame, double piece, 22-gauge galvanized steel mechanically joined, zinc plated steel concealed linkage and blade pin, oil impregnated bearings, self compensating stainless steel side seals and silicone blade seals. Leakage rates shall not exceed 10 cfm/ft^2 at 4" w.c. static pressure differential for a 24" x 24" damper. Provide extended shaft for proper and adequate actuator connection and operation. Damper blades shall not exceed 6" in height.

OR

Dampers shall be constructed of a minimum of 13 gauge galvanized steel frame, 1/16" extruded aluminum air foil blades, zinc plated steel concealed in frame linkage, zinc plated steel blade pin, oil impregnated bronze bearings, self compensating stainless steel side seals, neoprene blade seals. Leakage rates shall not exceed 7 cfm/ft^2 at 4" w.c. static pressure differential for a 24" x 24" damper. Provide extended shaft for proper and adequate actuator connection and operation. Damper blades shall not exceed 6" in height.

C. Damper blade operation shall be as follows:

APPLICATION	OPERATION
Modulating Air Volume Control	Opposed Blade
Mixing Plenum	Parallel Blade/Opposed Blade
Isolation/Shut-off Service	Parallel Blade

D. Pneumatic Dampers Operators:

1. All damper operators shall be of the synthetic elastomer diaphragm piston-type and shall be fully proportioning unless otherwise specified. Dampers operators shall have metal bodies. The operators shall have ample power to overcome friction of damper linkage and air pressure acting on the damper blades. The damper operator mounting arrangement shall be outside the airstream wherever possible. The operators shall have external adjustable stops to limit the stroke. The operator linkage arrangement shall permit normally open or normally closed positions of the damper as required by the sequence of operation.

2. Damper operators on modulating dampers that are sequenced with other control devices shall have a pilot positioner of the full relay type with an interconnecting linkage to provide mechanical feedback so as to accurately position and control the damper.

3. Pneumatic Type Damper: Size each actuator to operate dampers with sufficient reserve power to provide smooth modulating action or 2-position action as specified.

E. Automatic Control Valves:

1. Control valves shall have equal percentage plugs.

2. Control Valve Construction:

a. Small Valves 1/2" through 1": Valves shall be constructed with a cast brass body and screwed ends. Trim shall consist of a removable cage providing valve plug guiding throughout the entire travel range. A stainless steel stem shall be provided. Bonnet, cage and the stem and plug assembly shall be removable for servicing. Body rating shall be 400 psi at 150 deg. F.

b. Valves - 1/2" through 2": Valves shall be constructed with a cast brass body and screwed ends. For special duty, valves may be selected by the control manufacturer to have either bronze or cast iron bodies with screwed or flanged ends.

c. Valves - 2 - 1/2" and above: Valves shall be constructed with a cast iron body and have flanged connections.

Include the paragraph below where required.

d. For motorized plug, butterfly and ball valves, the operator shall be provided with the valve by the valve manufacturer. See Section 15100.

e. Steam control valves shall be suitable for superheat conditions where superheat may occur in operating system conditions.

3. Control Valve Operators/Actuators:

a. All automatic control valves shall be fully proportioning with modulating plugs for equal percentage of linear flow characteristics and shall be provided with actuators of sufficient power for the duty intended. Valve body and actuator selection shall be sufficient to handle system pressure which will be encountered on the project.

b. Where required by the sequence of operation, valves shall be capable of being sequenced either with other valves or other pneumatically actuate devices. Where such sequencing is required the actual spring range, when adjusted for spring shift, shall be such that no overlapping occurs. In the event that spring shift can cause an overlap, a pilot positioning operator shall be furnished.

c. Actuator housings shall be cast aluminum, with synthetic rubber diaphragm, spring return type.

4. Temperature control contractor and manufacturer shall size control valves for proper control characteristics for each application.

5. Water control valves shall be sized for a pressure drop between 4 to 6 psig at full flow condition.

6. Steam control valves shall be sized as follows:

a. For line pressures 15 psig and less: The pressure drop across the valve shall be 80% of the inlet gauge pressure at full flow condition.

b. For line pressures greater than 15 psig: The pressure drop across the valve shall be equal to the critical pressure drop which is 45% of the absolute inlet pressure.

7. Select valves to fail in normally open or closed position as follows:

Edit the following very carefully.

a. Steam Convertors:

1) Research Labs & Animal Labs:

a) 2/3 Capacity Valve N.C
b) 1/3 Capacity Valve N.C.

2) Hospitals, Patient Care, Schools N.O.

b. Terminal Heating Devices:

1) Offices, Patient Care, Hospital, Public Areas and schools

N.O.

2) Research labs, computer equipment rooms, telephone equipment rooms, animal holding rooms, etc.

N.C.

c. Chilled Water Service:

1) Offices, Patient Care, Hospital, Schools

N.C.

2) Research labs, computer equipment rooms, telephone equipment rooms, animal holding rooms, etc.

N.O.

d. All humidifier Valves:

N.C.

e. All Pre-Heat (Outside Air) Coil:

N.O.

f. or as dictated by life safety, freeze protection, humidity, fire or temperature protection.

2.10 INPUTS:

A. All input accuracies required by this section shall be end-to-end (from sensing point to BAS display). End-to-end accuracy includes all errors due to the sensor, transmitter, wiring and BAS signal measurement and A/D conversion.

B. Thermistors or solid state sensors shall be provided for temperature sensing applications except where accuracies or ranges required cannot be met by these devices, RTD's shall be used. The sensors shall be powered by the BAS panel or Dedicated Controller. The solid state sensors shall be accurate to within ±0.5□F. over the following ranges and meet the following requirements:

1. Room Type Instruments: 50□F to 100□F. For room space applications: Sensor shall be surface recessed mounted in a plastic aluminum/stainless cover with an insulated baseplate & vandelproof screws.

Each thermostat have the following features:

a. Exposed/Concealed setpoint adjustment dial with temperature graduation indication.

b. Exposed graduated temperature indicating thermometer.

c. All/Public area thermostats shall be provided with a plastic/stainless steel vented, lockable security cover.

2. Duct & Plenum Applications: -30□F. to 240□F. Supply, return, exhaust or mixed air averaging type, which shall have an extended element of sufficient length to cover the entire duct cross-section with a minimum of three passes. If a single averaging

thermistor of sufficient length to meet the preceding are not available then two or more sensors and AIs shall be used and averaged in software.

3. Water Temperature Applications: 30□F to 230□F.

C. Where RTD's are required, they shall be 1000 ohm platinum type and be supplied with a 4-20 mA DC transmitter. The sensor and transmitter shall be a single unit. They shall be accurate to within ±1.0□F. over the range of 32□F. to 600□F.

D. Where thermocouples are required, they shall be type J and be supplied with a 4-20 mA DC transmitter. They shall be accurate to within ±2.0□F over the range of 32□F to 1300□F.

E. Provide matched temperature sensors for applications which require both inlet and outlet temperatures of any device.

F. Thermowells shall be monel, brass or copper for use in copper water lines; and 300 series stainless steel for all other applications.

G. Outdoor Air Temperature & Humidity Transmitter:

1. Provide Vaisala HMD60Y0 relative humidity and temperature probe with membrane filters and UV stabilized solar radiation shield. Probe shall have a temperature measuring range of -40□F. to +120□F. with an accuracy of ±.54□F at 68□F. and relative humidity measuring range of 0 to 100% RH with an accuracy of 2% 0 to 90% RH with a repeatability better than 1% RH per year. RH and temperature probe shall be capable of a continuous temperature operating range of -40□F. to +120□F. Provide necessary transmitter for output signals.

2. Provide 1 spare set of protective filters for each transmitter Viasala No. 17039.

H. Humidity Transmitter:

1. Duct humidity transmitters shall be Vaisala Model HMD60U. Transmitters shall measure relative humidity from 0-100% RH with repeatable accuracy of ±2% RH. Long range RH stability shall be better than 1% RH/year. Duct mounting enclosure shall be cast aluminum, NEMA 4. Instruments shall be temperature compensated over entire range of operation. Sensor shall utilize the registered HUMICAP H-sensor. Sensor filter shall be membrane type, 18.5 mm. Provide 4-20 mA output signal to building automation control system.

2. Wall Mounted Humidity Transmitter: Wall mounted humidity transmitter shall be Vaisala Model HMW60U. Transmitter shall measure relative humidity from 0 to 100% RH, ±2% accuracy, wall mounted ABS plastic box, with a long range RH stability better than 1% RH/year and temperature compensated over the entire range. Sensor shall utilize the registered HUMICAP H-sensor. Sensor filter shall be membrane type 18.5 mm and a 4-20 mA output signal.

a. Provide 1 spare set of filters for each transmitter Viasala No. 17039.

I. Humidity and temperature calibrator kit:

1. Provide Viasala HMK41 Kit for single point calibration of air temperature and humidity transmitters. Kit shall include:

a. HMI41 Sensor.
b. HMP46 Probe.

c. N.I.S.T. Certificate.
d. 1911622 Calibration Cable.
e. Carrying Case.

EDIT NOTE: Verify with Owner the need for a calibration kit. Cost is approximately $1200.00

J. Pressure Sensors, Transmitters and Differential Switches:

1. Pump/Liquid (wet) differential pressure switches shall be as manufactured by BARKSDALE with neoprene diaphragm, stainless steel internal parts, NEMA 4 housing.

2. Air Differential Pressure Transmitters shall be Modus model T30 or T40 (as required) with an accuracy of ±1% of range (including nonlinearity and hysteresis), solid state circuitry, no moving parts, capacitance principle capable of sensing positive, negative and differential pressures. Transmitter shall have 4-20 mA output signal and be powered by the control system or dedicated controller and capable of withstanding momentary overpressure of 8 times the pressure range.

3. Differential air pressure switches for filter or proof of airflow status shall be Dwyer Series 1910, with automatic reset, SPDT.

4. Hi-static pressure safety switches shall be Dwyer series 1900 MR, with manual reset, snap switch, SPDT, with repetitive accuracy within 3%.

5. Water/Liquid/Steam/Refrigerant Pressure Transmitter: Kele & Associates Model SA, stainless pressure transmitter with 4-20 mA output signal, watertight enclosure with stainless steel bulkhead fitting, accuracy of ±1% full scale, temperature compensated, 300 series stainless steel wetted parts.

a. Provide Model 47S pressure snubber for applications where the transmitter is subjected to fluid hammer, pressure surge or pulsation.

b. Provide Model PT steam syphon pigtail steam applications and where the fluid temperature is higher than the maximum operating temperature rating of the transmitter.

6. Air and Vacuum Pressure Transmitter: Kele & Associates Model P100GTE, solid state, 4-20 mA signal, with a full scale accuracy of 1%.

K. Output Devices:

1. Control Relays: Control relay contacts shall be rated for the application, with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage. Provide with LED to indicate status.

2. Analog output transducers shall be of positioning type with position feedback and control internal to the transducer. As an option, position feedback may also be input to the BAS.

3. Analog output transducers shall meet the following requirements:

a. 4-20 mA DC output.

b. Two-pipe electromechanical design or microprocessor-based design.

c. 3-15 psi output range adjustable to a 0-20 psi range minimum.

d. Linearity, repeatability and hysteresis no greater than 2% of full scale.

e. Air capacity of 1000 SCIM minimum.

f. Air consumption of no more than 100 SCIM.

g. Pressure gauges shall be installed on the branch and supply lines.

h. Acceptable transducers are the Bellofram T1000, Fairchild T5700, Johnson N6810, Mamac EP-310 or an equivalent.

4. Electronic analog output transducers shall output a signal to match the controlled device. The Contractor shall be responsible for verifying the required signals for all controlled devices. Transducers shall be completely solid-state with no mechanical parts.

5. Time Delay Relays: Time delay relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed is a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Relays shall be equipped with coil transient suppression, devices to limit transients to 150% of rated coil voltage. Delayed contact openings or closing shall be adjustable from 1 to 60 seconds with a minimum accuracy of ±2% of setting.

6. Latching Relays: Latching Relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.

2.11 GAUGES:

A. General: Provide air pressure gauges for indication of supply and control air pressure at each branch for all control valve sizes 1" and larger, as well as all control dampers, all controllers, relays and EP and PE switches.

B. Air pressure gauges shall be a minimum of 1-1/2" diameter, resistant to effects of shock, pulsation and vibration, with a full scale accuracy of ±2.5%.

C. Round receiver gauges for continuous indication of analog values shall be 4" dial face instruments. Gauges shall be calibrated in appropriate units for the variable being measured and shall operate through their full range on a change in air pressure from 3 to 15 psi. Accuracy shall be plus or minus 1/2% of full scale.

2.12 POSITIONERS:

A. Positive positioning relays shall be provided on valve actuators and damper operators when required to provide sufficient power, sequencing and repeatability.

B. Provide for smooth gradual operation over operating span adjustment of 0 to 15 psi and start point adjustment of 3 to 10 psi.

2.13 CUMULATORS, SWITCHES AND MISCELLANEOUS ITEMS:

A. Provide all cumulators, switches and other miscellaneous items as may be required for the successful operation of the temperature regulation systems specified herein and/or shown on Drawings.

B. Cumulators shall be of the positive and gradual acting type.

C. Provide suitable indicating plates with all switches.

D. Pressure/Electric switches shall be micro switch type.

E. Range shall be 0 - 20 psi with electrical rating of 10 amperes minimum for 115V/1/60.

2.14 POWER MONITORING:

A. General: Provide current switches, current transducers, voltage transducers, current transformers as required to meet the specified sequence of operation and indicated below.

B. Current Operated Switches: AC current switch, Neilsen - Kuljian Model PD50AC, or PD75, solid state, 5 year warranty, three selectable ranges for optimum adjustability and resolution. Provide external current transformer where required.

C. Current Transducers: AC current to DC current output, ±.5% accuracy, 4-20 mA output signal, Kele and Associates Model 4CMA. Provide external current transformer where required.

D. Voltage Transducers: Kele & Associates Model PVM or LVM as required for each application, ±1/2% accuracy, 4-20 mA DC output.

2.15 VIBRATION MONITORING:

A. Vibration Switch: Kele & Associates Model 502 vibration switch, frequency range of 120 to 30,000 CPM, 3 second time delay to prevent triggering due to transients 4-20 mA output signal, capable of being wired for automatic reset or latch and remote reset, ±5% accuracy, alarm setpoint and shutdown limit, NEMA 4 enclosure, capable of being mounted with the sensitive axis in any plane including inverted position and a velocity range of .15 to 1.5 in/sec.

EDIT NOTE: If duct mount is used, may need to filter air upstream of sensor. Verify with application, contact manufacturer's representative.

2.16 GAS DETECTION SENSORS:

A. Carbon Dioxide Sensor: SELECT WALL OR DUCT MOUNT. Viasala GMD20 (Duct) GMW20 (Wall); , designed to monitor CO_2 levels, in accordance with ASHRAE Standard 62-1989,4-20 mA output, accuracy at 20□C <(20ppm +1.5% of reading), 0-2000 PPM range, adjustable to 20000 ppm.

B. Refrigerant Leak Detection: MSA Instruments. "CHILLGARD RT" leak detection system, monitor and multipoint sequences, complies with ASHRAE Standard 15-1992, 0-100 PPM, 10% reading, 0-100 PPM linear reading, ±2% of full scale for 100-1000 PPM, 1 PPM sensitivity for R-123, resolution of 1 PPM, capable of 6 sampling points, suitable for either R-123, R-134A, R-22, ammonia, complete with alarm relays, 4-20 mA analog output, NEMA 4 enclosure, calibration kit, audible horns, zero & span gas scrubber.

C. Carbon Monoxide Sensor: Kele & Associates Model WCO-1, solid state sensor with a life expectancy of over 10 years, 0-200 PPM digital display, 4-20 mA analog output, test switch, automatic calibration and kit, alarm relay contact. Provide multiple sensors for adequate coverage. Each sensor shall be individually wired directly back to controller.

D. Oxygen Monitor Sensor: Davis Instruments Teledyne Model 335, with a range of 0-25% O_2, 0.5% sensitivity of full scale, ±2% accuracy at constant temperature, solid state electronics, two adjustable alarm setpoints and form C relay contacts, built-in audible and visual indication, AC powered, NiCad battery back-up and battery test switch. Provide calibration equipment and span gas.

2.17 TEMPERATURE CONTROL CABINETS:

A. General: All controllers and field interface devices shall be installed in control panel cabinet/enclosure as described below.

B. Cabinets shall be UL listed, 14 gauge furniture grade steel, finished with baked enamel painted finish inside and out, cabinet doors shall have piano hinge and standard key cylinder locking latch.

Cabinets shall include Lexan windows to view controls without opening the door.

C. Control panels located outdoors shall be NEMA 4X.

D. All devices installed in or on the control cabinet shall be labeled with a fixed mounted, color contrasted, engraved laminated plastic tags, including describing the function of the device, similar to the following example:

ΔP TRANSMITTER DEVICE

Label

DSP-1, AHU-1 SUPPLY DUCT STATIC PRESSURE TRANSMITTER

E. All pneumatic devices within the panel shall be factory prepiped. A "pneumatic terminal" numbering system shall be applied to pneumatic lines within a panel with aforementioned numbers matching pneumatic terminals shown on control diagrams. This feature is required to assist system checkout and service.

F. All electrical devices within the panel shall be prewired to terminal strips with all inter-device wiring within the panel completed prior to installation of the system.

G. Mount control panels adjacent to associated equipment on vibration free walls or free standing steel angle supports or "Unistrut" support stand.

2.18 VARIABLE FREQUENCY DRIVES:

A. Variable frequency drives shall be arranged so that it can be operated in an open circuit mode, disconnected from the motors, for start-up adjustments and trouble shooting.

B. Automatic operation shall be from a 4-20 milliamp signal follower, which shall follow a transducer signal. The signal follower shall contain the following design features.

1. Shall accept a transducer output signal and condition it to produce a speed reference signal for the invertor.

2. Minimum speed adjustment (Zero to Maximum RPM).

C. Wire all safeties to operate both in hand and auto positions as well as drive and by-pass sections.

D. Provide communication cabling and interface necessary to forward VFD computer communication information to and from the BAS/VFD. See Section 15040.

2.19 HIGH & LOW TEMPERATURE LIMIT CONTROL DEVICES:

A. Provide PENN A70 series or equal, DPST, manual reset, two isolated sets of contacts. Control responds to temperature along any one foot of entire element.

B. Vapor charged sensing element shall be calibrated for altitude of project site.

C. Provide multiple limit control devices as required to provide complete and full coverage of the entire coil face area and/or duct cross section area.

2.20 ELECTRICAL MATERIALS:

A. All wiring shall be installed in conduit. See Division 16 for conduit installation requirements. Where wiring is exposed in plenum locations (i.e. open cable tray, wiring shall be plenum rated.

B. Conduit and Conductors: Types as indicated in Division 16 sized per Division 16 except for low-voltage twisted pair or single jacketed cable (1/2" minimum). All low voltage conductors shall be stranded 22 gauge copper minimum; twisted pair.

C. Fittings per Division 16: Bushings or nylon insulated throats are not required for jacketed cables.

D. All J-boxes shall be identified and labeled per Division 16.

E. All conductors and cables shall be labeled per Division 16.

F. Conduit and box supports shall be per Division 16.

G. Junction boxes shall be of types and sizes as indicated in Division 16.

H. Conduits shall not exceed 40% maximum fill for single conductor and jacketed cables.

I. Fiber Optic Cable:

1. Acceptable fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140. Only glass fiber is acceptable, no plastic.

2. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

J. Coaxial Cable:

1. Coaxial cable shall conform to RG62 or RG59 rating.

2. Provide plenum rated coaxial cable when running in return air plenums.

K. All temperature control panels & controllers shall be provided with fuse protection on both incoming power load supply (primary side) and on low voltage side of control transformer (secondary side).

L. Provide lightning arresters Kele & Associates Model 392-SVSR2 or equal, at all points where communication cables exit or enter the building.

M. All communication cabling shall be shielded type.

2.21 CONTROL AIR PIPING MATERIALS:

A. General: Paragraphs below only describe the material types, see Part 3 - Installation for application, use and additional requirements.

B. Copper air tubing shall be hard drawn/soft type K or L, ASTM B88; wrought copper/cast-bronze fittings, joined with Evergleam 496 silver solder or equal 5% minimum silver content brazing alloy; except brass compression-type fittings at connections to equipment.

C. All polyethylene tubing shall be classified as flame retardant and shall be self-extinguishing and rated for plenum application (Type FR). The finished tubing shall be manufactured from a compound complying with subject UL94 Vertical Burning Test for classifying materials 94V-0, 94V-1 or 94V-2.

2.22 TEMPERATURE CONTROL AIR COMPRESSOR AND ACCESSORIES:

Use this Specification for up to 15 HP compressors, for larger systems use Section 15481 and make the appropriate coordination description.

A. Provide duplex type air compressor with sufficient capacity to supply compressed air to the temperature control system and sized to operate not more than 33% of time during any one-hour period.

Include compressor HP, SCFM & PSIG if you are selecting capacity, otherwise do not include.

B. Air compressor system shall consist of the following:

1. Duplex air compressor tank mounted factory pre-piped & wired with the following:

a. Compressor and tank package shall be Quincy QR-25 system or approved equal, with a capacity of _____SCFM at 100 PSIG, _____ RPM, _____ HP/ea.

b. Low resistance intake air combination filter/silencer, 99% filtration efficiency at 1 micron, sized for compressors rated flow.

c. ASME stamped, galvanized steel tank receiver with a _____ gallon capacity.

d. ASME safety relief valve.

e. Discharge pressure gauge.

f. One automatic condensate drain valve and one manual condensate drain mounted on receiver.

g. Discharge check valves.

h. Receiver shut-off valve.

i. V-belt drive with adjustable motor drive bases.

j. OSHA belt guards.

k. Duplex motor starters and lead-lag alternator panel with individual fused disconnects, H-O-A switches, pilot lights, control transformer, with auto re-start on loss power. Starters and motors shall comply with Section 15040. Pump compressors shall run on high demand.

l. NEMA rated pressure switches.

m. Crankcase lubrication level indication.

n. Air-cooled aftercooler.

o. Low oil level shutdown safety switch.

p. Pressure lubrication with positive displacement oil pump and spin-on oil filter.

q. 5 year warranty.

C. Provide the following compressed air system accessories:

1. Air cooled NON-CFC EPA approved refrigerant, refrigerated air dryer sized to reduce dew point of control air supply to 35□F., at 100 PSIG and 100□F. ambient temperature for the rated capacity of compressor system at _____ SCFM. Air dryer shall include non-cycling hermetically sealed compressor with non-fouling, self cleaning, smooth surface copper heat exchanger, self-regulating hot gas by-pass, self contained integral automatic condensate drain, electric motor overload protection, refrigerant service valve, self contained controls and the following instrumentation:

   a. Power ON light
   b. ON/OFF switch
   c. Low ambient control
   d. Refrigerant suction pressure gauge
   e. High temperature light

   Refrigerated air dryer shall be as manufactured by Wilkerson or Hankison. Model _____.

2. Provide primary efficiency coalescer filter between the compressor and refrigeration air dryer capable of particle removal down to .5 micron, with a maximum downstream remaining oil content of .5 ppm by weight at 99.97% efficiency, DOP test. Primary efficiency coalescer filter, Wilkerson filter type B or equal, sized for minimal pressure

drop at rated compressor system flow. The primary efficiency coalescer filter shall be pre-filtered by a general purpose filter Wilkerson filter type A or equal, capable of removing particles sizes down to 5 micron.

Each filter shall include a direct mounted differential pressure gauge indicating when a filter change is required by a change in color indicator as manufactured by Wilkerson Model DP1 or equal.

3. Provide extremely high efficiency coalescer filter on discharge side of refrigerated air dryer capable of particle removal down to .01 micron, with a maximum downstream remaining oil content of .01 ppm by weight at 99.9999% efficiency, DOP test.

   High efficiency coalescer filter shall be Wilkerson type C or equal, sized for minimal pressure drop at rated compressor system flow. Provide direct mounted differential pressure gauge as specified above for primary and primary coalescer filters.

4. Final filtration shall be an activated carbon element for removal of oil vapor whether petroleum or synthetic based to a remaining oil content of.003 ppm by weight based on Sodium Flame Test.

5. All filter housings shall be impact resistant high strength plastic bowls with quick disconnect metal bowl guard and safety latch OR all metal bowl with liquid level sight gauge and manual/automatic mechanical float with manual override drain valves. All filter housing seals shall be compatible with compressor lubricant.

6. Automatic Drain Devices:

Edit the following types as required.

   a. Fully automatic, float operated, non-electrical, Hankison Snap-Trap with pilot valve, magnet, float, orifice filter, stainless drain filter, separate manual override drain valve, metal bowl with sightglass, Viton Seals with a capacity of .3 gallon per hour based on cycle per minute.

For large high moisture systems use the following paragraph.

   b. Fully automatic, heavy duty float operated, non-electrical Hankison Trip-L-Trap automatic drain, constructed of stainless steel, 300 psig maximum operating pressure, Viton seals, float and arm, pilot valve, magnet, with manual drain valve with a nominal capacity of 3 gallons per hour based on one cycle per minute.

   c. Completely automatic electric timed drain valve(s), Hankison 532 Series, complete with solid state timer, ASCO diaphragm type solenoid valve with 1/2" orifice, external adjustment knobs, manual override switch, status light indication, 150/300 psig construction, rugged non-corrosive NEMA 4 construction, heavy duty class F coil. Timer shall be adjustable for drain time from .5 to 25 seconds and a time cycle between drain opening from 1 to 45 minutes.

   d. Fully automatic electric demand drains Hankison 541/542 series, solid state controller, with capacitance sheath type sensor, pilot operated, alarm circuit automatically activates controller to switch to timed cycle with auto re-set after fault correction, two sets of auxiliary contacts for remote monitoring (1 N.O., 1 N.C.). NEMA 4 construction, status lights, manual override (push-to-test) button

and multiple inlet port configuration to allow variety of piping arrangement and manual drain port. Capacity shall be selected for system operating conditions.

Provide reservoir which is compatible with the system containments to be removed and electric internal heater with thermostat where installation may be subjected to temperatures below 35°F. ambient.

7. System Compressed Air Pressure Reducing/Regulators:

   a. Provide Fisher Model 67AFR, constructed of aluminum body, tamper resistant, with glass filter, outlet pressure gauge, internal relief and Kunkle Model 30 relief valve set for appropriate pressure relief protection to the system downstream of the regulator valve. Valves shall be sized and selected for proper pressure regulation and control by the manufacturer.

8. Point of use PRV: Where noted on drawings as point of use air piping PRV, provide Wilkerson modular air regulators R16/R26 or equal, with pressure gauge and mounting bracket.

9. Desiccant Dryer(s): Provide Wilkerson DE Series compact heatless air dryer Model capable of a dew point of -40°F., at SCFM flow rate, at psig inlet pressure and □. inlet temperature with a maximum purge rate of SCFM (@ 70□F.), including the following features:

   a. Moisture indicator
   b. N.C. heavy duty solenoid valves
   c. Solid state timer
   d. Spring loaded desiccant beds and quick change screw-on towers
   e. High humidity alarm, with remote alarm, contact, electronic humidity sensor and outlet air shut-off valve
   f. Instrumentation package, including two tower pressure gauges and on/off switch
   g. Fungus proof construction
   h. Mufflers
   i. Manifold bracket, cover and screws
   j. After filter type AF .5 micron filter for removal of desiccant dust, complete with pressure regulator and gauge Wilkerson Series RIG/R26 and safety relief valve.
   k. Explosion-proof construction.

2.23 END SWITCHES:

A. All end switches shall be NEMA rated contacts and NEMA 4X enclosure, either SPDT, DPDT DPST as required to meet the sequence of operation, complete the points list and necessary interlocks or safeties control wiring. End switches shall be as manufactured by Cutler-Hammer or Allen-Bradley.

B. All end switches shall be designed and configured to provide positive indication of a control device (i.e. damper or valve) position for the service intended.

PART 3- EXECUTION

3.1 INSTALLATION:

A. The Contractor shall install all equipment, control air piping/tubing, conduit and wiring parallel to building lines.

B. All automatic control valves and control dampers furnished by the Temperature Control Contractor shall be installed under his supervision by the Mechanical Contractor.

C. GENERAL INSTALLATION REQUIREMENTS:

1. Spare conductor capacity, equal to a minimum of (2) additional sensors shall be provided to each underfloor sensor and pendant type sensors.

2. Wiring shall be installed in conduit throughout.

3. Horizontal runs of conduit, trays, tubing or wiring shall be hung from structural members using new supports, or where feasible, utilizing existing temperature control conduit and piping. The Contractor shall verify adequacy of existing systems and warrant these systems as if they were new. Single runs of conduit, tubing or wire shall be by clevis ring and all thread rod. Multiple runs shall be by "Trapeze" or "Unistrut" supports. "Plumber's Strap" shall not be allowed. Maximum distance between supports shall be per the NEC. Existing supports shall only be used upon written concurrence by the Architect, Engineer or Owner.

4. All vertical runs of conduit or tubing shall be through new core drills. Existing core drills may be used if approved by the Owner. The installation shall be supported above each floor penetration using clamps to "Unistrut".

5. All wire that enters or leaves a building structure shall be installed with lightning protection per NEC.

6. All wire terminations shall be with compression type round hole spade lugs under a pan head screw landing; Stay-Kon or equivalent. All wire splices shall be with compression type insulated splice connectors or properly sized "wire-nut" connectors. Hand twisted, soldered and/or taped terminations or splices are not acceptable.

7. Where tubing, wiring or conduit penetrate floors or walls, sleeves with bushings shall be provided for tubing and wires. The conduit or sleeve opening shall be sealed with fire proof packing so the smoke and fire rating of the wall or floor is maintained.

Edit the following paragraph for AT&T Projects.

8. Under no circumstances shall wire, tubing, tray, J-boxes or any BAS equipment be run in, mounted on, or suspended from any of the telephone system's equipment, cable trays or support structure (Grey Iron).

9. All the material installed under this contract must be mounted on, or supported from the building structure or supports furnished by this Contractor.

Edit the following paragraph for each project.

10. All air for new pneumatic BAS devices shall be obtained from the existing pneumatic system.

11. Air supplies shall be supplied from mains. Do not connect to branch lines.

12. Provide an isolation valve on air line connections to each air controlled device which will be added.

13. Install 0-20 psi pressure gauges at all air controlled devices which will be added.

D. CONTROL AIR PIPING AND TUBING:

1. Provide and install control air piping and tubing as specified in the following table:

Edit the following table for each project.

APPLICATION/LOCATION	MATERIAL/INSTALLATION
ALL PIPING	COPPER IN CONDUIT
ALL PIPING	COPPER WITHOUT CONDUIT/OR PLASTIC IN CONDUIT
SURFACE MOUNTED IN SERVICE/UTILITY AREAS. I.E. LOADING DOCKS, GARAGE	COPPER/OR PLASTIC IN/CONDUIT
MECHANICAL ROOMS	COPPER IN WITHOUT CONDUIT OR PLASTIC IN CONDUIT
ABOVE LAY-IN CEILINGS	COPPER OR FLAME RETARDANT POLYETHYLENE 25/50 FLAME/SMOKE RATING PLENUM RATED PLASTIC/ WITHOUT/IN/CONDUIT
SHEET ROCK, PLASTER OR OTHER SIMILAR NON-ACCESSIBLE CEILING SYSTEMS	COPPER IN/WITHOUT/CONDUIT
SHAFTS, CHASES, DROPS IN WALLS	COPPER/OR/FLAME RETARDANT POLYETHYLENE 25/50 FLAME/SMOKE RATING PLENUM RATED PLASTIC/WITHOUT/IN/CONDUIT
OTHER APPLICATIONS NOT GIVEN ABOVE	COPPER/IN CONDUIT
LIFE SAFETY SYSTEMS I.E. SMOKE DAMPERS	COPPER (BRAZED), MINIMUM 5% SILVER CONTENT

2. Piping shall be installed horizontally level or vertically plumb with adequate pitch to drip pockets. No piping shall be concealed within duct insulation. All piping shall be supported using straps, cleats or hangers; wire will not be permitted. Where more than one (1) pipe in enclosed in conduit or tray, furnish color coded or numbered piping. Type FR polyethylene tubing may be used in local control panels that are enclosed or have side panels.

3. All accessory pneumatic and pneumatic electric devices shall have a pneumatic test point on the device output which will allow the output signal to be measured without interruption of the control function.

E. Control Wiring:

1. Run wiring in metallic conduit, tubing or raceways. Exceptions are as follows:

a. NEC Class 2 low voltage wiring where not exposed to view such as above suspended ceilings, in shafts, etc., may be run in cable (when approved by code authority).

b. Wiring enclosed in temperature control panels.

2. Where conduit is used, provide steel fittings.

3. Low Voltage Conductors: 18 gauge minimum, except 19 gauge may be used for home runs to central panels and 22 gauge minimum for resistance or thermistor sensing element connections.

4. Wire control interlocks and control panels, except one 120V power circuit to each temperature control panel shown on drawings and schedules shall be provided under Division 1.

5. All wiring shall comply with the requirements of local and national electrical codes.

6. Do not interlock alarms with starter switching to bypass alarm when equipment is manually disconnected.

7. Variable frequency drives shall be arranged so that it can be operated in an open circuit mode, disconnected from the motors, for start-up adjustments and trouble shooting.

8. All costs of controls, wiring conduit and associated labor shall be included in the temperature control bid. The control wiring shall be installed under the supervision of this Contractor.

3.2 ENCLOSURES:

A. The tubing and wiring within all enclosures shall be run in plastic trays. Tubing and wiring within BAS panels may be run using adhesive-backed tie wraps.

B. All plastic tubing shall be connected to enclosures through conduit. All copper tubing shall be connected to enclosures through bulkhead fittings.

C. Mount all enclosures, including those which house BAS Panels, Slaves and Field Device Panels, so that the top of the enclosure does not exceed six feet, six inches (6'-6"); and the center of any keypad/LCD combination does not exceed five foot, six inches (5'-6") from the floor or is less than four feet zero inches (4'-0") from the floor.

D. Field Device Panels contain related Field Devices such as relays, control power (24V) transformers, output transducers, etc., that are outboard of the BAS Panels or Dedicated Controllers. Each Field Device Panel shall be mounted within an enclosure. The enclosures shall be provided with lockable latches that will accept a single key common to all Field Device Panels, BAS Panels and Slaves.

3.3 EXISTING CONTROLS:

A. Remove all existing controls, controllers, receiver/controllers, thermostats, sensors, Field Devices, gauges, etc.; and all associated wiring, piping and mounting hardware whose functions are being replaced by the BAS.

Edit MOP paragraph below for each project.

1. When existing equipment is removed, coordinate with a detailed Method of Procedure (MOP). Do not remove until Owner reviews.

2. Refer to General Conditions.

3.4 INSTALLATION PRACTICES:

A. The Contractor shall install and calibrate all Field Devices, sensors and transducers necessary for the complete operation of the I/O points described herein.

B. Sensors shall be removable without shutting down the system in which they are installed.

C. All immersion sensors shall be installed in new, welded thermowells supplied by the Contractor. Existing thermowells may be reused with concurrence from the Owner. Coordinate any required shutdown with Owner.

D. Thermistor wire leads shall be permanently terminated at panels or controllers with wire clamps.

E. Where none exist, furnish and install pressure/temperature gauges adjacent to each immersion type sensor.

F. Sensors shall be installed with the use of a wet or hot tap without draining the system if required.

3.5 CLEANING AND FLUSHING:

A. All control air tubing shall be thoroughly cleaned before placing in operation to rid the system of dirt, piping compound, mill scale, oil, and any other material foreign to the air being circulated.

1. Clean exterior surfaces of installed piping systems of superfluous materials. Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

2. After installation of piping, but prior to installation of outlet valves, blow lines clear with Grade "D" oil-free dry air or nitrogen.

3. Control air piping which is required to be brazed shall be provided with a nitrogen purge during the brazing process.

3.6 CONTROL AIR LEAK TESTING:

A. All new control air piping and tubing systems shall be tested at 30 psi with no loss of pressure over an 8 hour period. The test shall be witnessed by the Architect, Engineer or Owner.

B. Ensure that the test pressure which might damage equipment does not reach such units by valving them off or otherwise isolating them during the test.

C. Open and close all system valves at least once while the system is pressurized to test valve packing. Tighten as required.

3.7 IDENTIFICATION:

A. All control air piping/tubing, J-boxes, conduit and wiring shall be labeled.

B. Electrical devices, wiring, conduit and J-boxes shall be labeled and identified as required by Division 16.

1. As a minimum regardless of Division 16 requirements, all temperature control J-box covers shall be painted blue [___] in color on both sides of cover.

C. Main supply control air piping and tubing shall be labeled with Brady or equivalent markers or pre-printed identification sleeves at each end and junction point, and protected. Identification scheme shall be consistent with the drawings.

D. Identification shall be provided for all enclosures, panels, junction boxes, controllers or Field Devices. Laminated, bakelite nameplates shall be used. The nameplates shall be 1/16-inch thick and a minimum of 1 inch by 2 inches. The lettering shall be white on a blue [___] background with minimum 1/4-inch high engraved letters. The nameplates shall be installed with pop rivets.

1. All new devices will be tagged. Color code to differentiate between new devices.

E. Thoroughly clean the surface to which the label shall be applied with a solvent before applying the identification. Use an epoxy to affix the identification in addition to any adhesive backing on the identification.

F. The plan code designation shown on all shop drawing identification shall be consistent with the contract documents.

G. All I/O Field Devices that are not mounted within Field Device Panel enclosures shall be identified with engraved plastic laminated nameplates installed so that they are visible from ground level.

H. The identification shall show the designation used on the record documents and identify the function such as "mixed air temperature sensor" and "fan status DP switch".

I. Calibration settings shall be marked with paint or indelible ink.

3.8 LOCATIONS:

A. All sensing devices and locations shall be located by the Contractor as shown on the submittal shop drawings with final review by the Engineer.

B. Wall mount space sensors shall be mounted five (5) feet above finished floor. Pendant mount space sensors shall be mounted eight (8) feet above finished floor.

C. Enclosures housing Field Devices shall be located immediately adjacent horizontally to the BAS panels or Slaves which are being interfaced to.

3.9 VALVES, WELLS, FLOW SWITCHES AND AUTOMATIC CONTROL DAMPERS:

A. The Controls Contractor shall have his control equipment on the project site when required and give the Owner 24 hours written notice when systems must be shut down for installation.

3.10 TEMPERATURE SENSORS:

A. Temperature controls trades shall verify all wall mounted temperature sensors locations with the Architect/ Engineer/Owner in order to avoid interference with wall mounted and space furnishings.

1. Where interferences require moving the temperature sensor more than two feet, consult with the Architect/Engineer for relocation.

B. Temperature sensors shall be mounted on suitable insulated base and secured to the wall in such a way as to be easily removed from wall without damage to the sensor.

C. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate thermostats 60" (1524 mm) above floor.

3.11 EQUIPMENT PROTECTION AND COORDINATION:

A. Where existing walls are penetrated with conduit or piping, provide a fire stop assembly which meets or exceeds the original rating of the assembly. Refer to Division 15.

B. Extreme care must be exercised while working in existing facilities and around operating equipment, particularly sensitive telephone switching and computer equipment. Close coordination with the Owner is required for the protection of this operating equipment from dust, dirt and construction material while maintaining the operational environment for the equipment. Under no circumstances shall the power or environmental requirements of the operating equipment be interrupted during the installation and check-out without submitting to the Architect, Owner and Engineer for approval.

C. A detailed Method Of Procedure (MOP) stating the steps to be taken, time schedule and impacted systems for the service interruption shall be submitted to the Architect for approval prior to beginning work. Refer to Division 1 and Division 15 for requirements.

3.12 CLEANUP:

A. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned and all other areas shall be cleaned around equipment provided under this contract. Clean the exposed surfaces of tubing, hangers, and other exposed metal of all grease, plaster, dust, or other foreign materials.

B. Upon final completion of work in an area, vacuum and/or damp wipe all finished room surfaces and furnishings. Use extreme care in cleaning around telephone switching and computer equipment and under no circumstances shall water or solvents be used around this equipment.

C. At the completion of the work and at the end of each work day, remove from the building, the premises, and surrounding streets, etc., all rubbish and debris resulting from the operations and leave all equipment spaces absolutely clean and ready for use.

3.13 SOFTWARE, DATABASE AND GRAPHICS:

A. Software Installation: The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any

operating system software or other third party software necessary for successful operation of the system.

B. Database Configuration: The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

C. Color Graphics: Unless otherwise directed by the Owner, the Contractor will provide color graphic displays for all systems which are specified with a sequence of operation, depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the Owner.

3.14 TEMPERATURE CONTROL DRAWINGS:

A. Upon completion of project and after record drawings of the temperature controls have been prepared and reviewed, the Contractor shall provide one (1) complete set of temperature controls drawings at each temperature control panel. Each set of drawings shall be laminated in a plastic coating. The drawings shall consist of only those control functions associated with the specific control panel and any relevant or pertinent network interface information.

The laminated drawings shall have a grommet connection attached to a metal cable or chain which is mechanically fastened to the temperature control cabinet.

3.15 START UP AND TESTING:

A. Prior to Beneficial Use of the BAS, the Contractor shall supply to Architect/Engineer two (2) debugged printouts of all software entered into the BAS. Also supply all user's programming and engineering manuals required to interpret the software. Included in the printouts, though not limited to, shall be the following:

1. Point data base.

2. All custom control programs written in the BAS control language.

3. All parameters required for proper operation of BAS control and utility firmware such as start-stop routines, etc.

4. Printouts or plotted detailed copies of the complete interactive system graphics.

B. The software printout shall be fully documented for ease of interpretation by the Architect/Engineer and Owner, without assistance from the Contractor. English language descriptions shall be either integrated with or attached to the BAS printout. Specifically, the following shall be documented:

1. All point (I/O and virtual) names.

2. All BAS Programming Language commands, functions, syntax, operators, and reserved variables.

3. Use of all BAS firmware.

4. The intended actions, decisions, and calculations of each line or logical group of lines in the custom control program(s). Sequences of operation are not acceptable for use in this documentation requirement.

5. Complete descriptions of and theories explaining all software and firmware algorithms. The algorithms to be described include, but are not limited to, PID, optimum start/stop, demand limiting, etc.

C. Documentation that was supplied as part of the submittals need not be submitted at this time.

Edit the following paragraph based on CRA's scope of work contract.

D. Upon review of software, a point-to-point test of the BAS installation shall commence. The Contractor shall provide two men equipped with two-way communication and shall test actual field operation of each control and sensing point. This procedure shall occur during off hour periods. The purpose is to test the calibration, response, and action of every point. Any test equipment required to prove the proper operation of the BAS shall be provided by and operated by the Contractor. The Engineer and/Owner will be present to oversee, observe, and review the test. Demonstrate compliance that system functions per the Sequence of Operation.

1. Upon review of the point-to-point demonstration, the Contractor shall start up the BAS by putting all controlled equipment in automatic and enabling software. Contractor shall commence final software and overall BAS hardware/software debugging.

Edit for 2 & 3 applicable projects.

2. The point-to-point demonstration shall include any existing BAS equipment if it affects the operation of the equipment included under this contract.

3. As a minimum, existing conditions shall be maintained during system changeover.

E. Final acceptance of the BAS is contingent upon a hardware/software system test. All groups of points that yield a system of control shall be tested for compliance with the sequences of operation. Included in the test, but not limited to, shall be:

1. BAS loop response. The Contractor shall supply a trend data output in graphical form showing the step response of each BAS loop. The test shall show the loop's response to a change in set point which represents a change in the actuator position of at least 25% of its full range. The sampling rate of the trend shall be from one to three minutes depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that does not yield temperature control of + 0.2□F or humidity control of + 3% RH shall require further tuning by the Contractor.

2. Interlocks and other sequences.

3. BAS control under HVAC equipment failure.

4. HVAC operation under BAS equipment failure.

5. Battery backup.

6. BAS control under power failure/restart.

7. Reset schedules.

8. BAS alarm reporting capability.

F. A detailed test report as defined under Submittals shall be provided indicating its completion and proper system operation.

G. The BAS will not be accepted as meeting the requirements of Beneficial Use until all tests described in this section have been performed to the satisfaction of both the Architect/Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor shall be exempt from the Beneficial Use requirements if requested in writing by the Contractor and concurred by the Owner and Architect/Engineer. Such tests shall be performed as part of the BAS warranty.

1. A typed written document stating that the system has been fully checked out on a point by point basis shall be submitted to the Architect/Engineer. All documentation associated with the check out shall be included.

3.16 PROJECT RECORD DOCUMENTS:

A. The Contractor shall be responsible for updating all existing Project Record Documents associated with the Scope of Work outlined in the Drawings and Specifications.

B. Prior to final completion of the installation, prepare a complete set of record drawings on a clear and legible set of ANSI size 'B' (11" x 17") mylar reproducible prints. The content, format and procedure of the submittal shall be as described by the General Conditions.

C. Provide one laminated and framed set of control drawings for each new BAS control panel and one for the Facility Control Room, locate as directed by the Engineer.

Edit the following as required.

D. Prior to final completion of the installation, prepare three (3) operation and maintenance manuals. The information is to be inserted in the existing operation and maintenance manuals or provided in a tabbed and indexed, 3 screw and post binder. The information shall include:

1. Operator's manual with step-by-step procedures for logging on/off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, and changing firmware parameters.

2. Programmer's manual with complete description of the custom control language and associated editor, including sample written programs. Provide complete sets of all programming forms, applications memorandums, and addenda to the programmer's manual. All software or firmware algorithms shall be completely described and documented.

3. Maintenance, Installation, and Engineering manual(s) that clearly explains how to debug hardware problems, how to repair or replace hardware, preventive maintenance guidelines and schedules, calibration procedures, and how to engineer and install new points, panels, and Operator Interfaces.

4. Documentation of all software. List separately all software parameters that will need updating by the Owner such as, though not limited to, holiday, seasonal and start/stop schedules, comfort and duty cycling schedules.

5. All programs, code, databases, graphic files, CADD drawings and symbol libraries generated for operation of the system shall be included as a part of the system documentation. This information shall be submitted both in hard copy bound format and magnetic media format.

6. Input/output schedules, data sheets, and all other items required under Submittals. Describe all regular maintenance that will need to be performed on the BAS hardware. List replacement parts with part numbers.

7. Complete original issue documentation and software diskettes for all third party software furnished and installed as a part of the system or required for the operation of the system including text editors, control language program and compiler, database managers, graphics and CADD packages, operating systems and communications software.

8. Complete original issue documentation, installation and operational manuals and supporting software for all third party hardware furnished and installed as a part of the system or required for the operation of the system including remote terminals, user's computer workstation, monitors, graphics and memory boards, printers and modems.

9. During the warranty period, all copies of the drawings and manuals shall be updated to include all hardware and software changes. A final update at 1 year shall be provided to the Owner.

E. All of the above documentation shall record both the equipment installed under this contract and the exact termination to all other existing control or BAS equipment.

F. The record drawings shall document the complete existing control system. This includes all mechanical equipment in work area which has automatic control.

3.17 WARRANTY:

A. The Warranty period shall begin on the date of beneficial use completion as authorized by the Architect/Engineer and Owner in writing. Beneficial use shall not occur before the Contractor has performed the tests required. With these requirements met, beneficial use shall not occur until, in the opinion of the Architect/Engineer, the BAS is sufficiently complete to be utilized for the purposes for which it is intended.

1. The warranty start date shall not begin until all phases of the Project are complete, i.e., the Project shall have a single warranty start date.

B. The BAS system shall be guaranteed to be free from defects in material and workmanship and in software design and operation for a period of the warranty after completion of the contract. The Contractor shall provide the necessary skills, labor, and parts to assure the proper operation of, and to provide all required current and preventive maintenance. This warranty shall become effective starting the date of Beneficial Use completion.

1. The hardware warranty shall include all equipment which has been purchased by the Contractor. The existing hardware is not subject to the warranty requirements.

2. All software work completed by the Contractor, associated with existing hardware, is subject to the warranty requirements outlined herein.

3. The Contractor shall respond to all calls during the warranty period for all problems or questions experienced in the operation of the installed equipment and shall take steps to correct any deficiencies that may exist.

4. The response time to any problems shall be four (4) hours maximum 24 hours per day, 7 days per week. Corrective action, temporary or permanent shall be made within one business day.

C. The Contractor shall perform a monthly on-site or via telephone MODEM inspection of the operation of the system. They shall report to the Owner in writing after each inspection, define any problems with the system and its operation, and define the procedure which will be taken to correct the problem. Contractor shall comment on the possible resolution of any problems that are out of the scope of their Contract.

1. Any problems shall be corrected as required by the warranty requirements.

D. The system shall be polled via the telephone modem for any alarm signals or "abnormal off" messages. Upon receiving such a message the Contractor shall take indicated corrective action.

E. The Contractor shall maintain a backup of all BAS software installed in the system. The backup shall be updated monthly or whenever a change to the software is made. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge unless it is due to a power failure of a duration longer than the battery backup.

F. The Contractor shall optimize all control software to assure acceptable operating and space conditions, and peak energy efficiency.

G. At the end of the warranty period, the Contractor shall supply updated copies of the latest versions of all Project Record Documentation. This includes final updated drawings, software documentation and magnetic media backups that include all changes that have been made to the system during the warranty period.

3.18 TRAINING:

Adjust number of hours of training based on Owner, size and complexity of project.

A. The Contractor shall provide [_] hours of training for the building operators. The training sessions shall be broken into [_] [_]-hour sessions. The training session shall be made available to the Owner prior to the end of the warranty period but after final completion of the contract. The session shall be given at the Owner's facility. Scheduling shall be approved by the Owner. The training shall focus on general design, operation, and maintenance procedures of the products installed, though not necessarily the specific system designed, and shall cover:

1. Hardware configuration including PC boards, switches, communication and point wiring, and location and installation of all sensors and control devices.

2. Hardware maintenance, calibration, troubleshooting, diagnostics, and repair instructions.

3. Operation of man-machine interface including logging on/off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, and changing firmware/software parameters.

4. Programming the BAS using the editor and the design of custom control software.

5. Recovery procedures from both BAS and HVAC failures.

B. The Instructor for the above session shall be an employee of the Contractor, who is qualified to provide customer training and applications support.

3.19 SEQUENCE OF OPERATION:

END OF SECTION 15971