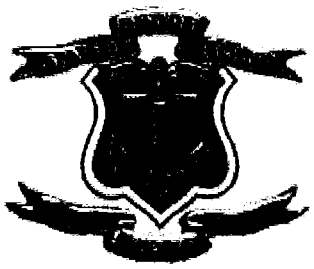

State of Rhode Island
Department of Administration / Division of Purchases
One Capitol Hill, Providence, Rhode Island 02908-5855
Tel: (401) 574-8100 Fax: (401) 574-8387

Solicitation Information
July 3, 2015

ADDENDUM # 1

RFP# 7549703

TITLE: RENOVATIONS RANGER HALL-HARRINGTON SCHOOL OF COMMUNICATIONS AND MEDIA, UNIVERSITY OF RHODE ISLAND

Submission Deadline: Monday July 20, 2015 at 11:00 AM (Local Time)

Notice To Vendors:

- **There will be a non-mandatory walk thru at the site on Tuesday July 7, 2015 at 2:00 PM for anyone interested in attending**
- **Attached included**
  - **Sign in sheet from mandatory pre bid conference held on July 2, 2015**
  - **Additional information for this project**

Tom Bovis
Interdepartmental Project Manager

Interested parties should monitor this website, on a regular basis, for any additional information that may be posted.

State of Rhode Island
Division of Purchases
One Capitol Hill
Providence, RI 02908

"MANDATORY" PRE-BID CONFERENCE SIGN IN SHEET

Mandatory Pre-bid Conference: Any vendor who intends to submit a bid proposal in response to this solicitation must have its representative attend this mandatory prebid conference, sign, and complete all required information on this Sign-In Sheet. Failure to comply with this requirement will result in the rejection of any bid proposal.

BID NUMBER:	7549703
BID TITLE:	RENOVATIONS RANGER HALL URI
PRE-BID DATE AND TIME:	7/2/2015 14:00

Purchasing Representative:
TOM BOVIS
Mandatory Pre-bid START TIME:
Mandatory Pre-bid END TIME:

	COMPANY NAME	COMPANY REPRESENTATIVE	SIGNATURE	ADDRESS	CONTACT E-MAIL	CONTACT PHONE NUMBER AND FAX NUMBER	PROPOSAL SUBMITTED (For Purchasing Use Only)
1	SYNET	JAY PETERS		205 HALLEVE RD WARWICK, RI 02886	JPETERS@SYNETINC.com	401-862-1326	
2	Delta Mechanical	DAVID STANGELO		44 Wildclaire Street	David ST.Angelo @Yahoo.com	401-737-3500	
3	Iron Construction	Justin DeProspero		875 Centerville Rd WARWICK, RI	Estimating2 iron.com	401 580 2062	
4	AHLBORG CONST.	JAIME SENRA		20 COLLEGE HILL WARWICK RI	JSENRA@AHLBORG.com	508 542 4717	
5	BENTLEY Builders	TOM LENSKA		250 SCRABBLETOWN N. KINGSTOWN RI	T.LENSKA@BENTLEYBuilders LLC.com	401.578-78	
6	TRIAC Builders	Todd Broderick		28 Wolcott St Providence	todd@triacbuilders.com	401-500 399	
7	SimplexGrinnell	Sophie McGUIRE		690 Narragansett Park Dr. Pawtucket	SMCGUIRE@simplexgrinnell.com	401-228-4735	
8	E W Burman	Amy Burman		33 Vermont Ave Warwick RI 02888	estimating@ewburman.com	401 738 54	
9	Tower Const. Corp	SAN TOMMASSA		255 LINCOLN AVE WARWICK, RI	ESTIMATING@ TOWERCONSTRUCTIONCORP.COM	401-943-01	
10	ADS Construction	Darlene DeTroia		300 Wampanoag Trail, East Prov.	asec@msn.com	401-431-1228	
11	Maron Construction	William Hunter		180 Buttonhole Dr.	Wchunter@gmail.com	401-272-4930	
12	HV COLLINS	KEVEN THIBODEAU		99 GANO ST PROVIDENCE	KTHIBODEAU@HVCOLLINS.com	401-421-4050 401-421-929	
13							
14							
15							

** VENDOR: PLEASE SUBMIT A BUSINESS CARD IF AVAILABLE**

SECTION 23 09 00

HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1. Section 23 05 00 - Common Work Results for HVAC.
2. Section 23 05 50 - Basic Mechanical Materials and Methods.
3. This section is a part of each Division 23 Section (Mechanical).
4. Specified elsewhere:
5. Variable Speed Control
6. Motors
7. HVAC Pumps
8. Terminal Heat Transfer Units
9. Fans
10. Air Handling Units
11. Testing, Adjusting and Balancing
12. Basic Elec. Materials Methods
13. Electrical Wiring

B. Technical Proposals

1. Technical proposals shall be prepared in accordance with these specifications. Four (4) copies of the proposal shall be submitted with the bid. Proposals that are unbound, loose, loose in a file folder, stapled, stapled in a manila file folder, etc., will not be acceptable. The technical proposal shall include the following data/information as a minimum. The order of listing here is not intended to indicate, nor should it be construed to indicate, the relative importance of the data/information:

   a. Information on organizational capability to handle this project (management, personnel, manufacturing, single source responsibility, etc.). Provide an organizational chart of the local factory branch office indicating the project team and each person's role in the project. Provide a resume for each project team member and all management personnel.
   b. A comprehensive bar chart project schedule indicating submission of shop drawings, equipment delivery, installation, start-up commissioning, training, milestones, and all critical path tasks.
   c. A project specific on-site and off-site training program which demonstrates specification compliance.
   d. BMS Configuration as Proposed:

2. Modularity.
3. Provisions against obsolescence due to technological advancement.
4. Detailed description of all operating, command, application and energy management software provided for this project.

5. Provide a riser drawing of the system architecture. The drawing shall indicate the model number, location and service of each primary control panel, secondary control panel, PC workstation and all other network hardware.
6. A complete description of the chiller plant integration and/or optimization package, if applicable.
7. A complete description of all interface and/or integration packages.
8. Provide a complete submittal of all hardware, software, sensors and end devices (valves, damper operators, airflow stations, etc.).
9. Description of manual override operation and BMS monitoring of manual override operation and BMS monitoring of manual override for each type control point in system.
10. A list of references (include Owner contact name and phone number) for five (5) projects completed by the local branch office within the last five years of similar size, schedule and complexity.
11. A line by line BMS specifications concordance summary. The summary shall be in table form and indicate each article and paragraph by number and whether the proposed BMS contractor "Does Comply" or "Does Not Comply" with the paragraph. If the item does not comply, the bidder shall provide a written explanation.
12. A signed certificate stating the Contractor "has read the performance and functional requirements, understands them, and the technical proposal will comply with all parts of the specification" or a signed line by line specification concordance statement. Certificate or statement shall be signed by a person having the authority to guarantee the statement.

1.2 SUMMARY

A. General Work Description

1. Building Management System (BMS) controls contractor shall provide:

a. A fully integrated building management system (BMS), UL-listed, incorporating direct digital control (DDC) for energy management, equipment monitoring, and HVAC control.
b. Electronic sensors.
c. Actuators of terminal equipment valves and dampers shall be electric. All sensors shall be electric/electronic.
d. Actuators for valves and dampers located within the MER's shall be electric.
e. All line voltage and low voltage wiring, conduit, panels, and accessories for a complete operational system. All final electrical connections to each stand-alone DDC Controller.
f. BMS Contractor shall be responsible for all electrical work associated with the BMS and as shown in the contract documents. The BMS contractor shall be responsible for all electrical work associated with any BMS interface to any other systems including but not limited to HVAC and plumbing systems.
g. The BMS contractor shall furnish all wells for water monitoring devices, flow switches, and alarms.
h. A complete operational system including all work required for a completely operational system as defined in the entire set of drawings and specifications, including but not limited to associated specifications for mechanical and electrical work, all contract drawings, BMS Point List, and remote function schedule.

i. The BMS system as a whole shall have the capability to be easily expanded through the addition of point modules and/or controllers. No equipment shall be installed which cannot, as installed, accommodate an upgrade the entire system by at least 25%. A 25% system upgrade shall include 25% more points (of each type) either via point modules or controllers and 25% more memory capacity for future connections.

j. Provide appropriate labor jurisdiction to mount, wire and pipe airflow measuring stations in the field. Provide manpower as required to meet project schedule.

1.3 DEFINITIONS

A. AI - Analog Input

B. ANSI - American National Standards Institute

C. AO - Analog Output

D. ASCII - American Standard Code for Information Interchange

E. AWG - American Wire Gauge

F. BMS - Building Management System

G. CPU - Central Processing Unit

H. CRT - Cathode Ray Tube

I. DAC - Digital to Analog Converter

J. DDC - Direct Digital Control

K. DI - Digital Input

L. DO - Digital Output

M. EEPROM Electronically Erasable Programmable Read Only Memory

N. EMI - Electromagnetic Interference

O. FAS - Fire Alarm Detection and Annunciation System

P. HOA - Hand-Off-Auto

Q. IEEE - Institute of Electrical and Electronics Engineers

R. I/O - Input/Output

S. LAN - Local Area Network

T. LCD - Liquid Crystal Display

U. LED - Light Emitting Diode

V. MCC - Motor Control Center

W. NC - Normally Closed

X. NO - Normally Open

Y. OWS - Operator Workstation

Z. OAT - Outdoor Air Temperature

AA. PC - Personal Computer

BB. RAM - Random Access Memory

CC. RFI - Radio Frequency Interference

DD. RH - Relative Humidity

EE. ROM - Read Only Memory

FF. RTD - Resistance Temperature Detector

GG. TCP/IP- Transmission Control Protocol/Internet Protocol

HH. UPS - Uninterruptible Power Supply

II. VAC - Volts, Alternating Current

JJ. VAV - Variable Air Volume

KK. VDC - Volts, Direct Current

LL. WAN - Wide Area Network

1.4 SYSTEM DESCRIPTION

A. General Product Description

1. The building management system (BMS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.
2. The building management system shall consist of the following:

a. Independent, Primary Control Panels (PCPs) for control of each air handler, each AC unit, each pumping system, each hot water system (including pump control). The intent of this specification is that the loss of any one Primary Control Panel shall affect only the points connected to that specific PCP and shall not affect the operation of any other HVAC system. Motors in motor control centers shall be controlled only from Primary Control Panel associated with the respective HVAC system. It shall not be acceptable to control all motors in a MCC from a Primary Control Panel(s) dedicated to the MCC.

b. Stand-alone, Secondary Control Panels for terminal equipment only (VAV units, etc.).
c. Portable operator's terminals (POTs) to be connected and communicating simultaneously with the entire Primary Network from any Primary Control Panel. The portable operators terminals shall be able to simultaneously monitor, adjust, trend, edit, modify, add, delete, backup the entire B.M.S system (including Secondary Control Panels, Primary Control Panels, etc.) point database and all programs.
d. Personal computer operator workstation(s) and associated peripherals. The personal computer operator workstation shall reside on the same network as the primary control panels.

3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Primary Control Panels, Secondary Control Panels and operator devices.
4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each Primary Control Panel shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection (including a wire break) shall affect only the system controlled by the specific PCP and shall not interrupt the operation of any other SCP, PCP, etc. In addition, the failure shall not affect or interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
5. Primary Control Panels shall be able to access any data from, or send control commands and alarm reports directly to, any other Primary Control Panels or combination of Primary Control Panels on the network without dependence upon a central or intermediate processing device. Primary Control Panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.
6. Operators shall be able to assign password access and control priorities to each HVAC system or interfaced system individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the system that the operator is authorized for. All other systems shall not be displayed at the PC workstation or portable terminal. Passwords and priority levels for every system shall be fully programmable and adjustable. This provision shall be applicable to all systems accessed either locally or remotely.

1.5 SEQUENCE OF OPERATION

A. Refer to Section 23 09 93 for Sequence of Operations for HVAC Controls.

1.6 SUBMITTALS

A. General

1. Indicate at the beginning of each submittal, all substitutions and deviations from requirements of Contract Documents.

B. Product Data

1. Technical bulletins and catalog data for all equipment and system components. Clearly identify, by use of symbol or tag number, the service of each item. All irrelevant information shall be marked out leaving only pertinent data.

C. Shop Drawings

1. Shop drawing submittals shall comply with Division 01 and other specified requirements and shall include sufficient data to indicate complete compliance with Contract Documents. Submission shall be in the form of drawings, brochures, bulletins, catalog data and/or narrative descriptions.
2. Submission shall include, but not be limited to:

    a. Symbol and abbreviation lists.
    b. System block diagram showing quantity and location of personal operator workstation(s), Primary Control Panels, Secondary Control Panels, and locations of power feeds to BMS and other major system components. Show quantity and location of compressed air plant if compressed air plant is specified.
    c. Control diagrams for all systems controlled. Controls shall be shown on system flow diagrams.
    d. Power wiring diagrams and electrical requirements.
    e. Interfaces (software and hardware) with other equipment provided in other sections of specifications including but not limited to chiller control system.
    f. Narrative description of operation for each system, enumerating and describing the function of each component. Include alarm and emergency sequences, and equipment interlocks.
    g. Description of manual override operation for every input and output point.
    h. Complete input/output point schedule. Identify point function, type and location.
    i. Spare capacity provisions.
    j. Detailed bill of materials.
    k. Valve and damper schedule: Provide identification numbers, location, system, dimensions and performance data. Include damper leakage rates.
    l. Device mounting details. Include as a minimum:

        (i) Sensing elements in ducts and casings.
        (ii) Sensing elements in piping.

    m. Ladder wiring diagrams.
    n. Other information as requested herein.
    o. Complete full size drawings, 11" x 17" minimum.

D. Programming

1. Point identification code.
2. System advisory messages, printouts, logging formats.
3. Drawings of system graphics showing monitored points. (Include only if graphics are specified elsewhere in this specification).
4. Software flow-charts for applications and DDC programs.
5. Person machine interface program, including commands, alarm annunciation, logs and programming capabilities.
6. Description of system operation under failure conditions.

E. Samples

1. All wall, pipe and duct sensors.
2. All other devices mounted on finished surfaces.

3. Valve, damper, panel and sensor tags.

F. Quality Control Submittals

1. UL, FM, CSA listing compliance certificates.
2. Final calibration, commissioning and testing reports.

G. Time Requirements

1. Within thirty (30) days of award of contract manufacturer shall provide schedule of all submittals employing format as provided hereinafter and enumerating all drawings, samples and miscellaneous submittals by name, quantity, etc.

1.7 QUALITY ASSURANCE

A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

B. All portions of the system must be of the same manufacturer and must be designed, furnished, installed, commissioned and serviced by manufacturer employed, factory trained employees. Systems proposed by distributors, manufacturer's representatives, and/or independent contractors shall not be considered and are not acceptable.

C. Single source responsibility of supplier shall be the complete installation and proper operation of the BMS and control system and shall include debugging and proper calibration of each component in the entire system.

D. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

E. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

F. BMS shall comply with UL 916 PAZX and 864 UDTZ and be so listed at the time of bid.

G. System devices shall have UL 864 (UUKL smoke control) and shall be so certified at time of bid.

H. All system components shall be fault-tolerant. System shall include:

1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3 Hertz variation in line frequency.
2. Static, transient and short-circuit protection on all inputs and outputs.
3. Protection for communication lines against incorrect wiring, static transients and induced magnetic interference.
4. Network-connected devices to be AC coupled or equivalent so that any single device failure will not disrupt or halt network communication.
5. All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and remote system low battery indication.

I. The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BMS systems and shall meet the following qualifications.

1. A minimum of ten (10) years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BMS systems similar in size and complexity to this project.
2. A maintained service organization consisting of at least ten (10) competent servicemen, within 50 miles of the project site, for a period of not less than ten years.
3. The Bidder shall not be considered qualified to bid this project unless they can provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.

J. The system manufacturer/installer shall provide a full-time, experienced project manager for this work from beginning of control installation until final completion. The project manager responsible for direct supervision of the design, installation, start-up and commissioning of the BMS as well as attending of project meetings whenever directed by the owner, construction manager, and/or mechanical contractor. It shall not be acceptable to change the project manager after the project has begun and before final completion.

K. Comply with all current governing codes, ordinances, and regulations including UL, NFPA, the local Building Code, NEC, etc.

L. The manufacturer of the building management system shall provide documentation supporting compliance with ISO-9002 (model for Quality Assurance in Production, Installation and Servicing). The intent of this specification requirement is to ensure that the products and services that the manufacturer and installer provide are delivered through a Quality System and Framework that will assure consistent quality throughout the project.

M. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to Primary Control Panels, Secondary Control Panels, personal operator workstations, and portable operator's terminals, to be connected and directly communicate with any new BMS system equipment without bridges, routers or protocol converters.

N. In order to ensure the availability of rapid response, the BMS Contractor shall have a local facility or authorized service agent within a 50-mile radius of the job site. On-site emergency service shall be available on a 24-hour, 7-day-a-week basis.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.10 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 26 Section "Intrusion Detection" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 26 Section "Clock Control" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate equipment with Division 26 Section "Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

E. Coordinate equipment with Division 26 Section "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

F. Coordinate supply of conditioned electrical circuits for control units and operator workstation.

G. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

H. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

I. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

1.11 EXTRA MATERIALS

A. Furnish extra materials described below to match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Replacement Materials: Provide one replacement component for each unique control device including as a minimum:

1. Panels:

a. DDC panel board components.
b. Relays.
c. Power supplies and transformers.

2. Field input devices:

a. Space, air and water temperature sensors.
b. Space and air humidity sensors.
c. Air and water differential pressure transmitters.
d. Static pressure transmitter.
e. Air and water differential switch.
f. Freezestat
g. Current switches.

3. Field output devices:

a. Actuators for dampers and valves excluding butterfly valves.
b. Electric-pneumatic transducers or switches.

C. Maintenance Materials: Any unique or special tools that are required for proper operation, maintenance and repair as outlined in the system operation, maintenance and repair manuals shall be provided.

D. Provide a complete list of replacement and maintenance materials in the technical proposal.

1.12 RECORD DOCUMENTS

A. Owner's Manual General

1. Submit two (2) draft copies of owner's manuals for review. After review by authorized representative, the contractor shall incorporate review comments and shall submit four (4) interim final copies. Upon completion of project, acceptance of project by the owner, submit six (6) copies of final "as built" manuals and one (1) reproducible copy (3-mil sepia Mylar).
2. Update manuals with modifications made to system during guarantee period. Provide replacement pages or supplements in quantity stated above for "as built" manuals.
3. Assemble owner's manuals into multi-volume sets.
4. Protect each volume with a heavy-duty vinyl plastic binder. Volumes to have plastic printed dividers between major sections and have oversized binders to accommodate up to _ inch thick set of additional information.
5. Each binder to be silk screened with project name and volume title on front cover and binder.
6. On the first page of each manual identify with project name, title, owner's name, engineer's name, contractor's name, address and service phone number, and person who prepared manual.

B. Provide an operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. Include as a minimum:

1. Control flow diagrams for all building systems.
2. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.
3. Description of manual override operation of all control points in system.
4. BMS system manufacturer's complete operating manuals.

C. Provide a maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. Include as a minimum:

1. Complete as-built installation drawings for each building system.
2. Overall system electrical power supply scheme indicating source of electrical power for each system component. Indicate all battery backup provisions.
3. Overall system shielding and grounding scheme indicating all major components and ground paths.
4. Drawings showing installation details and locations of equipment.
5. Charts showing normal operating conditions at significant points such as electrical test points.
6. Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.
7. Parts lists with manufacturer's catalog numbers and ordering information.
8. Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.
9. Manufacturer's operating, set up, maintenance and catalog literature for each piece of equipment.
10. Maintenance and repair instructions.
11. Recommended spare parts.
12. Field test reports.

D. Provide a programming manual to serve as training and reference manual for all aspects of system programming. Include as a minimum include the following:

1. Complete programming manuals and reference guides.
2. Details of any special software packages and compilers supplied with system.
3. Information required for independent programming of system.
4. Point schedule including all points, real and pseudo.
5. Project specific software troubleshooting procedures.

E. Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01 00 00, General Requirements.

   a. Prepare data in the form of an instructional manual.
   b. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified, in three parts as follows:

      (i) Part 1: Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.
      (ii) Part 2: Operation and maintenance instructions arranged by system and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:

         (a) Significant design criteria.
         (b) List of equipment.
         (c) Parts list for each component.
         (d) Operating instructions.
         (e) Maintenance instructions for equipment and systems.

      (iii) Part 3: Project documents and certificates, including the following:

         (a) Shop drawings and product data.
         (b) Certificates.
         (c) Photocopies of warranties.
         (d) Photocopies of bonds.

2. Contents, Each Volume

   a. Table of Contents: Provide title of project; names, addresses, and telephone numbers of Architect/Engineer, Sub-consultants and contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.
   b. For each Product or System: List names, addresses and telephone numbers of Subcontractors and suppliers, including local source of supplies and replacement parts.
   c. Product Data: Mark each sheet to clearly identify specific products and component parts, and data applicable to installation. Delete inapplicable information.

d. Drawings: Supplement product data to illustrate relations of components parts of equipment and systems, to show control, flow and wiring diagrams. Do not use Project Record Documents as maintenance drawings.
e. Narrative Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions.
f. Warranties.
g. Bonds.

3. Manual for Equipment and Systems

a. Each item of equipment and each system: Include description of unit or system and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and tests, and complete nomenclature and model number of replaceable parts.
b. Panelboard Circuit Directories: provide electrical service characteristics, controls, and communications.
c. Include color-coded wiring diagrams as installed.
d. Operating Procedures: Include start-up, break-in and routine normal operating instructions and sequences. Include regulation, control stopping, shutdown and emergency instructions. Include summer, winter, and any special operating instructions.
e. Maintenance Requirements: Include routine procedures and guide for preventative maintenance and trouble shooting, disassembly repair, and re-assembly instructions; and alignment, adjusting, balancing, and checking instructions.
f. Provide servicing and lubrication schedule for dampers and actuators and list of lubricants required.
g. Include manufacturers printed operation and maintenance instructions.
h. Include sequence of operation by BMS manufacturer.
i. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required.
j. Provide control diagrams by controls manufacturer as installed.
k. Provide BMS contractor's coordination drawings, with color coded control piping diagrams as installed.
l. Provide list of original manufacturers' spare parts, current prices, and recommended quantities to be maintained in storage.
m. Additional requirements as specified in individual Product specification sections.
n. Provide a listing in Table of Contents for design data, with tabbed dividers and space for insertion of data.

4. Instruction of Designated Facility Personnel

a. Before final inspection, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment, and systems, at agreed upon times.
b. For equipment requiring seasonal operation, perform instruction for other seasons within six months.

c. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.
d. Prepare and insert additional data in Operation and Maintenance manual when need for such data becomes apparent during instruction.

5. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.
6. Furnish required number of manuals, in bound form containing data covering capacities, maintenance and operation of all equipment and apparatus. Operating instruction shall cover all phases of control and include the following:

a. Lubrication Schedule: Indicating type and frequency of lubrication required for dampers and actuators.
b. List of Spares: Recommended for normal service requirements.
c. Parts List: Identifying the various parts of the equipment for repair and replacement purposes.
d. Instruction Books may be standard booklets but shall be clearly marked to indicate applicable equipment.
e. Wiring Diagrams: Generalized diagrams are not acceptable, submittal shall be specifically prepared for this Project.

7. Instruct Owner on the maintenance instructions for draining and protecting chilled water coils in the winter.

F. Display of Maintenance Instructions

1. One set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

G. Record Drawings

1. The BMS contractor shall provide a complete set of "as-built" or record drawings. The drawings shall be prepared and delivered to the architect in an acceptable AutoCAD format.
2. The drawings shall indicate:

a. All BMS work installed exactly in accordance with the original design.
b. All BMS work installed as a modification or addition to the original design.
c. The dimensional information necessary to delineate the exact location of all wiring runs that are so concealed as to be untraceable by inspection through the regular means of access established for inspection and maintenance. Where shop drawings have been prepared and approved, the "as-built" drawings shall be cross-referenced to the respective shop drawing.
d. All wiring routing locations must be shown.

3. As-built record drawings shall include the updating of all equipment schedule sheets.

4. The record drawings shall be reproducible as directed.
5. The BMS Contractor shall make arrangements with the Engineer to obtain design drawings on CD ROM disks in AutoCAD format for use as a basis for the "as-built" drawings. These documents remain the property of Cosentini Associates and shall not be used for any other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings.
6. Prior to developing any "as-built" drawings, the contractor shall coordinate with the Owner and the Architect Engineer the drawing layers, etc., of the CAD drawings.
7. "As-built" information shall be submitted as follows:

    a. CAD drawing files on CD ROM disks in AutoCAD format. The version of AutoCAD to be utilized shall be the version in use by the Engineer at the time of the submission.
    b. Two (2) sets of reproducible drawings.
    c. Three (3) sets of blueprints.

8. The quantity of design drawings which are made available shall in no way be interpreted as setting a limit to the number of drawings necessary to show the required "as-built" information.
9. Progress prints of record drawings shall be submitted monthly during the construction period for Architect's approval.
10. This trade shall submit the "as-built" set for approval by the building department in a form acceptable to the department, when required by the jurisdiction.
11. The contractor shall provide files on disks in an ASCII format for all schedules, catalog information, installation instructions manuals (information) indexed by system and/or equipment.
12. All equipment and systems require proper identification and tagging, including a system description. This information must be coordinated with all design and shop drawings.

1.13 WARRANTY

A. The Contractor shall warranty the BMS to be free from defects in workmanship and material for a period of one (1) year from the date of acceptance by the Owner. During the warranty period, the Contractor shall furnish all labor to repair or replace all items or components that fail due to defects in workmanship or material. This contractor shall also provide all system software upgrades during the warranty period.

B. The Contractor shall provide an on-line troubleshooting service during the warranty period. The on-line system shall allow the contractor or owner's agent the ability to interrogate, troubleshoot and correct warranty defects remotely. This system shall be operational 24 hours a day, 365 days a year. If the local manufacturer's staff cannot resolve the problem, the corporate home office staff shall remotely connect to the system and troubleshoot the warranty defect.

C. The Contractor shall submit a written report within 3 days of all warranty defects, the action taken, and corrections made for each warranty call.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Electric, Electronic, and DDC Systems:

~~a. Alerton; IBEX or BACTalk.~~
~~b. Honeywell Inc.; Excel 5000.~~
~~c. Invensys, I/A.~~
~~d. Johnson Controls Inc.; Metasys.~~
e. Schneider Electric; Andover Continuum.
f. Siemens Inc.; System 600 Apogee.

2.2 SYSTEM ARCHITECTURE

A. The Building Management System (BMS) is designed to support the comfort, safety, and productivity of the building's occupants and property. BMS shall integrate multiple building functions including equipment supervision and control, alarm management, energy management, information management, and historical data collection and archiving.

B. The BMS shall use an open architecture and fully support a multi-vendor environment. To accomplish this, the BMS shall be able to use open communication protocol standards, a wide variety of third-party devices, applications via existing vendor protocols, as well as the latest software and network standards.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, network controllers and operator devices, while re-using existing controls equipment.

D. In order to meet these requirements, the BMS must be capable of many methods of integration, at each tier of the network:

1. First Tier Network:

a. The first tier network shall be based on a PC industry standard of Ethernet TCP/IP. PC Workstation LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels, and shall be capable of communicating over all industry standard media types.
b. The first tier network shall provide communications between operator workstations and first tier network controllers.
c. The first tier network will be compatible with other facility-wide networks. The first tier shall be capable of being connected to a facility network by way of standard networking practices.
d. The primary communication bus shall be installed so that a break in any bus does not affect the communications operation of the bus.

2. Second Tier Network

a. The second tier network shall be based on an industry standard open protocol communication method.
b. The second tier network shall provide communications between Intelligent Building Equipment and first tier network controllers.

3. Integration: The ability of control system components from different manufacturers to connect together and provide coordinated control. Integration shall extend to the operator's workstation software, which shall support user interaction with all control system components. Methods of integration include industry standard protocols such as: BACnet, LonMark/LonTalk, OLE for Process Control (OPC) or integrator interfaces between cooperating manufacturer's systems.

a. Open protocol integration.

(i) Original Equipment Manufacturer's (OEM) may provide connectivity by adopting the BMS manufacturer's protocol for their product. OEM devices include but are not limited to chillers, boilers, variable frequency drives, power monitoring system, and medical gas.

b. BACnet Protocol Integration

(1) The protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-1995. Supported media shall include fiber, 10base2, and 10baseT.
(2) A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.
(3) The network shall conform to BACnet conformance class 4, and provide the ability to monitor and control BACnet system points from the BMS.

c. Industrial Protocol Integration

(1) Industrial Standard protocols such as Allen-Bradley Data Highway, Modbus+, or Eurotherm-LIN, and others shall be capable of integrating with the BMS.
(2) The MNI software and hardware, in conjunction with the integrated systems, shall translate data from multiple systems into one system and one user interface. The MNI shall allow an operator to monitor and control data and systems through an Operator Workstation (OWS).

d. OPC (OLE for Process Control) Integration

(1) Operator Workstations shall utilize an OPC client/server architecture so that real-time data can be passed between other OPC compliant systems.

e. Echelon LON WORKS protocol.

(1) LonMark certified controllers communicating over LonTalk networks shall interface with the BMS by connection to the network controller, operator workstation, or first tier network.

f. Hardwired

(1) Analog and digital signal values shall be passed from one system to another via hardwired connections.

E. The BMS is required to interact with equipment such as chillers or boilers that are provided by other trades. The BMS Contractor shall furnish appropriate equipment and connections to properly integrate these devices. The specific method of integration and the compatible equipment manufacturers shall be stipulated in the BMS Contractor's proposal, and submittals. It is the responsibility of the General Contractor to ensure that compatible equipment is provided.

2.3 OPERATOR INTERFACE

A. Personal Computer Operator Workstation Hardware

1. Provide two (2) workstation(s) of equal capability. The workstations shall be located as per owner.
2. Personal computer operator workstation(s) shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.
3. Each workstation shall consist of the following, at a minimum:

   a. Full tower case personal computer with the latest Pentium processor, 128 MB RAM, 10 GB hard drive and controller, 3-l/2" diskette drive, read/write CD ROM drive, 2 GB MB internal tape drive, mouse and 101-key enhanced keyboard.
   b. Color monitor with SVGA display and a diagonal screen measurement of no less than seventeen inches (17"). Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective. Minimum resolution of 1280 x 1024, .26 or better dot pitch and 72 Hz minimum vertical refresh rate or maximum resolution. 65k colors.

4. Provide a black and white printer at each workstation for the recording of critical alarms, operator transactions, and systems reports. The printer shall have the following minimum requirements:

   a. 132 column/400 character per second draft quality and 100 character per second letter quality print speed minimum.
   b. 24 pin dot matrix.
   c. 64K buffer to hold data waiting to print.
   d. Software selectable under, emphasized, double strike and expanded (double width) characters capability.

5. Provide a color printer at one (1) workstation, in addition to the black and white printer, for printing of graphics and any other screen displays. The owner shall

choose the workstation to be connected to the color printer. The printer shall have the following requirements at a minimum:

a. Color laser jet with 2400 x 1200 dpi resolution.
b. 32K Buffer to store complete graphics for printing.

B. Personal Computer Operator Workstation Software

1. General

a. Provide software which includes the following:

(i) Scheduling and override of building operations.
(ii) Collection and analysis of historical data.
(iii) Editing, programming, storage and downloading of controller databases, programs, and parameters.

b. A 32-bit, multi-tasking Microsoft Windows NT or Windows 2000 environment that allows the user to run several applications simultaneously. Other Windows applications shall run simultaneously with the BMS software including but not limited to Word, Excel, Access, etc.
c. Provide a user interface that 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.
d. Operator specific password access protection shall allow the user to limit workstation control, display and data base manipulation capabilities for each object in the system. An object shall be defined as any input or output point, setpoint, system program, etc. The operator privileges shall "follow" the operator to any workstation or Primary Control Panel that the operator logs on to. Provide a minimum of 200 passwords.
e. Operators will be able to perform only those commands on the objects available based on their respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used to log-on.
f. An audit trail report to track system object changes which shall record operator initiated actions. These actions shall include, but not be limited to, changes made by a particular person, changes made to a specific piece of equipment, and/or changes made during a designated time frame. The changes shall be printed and archived for future reference either on command or automatically, at the operator's option. The operator activity tracking data shall be stored in a tamper proof buffer.
g. Software shall allow the operator to perform commands including, but not limited to:

(i) Start up and shutdown of equipment.
(ii) Setpoint adjustment.
(iii) Add/modify/delete time programming.
(iv) Enable/disable process execution.
(v) Lock/unlock alarm reporting.
(vi) Enable/disable totalization and/or trending.
(vii) Override PID loop setpoints.
(viii) Enter temporary override schedules.
(ix) Define holiday schedules.

(x) Change time/date.
(xi) Automatic daylight savings time adjustments.
(xii) Enter/modify analog warning and alarm limits.

2. Reporting

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

(i) A general listing of all points in the network
(ii) List of all points currently in alarm
(iii) List of all points currently in override status
(iv) List of all disabled points
(v) List of all points currently locked out
(vi) DDC Controller trend overflow warning
(vii) List all weekly schedules

3. Scheduling

a. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide schedules for 365 days in advance.
b. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
c. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.

4. Collection and Analysis of Historical Data

a. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data shall be stored on hard disk for future diagnostics and reporting.
b. Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred directly to an off-the-shelf spreadsheet package such as Excel. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.
c. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both historical and/or real-time dynamic point data. A minimum of 10 points shall be viewed

simultaneously on a single graph. The user may pause the graph and take "snapshots" of screens to be stored on the hard disk for future recall and analysis. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.

(i) Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.

(ii) Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

5. Dynamic Color Graphic Displays

a. All workstation(s) shall be provided with color graphics. All workstation(s) software shall include a graphical viewing and control environment and definition and construction of dynamic color graphic displays.

b. Provide system color graphics for each HVAC system and for each electrical, plumbing and/or piping system that is monitored and/or controlled by the BMS Provide scaled floor plans indicating equipment location, service, and system data as required.

c. Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems and hot water systems to optimize system performance analysis and speed alarm recognition.

d. 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.

e. 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.

f. The windowing environment of the PC operator workstation(s)shall allow the user to simultaneously view several graphics at a 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.

g. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays via an off the shelf graphics package similar to MicroGraphix Designer.

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

(ii) 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 aids the operator in the analysis of the facility.

h. Provide an automatically updated, dynamic display of the site-specific BMS architecture indicating the status of primary and secondary controllers, PC workstation(s) and networks.

i. Provide a separate dynamic display page of each HVAC (AHU, AC, chiller, cooling tower, fuel oil, etc.), electrical, and/or plumbing system connected to the BMS.

j. Provide a separate dynamic display page of each piece of terminal equipment (VAV box, fan coil unit, etc.) connected to the BMS.

k. Provide an additional (10) separate dynamic, graphic display pages at each workstation as required by the operating staff to further assist in daily system operations.

l. Graphics shall incorporate all system integration points communicated via hardware or software gateways and/or interfaces. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

6. System Configuration and Definition

7. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

a. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add, delete or modify any system object including Primary Control Panel(s), operator workstations(s), Secondary Control Panels, reporting definitions, control loops, energy management applications, time and calendar-based programming, totalization, historical data trending, custom control processes, graphic displays, operator passwords, alarm messages, etc.

b. Definition of operator device characteristics for individual points, applications and control sequences shall be performed using instructive prompting software.

(i) Programming shall be performed with the BMS system online and shall not interfere with BMS system operation.

(ii) Inputs and outputs for any process shall not be restricted to a single Primary Control Panel, but shall be able to include data from any and all other network 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).

(iii) Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation(s) are on-line without disrupting

other system operations. Changes shall be automatically recorded and downloaded to the appropriate Primary Control Panel. Similarly, changes made at the Primary Control Panels shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.

(iv) Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.

C. Telecommunication Capability:

1. Provide all hardware and software to allow operators at dial-up workstation(s) the ability to perform all BMS operator workstation functions as specified herein.
2. Auto-dial/auto-answer communications shall be provided to allow any part of the BMS to communicate with remote operator workstations and/or remote terminals on an intermittent basis via voice-grade telephone lines. Auto-dial Primary Control Panels shall automatically place calls to workstations to report alarms or other significant events.
3. DDC Controllers shall be able to store a minimum of 10 phone numbers of at least 20 digits. Retry a single primary number at a fixed interval until successful.
4. The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers. Provide as a minimum 3 secondary numbers when communications cannot be established with the primary device.
5. 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 network. Routines shall be provided to automatically answer calls from remote Primary Control Panels. The fact that communications are taking place with remote Primary Control Panels over telephone lines shall be completely transparent to an operator.
6. An operator shall be able to access remote buildings by selection of any facility by its logical name. The workstation dial-up program shall store the phone numbers of each remote site, so the user shall not be required to remember or manually dial telephone numbers.
7. A PC workstation may serve as an operator device on a network, as well as a dial-up workstation for multiple auto-dial Primary Control Panels or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with network activity nor shall network activity keep the workstation from handling incoming calls.
8. Dial-up communications shall make use of Hayes compatible modems and voice-grade telephone lines. Provide modems rated at 28,800 BPS.

D. Web Based Operator Interface:

1. A graphical interface shall be provided that allows customers to access the BMS data via the Internet or Intranet. This interface shall use HTML-based pages to send and receive data from a BMS system to a web browser.
2. The software shall run on the Microsoft Internet Explorer (5.0 or higher) and the Netscape (4.0 or higher) browsers.
3. The interface shall provide four levels of user access. Users will range from read-only access to BMS data (level 4) to having complete access to view and modify BMS data and user accounts (level 1).

4. The interface shall provide a user account utility, complete with a user profile database that includes user ID, encrypted password, access level, and language preference. Operators with the appropriate access level shall be able to add, modify, and delete users within the user profile database, as well as change users' access levels.
5. The interface shall provide a means by which the user can collect items (BMS data points) into "summary" groups. This functionality shall allow authorized users to perform actions ranging from viewing summary groups, to adding items to or deleting items from groups, to creating new summary groups.
6. The web-based interface shall provide the following four screens (or views) and the indicated functionality for each:

    a. Logon screen – allows the user to enter his or her user name and password for logging into the system.
    b. System view – which provides a browser to view the available OPC servers and the branches of information (BMS data points) registered within each.
    c. Summary view – allows the user to view items that have been grouped together into summaries, and allows authorized users to modify or delete groups or items within a group.
    d. User Account view – displays a list of the currently defined users and the corresponding user information. Users with level 2 access can change their passwords. Users with level 1 access can also modify and delete other users' information.
    e. The interface shall provide navigation tools for moving between the System, Summary, and User Account views. In addition, it shall provide tools for gaining access to help and for logging out of the system.

E. Portable Operator's Terminal

1. Provide one (1) portable operator's terminal(s).
2. The POT shall be hand-held and plug directly into individual Primary and Secondary control panels as described below. Provide a user-friendly, English language-prompted interface for quick access to system information.
3. Functionality of the portable operator's terminal connected at any Primary Control Panel:

    a. Logon to system using same operator passwords utilized with PC operator workstation(s) and/or remote modem(s).
    b. Access all network information from Primary Control Panels, if authorized by password level.
    c. Display all point, selected point, and alarm point summaries.
    d. Display all trending and totalization information.
    e. Add, modify, and/or delete any existing or new system point.
    f. Command, change setpoint, enable/disable any system point.
    g. Acknowledge all alarms.
    h. Connect to local logging and report printer.

4. Simultaneous connection of all POTs to any control panel shall not:

    a. Interrupt or interfere with normal network operation in any way.
    b. Prevent alarms from being transmitted.
    c. Preclude any centrally-initiated commands and/or system modification.

2.4 PRIMARY CONTROLLER

A. Primary Control Panel Hardware

1. Spare Capacity

a. All Primary Control Panels shall be installed with spare points (minimum 2 of each type) and spare memory capacity for future connections. Provide all hardware software, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

b. Provide all necessary hardware for a complete operating system as required. All hardware shall reside in each Primary Control Panel. Primary Control Panels shall not be dependent upon any higher level computer or another controller for operation.

c. Each Primary Control Panel shall, at a minimum, be provided with:

(i) Appropriate NEMA rated enclosure.
(ii) A stand-alone, multi-tasking, multi-user, real-time digital control microprocessor module.
(iii) Primary Network communication module, if needed for primary network communications.
(iv) Secondary Network communication module, if needed for secondary network communications.
(v) Memory module to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.
(vi) Data collection/ Data Trend capability.
(vii) Power supplies as required for all associated modules, sensors, actuators, etc.
(viii) Input/output point modules as required including spare capacity.
(ix) Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.
(x) A portable printer connection port.
(xi) A portable operator terminal connection port to allow the temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
(xii) Monitoring of all industry standard types of analog and digital inputs and outputs.
(xiii) Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.

d. Each Primary Control Panel shall continuously perform self-diagnostics on all hardware and network communications.

e. Each Primary Control Panel shall provide battery backup to support the real-time clock and all memory and programs for a minimum of 72 hours.

f. Each Primary Control Panel shall support firmware upgrades without the need to replace hardware.
g. Each controller shall support its associated secondary network(s).
h. Primary control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
i. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

j. Provide one primary control panel each AHU, AC unit, primary hot water system, etc.

2. Primary Control Panel Software

a. Provide all necessary software for a complete operating system as required. All software shall reside in each Primary Control Panel. Primary Control Panels shall not be dependent upon any higher level computer or another controller for operation.
b. All points, panels and programs shall be identified by a point descriptor. The same names shall be displayed at both the Primary Control Panel(s) (via portable terminal, printer or modem) and the PC operator workstation(s). In addition to the point's descriptor and the time and date, the user shall be able to print, display or store an alarm message to more fully describe the alarm condition or direct operator response. Alarm messages shall be coordinated with the Owner.
c. All digital points shall have a user-defined, two-state status indication.
d. Each Primary Control Panel shall, at a minimum, be provided with software for:

(i) Two-position control, proportional control, proportional plus integral control, proportional, integral, plus derivative control algorithms, all with automatic control loop tuning.
(ii) Limiting the number of times each piece of equipment may be cycled within any one-hour period.
(iii) 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. Upon the resumption of power, each DDC Controller 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 operations.
(iv) Priority load shedding.
(v) Energy management routines including time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start-stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating /

cooling interlock, supply temperature reset, priority load shedding, and power failure restart.

(vi) Custom, job-specific processes defined by the user, to automatically perform calculations and special control routines and sequences of operations.

(a) It shall be possible to use any system measured point data or status, any system calculated data, a result from any process or any user-defined constant in any controller in the system.
(b) Any process shall be able to issue commands to points in any and all other controllers in the system.
(c) Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
(d) The custom control programming feature shall be documented via English language descriptors.

(vii) Generate and receive automatic and manual operator messages and advisories.
(viii) Interactive HELP function to assist operators connected via POTs and modems.
(ix) Comment lines for all programs.
(x) Distributed, independent alarm analysis and filtering. Reporting of selected alarms during system shutdown and start-up shall be automatically inhibited. A minimum of six priority levels shall be provided for each point.
(xi) Automatically accumulate and store run-time hours for all digital points.
(xii) Automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and pulse input type points.

e. Trend data shall be stored at the Primary Control Panels and automatically uploaded to the PC workstation. All trend data shall be available for use in any 3rd party personal computer applications located in the BMS

f. Primary Control Panels shall be able to assign password access and control priorities. The logon password (at any PC workstation(s)or portable operator terminal) shall enable the operator to monitor, adjust and/or control only the systems, programs, primary control panel, and/or secondary control panels that the operator is authorized for. Passwords and priority shall be fully programmable and adjustable.

g. Primary Control Panels shall be able to access any data from, or send control commands and alarm reports directly to, any other Primary Control Panel or combination of controllers on the network without dependence upon a central or intermediate processing device. Primary Control Panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

h. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller 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 Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

(i) All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

(ii) 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. Priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller 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.

(iii) Alarm reports and messages will be directed to a user-defined list of operator devices or PC's.

(iv) In addition to the point's descriptor and the time and date, the user shall be able to print, display or store the alarm message to more fully describe the alarm condition or direct operator response.

(v) Each DDC Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

i. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points.

(i) DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

(a) Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided.

(b) Trend data shall be stored at the DDC Controllers and automatically uploaded to the workstation. Uploads shall occur based upon user-defined interval, manual command or automatically. All trend data shall be available for use in any 3rd party personal computer applications.

(c) DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance.

j. DDC Controllers shall automatically accumulate and store run-time hours for all digital input and output points.

k. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

l. DDC Controllers shall 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 and monthly basis for all points

2.5 SECONDARY CONTROLLER

A. Secondary Control Panel Hardware

1. Each Secondary Control Panel shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each secondary control panel shall be a microprocessor-based, multi-tasking, real-time digital control processor.

2. Provide a Secondary Control Panel for each of the following types of equipment (if applicable):
   a. Reheat Coils
   b. Variable Air Volume (VAV) Boxes
   c. Other terminal equipment

3. Each Secondary Control Panel shall, at a minimum, be provided with:

   a. Appropriate NEMA rated enclosure.
   b. A stand-alone real-time digital control microprocessor module.
   c. Secondary network communications ability.
   d. Power supplies as required for all associated modules, sensors, actuators, etc.
   e. Input/output points as required.
   f. Software as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.
   g. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.
   h. Each controller measuring air volume shall include a differential pressure transducer.
   i. SCR control of electric heaters.
   j. Fan speed controller for fan powered VAV boxes
   k. Fan relay for fan powered VAV boxes and fan coil units

4. Each Secondary Control Panel shall continuously perform self-diagnostics on all hardware and secondary network communications. The Secondary Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failure to establish communication to the system.
5. Provide each secondary control panel with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or a minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy

requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

6. The secondary control panels shall be powered from a 24 VAC source provided by this contractor and shall function normally under an operating range of +/- 10%, allowing for power source fluctuations and voltage drops. The controllers shall also function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 90% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

B. Secondary Control Panel Software

1. Provide all necessary software for a complete operating system as required. All software shall reside in each Secondary Control Panel. Secondary Control Panels shall not be dependent upon any higher level computer or another controller for operation.
2. Each secondary controller shall perform its primary control function independent of primary controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the primary control panel time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional and integral (PI) control for all applications. All PI parameters shall be field-adjustable by the user via a portable operator's terminal.
3. Secondary control panels shall support pressure independent terminal boxes including VAV cooling only, VAV with hot water or electric reheat, Fan-powered VAV and Fan-powered VAV with hot water or electric reheat. All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

2.6 INPUT DEVICES

A. General

1. All devices and equipment shall be approved for installation.
2. Provide the following field devices as required by the monitoring, control and optimization functions listed elsewhere in this specification.
3. All sensor signals shall be via a 4-20 ma loop.

B. Analog Inputs

1. Temperature Sensors (Not Including Space Temperature Sensors)

a. All temperature sensors shall use RTD (Resistance Temperature Detector) elements. All control signals shall be via a 4-20 ma loop.
b. Calibration adjustments: Zero & Span.
c. Any point, physical or calculated may be designated for trending.
d. Provide Minco or equal.
e. Range:

Liquid Immersion Temperature	+20/+120 F, +70/+220 F
Duct (Single Point) Temperature	+20/+120 F, +70/+220 F

Duct (Averaging) Temperature	+20/+120 F
Outside Air Temperature	-50/+122 F

2. Space Temperature Sensors

   a. RTD or thermistor type
   b. Accuracy: +0.5 F
   c. Operating Range: 80 Degree Range Maximum
   d. Setpoint Adjustment Range: 55 to 95 F
   e. Shall include a terminal jack integral to the sensor assembly to allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.
   f. Concealed setpoint adjustment switch with software limits.
   g. Push-button override switch. The override switch may be locked out, overridden, or limited as to time through software by an authorized operator.
   h. Room sensors shall not be located on outside walls.
   i. The length of wiring from the space temperature sensor to the controller shall not exceed 100 ft.

3. Humidity Sensors

   a. All control signals shall be via a 4-20 ma loop.
   b. Sensor Range: 0 to 100%
   c. Accuracy: ±2% RH
   d. Sensing element: Capacitive sensor
   e. Operating Temperature: 15F to 170F
   f. Supply Voltage: 12 - 36 VDC
   g. Provide Hycal or equal

4. Dewpoint Sensors

   a. Accuracy: + 2.0 Fdp
   b. Range: -40/+115 F DP

5. Water Differential Pressure Sensor

   a. Provide industrial grade sensors for all differential pressure bypass valves.
   b. Factory calibrated for operating range.
   c. Rated for system pressure.
   d. Manufacturers standard 316 stainless steel.
   e. 3 valve manifold and pressure gauges for supply and return pressures.
   f. Output shall be 4-20 ma.
   g. Rosemount 1151DP, with 316 stainless steel or approved equal.

6. Differential Pressure Transmitter

   a. Sensor

      Accuracy: 5% at 400 to 4000 FPM (2 to 20.4 m/s)
      Range: 0 to 4000 FPM (0 to 20.4 m/s)

7. Static Pressure Sensor

a. Accuracy: 1% full scale.
b. Transmitter: 4-20mA.
c. Range shall be as required by application.
d. Provide Setra or equal.

8. Airflow Measuring Stations

a. Station

(i) Airflow measuring stations required to accomplish the specified control sequence shall be furnished under this section but installed under the sheet metal section. Airflow measuring stations shall be of heavy gauge metal construction, and shall be furnished with an air straightening section with an open face area of not less than 97%.
(ii) Each airflow measuring station shall measure airflow by means of a network of static and total pressure sensors factory positioned and connected in parallel to produce an averaged velocity pressure. The measured velocity pressure converted to airflow (CFM) shall have an accuracy of 2% of the full scale throughout the velocity range from 700 to 4,000 FPM when measured under ideal laboratory conditions. The location of stations shall meet manufacturer's guidelines.
(iii) The maximum resistance to airflow shall not exceed 0.6 times the velocity head. The unit shall be suitable to withstand temperatures up to 250F.
(iv) All interconnecting tubing between the air measuring and any remote metering or control shall be furnished and installed by the supplier of the station. A minimum of one static and one total pressure sensor shall be used for every 16 sq. inches of duct cross sectional area for ducts up to four sq.ft. in cross section. For larger ducts, a minimum of one static and one total pressure sensor shall be used for every 36 sq. inches of duct cross sectional area.
(v) Interconnecting sensor manifolds shall equalize and relate each type of sensor measurement into one total pressure and one static pressure metering port. The permanent system pressure loss created by the unit shall not exceed .15 of a velocity head. Each airflow measuring station shall consist of 16-gauge sheet metal casing and an air straightening section with an open face area not less than 97%. The sheet metal contractor shall install air measuring stations.
(vi) Provide Air Monitor Fan-E or equal with an accuracy of + 2%, a turndown of 6 to 1, and no pressure loss across the station.
(vii) Final locations to be coordinated with sheet-metal contractor and manufacturer to ensure installed actual accuracy meets specifications.

b. Velocity Pressure Sensor For Airflow Measuring Stations

(i) Range: 0.1 to 0.5"wg (Size based on ABMS Output).
(ii) Accuracy: + 0.25" W.G.

(iii) Transmitter: 4 - 20 ma.

9. Analog Water Level Sensors

a. Furnish and install full height, analog level sensors for each location as specified. Sensor shall provide 4-20ma signal in proportion to basin water level. Provide waterproof enclosure and mounting hardware as required.
b. Sensor shall be Drexel Brook or equal.

10. Flow Meters

a. Provide insertion type, turbine flow meters designed to mount through a fully open, 1 inch full bore ball valve supplied by flow meter manufacturer. Meter flow range shall be 2-40 feet/second for liquid service. Meter linearity shall be +/-1% for a 10:1 range. Repeatability shall be 0.10%. Turbine head and stem shall be constructed of stainless steel, bearings shall be tungsten carbide, and housing and flange shall be carbon steel. Housing pressure rating shall be 350 PSI. A D.C. powered, two-wire transmitter shall be mounted on the flow meter. The flow transmitter output shall be a 4-20 madc signal that is linear with flow. Transmitter input shall be from magnetic pickup. Transmitter accuracy shall be 0.25% of span.
b. Provide an isolation valve kit for turbine flow meters, including isolation valve, bypass valve, nipple, etc., to allow service and removal under pressure and while system is operating.
c. Turbine meter shall be Onicon F 1220 or equal.

11. Methane Monitoring System

a. The methane leak detectors shall be catalytic-bead type with a demonstrated resistance to silicones and reduced sulfur compounds. Detectors shall have a typical life span of three years. The sensors shall have a dual housing with the sensor and transmitter in separate housings, with sensors located up to 50 feet from the transmitter. Housings shall be explosion proof for Class 1, Group B, C and D, Division 1 areas. Input power shall be 250ma at 24VDC. Response time shall be less than 5 seconds to final reading, from a step change in gas concentration. Sensor/transmitter repeatability shall be +/- 1% full scale. Transmitter signal shall be 4-20 ma.
b. The detection system shall be MSA model 487817 or equal.
c. Provide a calibration kit (flow system type) including zero gas and test gas. Turn over complete kit to owner at warranty start date.
d. Power 24VDC power supply as required from Emergency source.
e. Provide leak detection for each gas riser shaft. Provide three sensors per riser or as per manufacturers recommendation, whichever is greater. Submit sensor and electronic transmitter locations for approval.

12. Carbon Dioxide Sensor

a. The carbon dioxide detectors shall be catalytic-bead type with a demonstrated resistance to silicones and reduced sulfur compounds. Detectors shall have a typical life span of three years. The sensors shall have a dual housing with the sensor and transmitter in separate housings, with sensors located up to 50 feet from the transmitter. Housings shall be explosion proof for Class 1, Group B, C and D, Division 1 areas. Input power

shall be 250ma at 24VDC. Response time shall be less than 5 seconds to final reading, from a step change in gas concentration. Sensor/transmitter repeatability shall be +/- 1% full scale. Transmitter signal shall be 4-20 ma.

b. The detection system shall be MSA model 487817 or equal.
c. Provide a calibration kit (flow system type) including zero gas and test carbon dioxide gas. Turn over complete kit to owner at warranty start date.
d. Power 24VDC power supply as required from Emergency source.

13. Carbon Monoxide Monitoring and Control System

a. The sensor/transmitter shall be the MSA model 212376 with a range of 0-200 PPM full scale, or equal.
b. The sensor/transmitter shall incorporate a solid-state, semi-conductor type sensor offering a minimum useful life span of 8 years.
c. The sensor/transmitter shall be 3-wire, 4-20 ma design and shall operate on 24Vdc. The output of the unit shall be linearized to the full scale range.
d. The transmitter circuitry shall include full temperature and humidity compensation and shall incorporate a purge cycle to periodically heat the semiconductor to a high temperature to allow recovery from iterferent gases and high CO concentrations.
e. The response time of the unit, accounting for the purge cycle, shall be 150 seconds or less to 90% of a step change in CO level.
f. The sensor unit shall be provided with a suitable Nema enclosure for wall mounting in loading dock area and garage area.
g. Provide a green LED for power on, a red LED for sensor failure, a yellow LED for CO warning level reached and a red LED for CO alarm level reached. LEDs shall be visible from the outside of the unit enclosure.
h. Provide a calibration kit (flow system type) including zero gas and test gas. Turn over complete kit to owner at warranty start date.
i. Power 24VDC power supply as required from Emergency source.
j. Provide one sensor/transmitter per 5,000 square feet of parking garage and loading dock.

14. Hydrogen Leak Detectors

a. The hydrogen leak detectors shall be catalytic-bead type with a demonstrated resistance to silicones and reduced sulfur compounds. Detectors shall have a typical life span of three years. The sensors shall have a dual housing with the sensor and transmitter in separate housings, with sensors located up to 50 feet from the transmitter. Housings shall be explosion proof for Class 1, Group B, C and D, Division 1 areas. Input power shall be 250ma at 24VDC. Response time shall be less than 5 seconds to final reading, from a step change in gas concentration. Sensor/transmitter repeatability shall be +/- 1% full scale. Transmitter signal shall be 4-20 ma.
b. The detection system shall be MSA model 487817 or equal.
c. Provide a calibration kit (flow system type) including zero gas and test hydrogen gas. Turn over complete kit to owner at warranty start date.
d. Power 24VDC power supply as required from UPS source.
e. Provide for each battery room. Quantity of sensors shall be based manufacturers recommendation or as shown, whichever is greater, and submitted for approval.

15. Outside Air Volume Sensor/Controller

    a. Provide an outside airflow measuring and control system utilizing DDC controls as required by the plans and specifications. System shall be designed to provide accurate measurement without upstream and downstream ductwork.
    b. Outside airflow measuring and control system shall have a velocity range from 45 ft/min to 6000 ft/min with a minimum accuracy of 5.0%. Each sensor in the array shall be independently processed for velocity value.
    c. Provide 0-10 VDC or 4-20 ma signal proportional to velocity to Control Panel. Control Panel shall modulate damper to maintain setpoint.
    d. Provide Dybec, Ruskin or equal.

C. Binary Inputs

1. Water Differential Pressure Switches

    a. Range:8 to 70 PSI
    b. Differential: 3 PSI
    c. Maximum differential pressure: 200 PSI
    d. Maximum pressure: 325 PSI
    e. Provide Mercoid or equal
    f. Shall be used for all pump status specified in the point schedule.

2. Air Differential Pressure Switches

    a. Diaphragm type.

    b. Die-cast aluminum housing.
    c. Adjustable setpoint.
    d. Switch rating shall be a minimum of 5 amps at 120 VAC.
    e. Switches shall be SPDT.
    f. The switch pressure range shall be suited for the application.
    g. Provide Dwyer or equal.

3. Freezestats

    a. Furnish and install, for each air handling unit with outdoor air connections, a low temperature safety thermostat (freezestat) with a 20 ft. sensing element.
    b. There shall be one freezestat per coil section.
    c. Element shall be installed in a serpentine fashion across the inlet of the cooling coil in the air stream.
    d. Element shall be arranged to stop the unit supply fan and its associated return air fan should the temperature at any point along the sensing element fall below 35oF for an adjustable time period.
    e. Low temperature detector shall be automatic reset, DPDT type.
    f. Provide manual reset button at primary control panel and time delay relay to lockout fan if freeze condition exists for more than 60 seconds. Time delay relay shall be adjustable up to 5 minutes.

4. Current Sensing Relay

a. Provide and install current sensing relays for all motor status points 5HP and greater. Sensor shall be split core, two wire, loop powered and sized for expected amperage. Unit shall be UL listed. Provide status LEDs for current sensed below setpoint, current sensed above setpoint and loop power failure. The unit shall automatically range itself and have solid state outputs.

D. Miscellaneous Monitoring Systems

1. Energy Metering System

a. Provide energy (condenser, chilled, and hot water) electric metering, reporting and tracking system including all meters, sensor and software. The system shall record, store and report energy consumption, integral to the BMS operator workstation(s)software. The software shall be Excel spreadsheet based, and operate in a Windows environment.

b. For all water flow meters, provide supply and return temperature sensors for "Delta-T" calculation of BTU consumption. Monitor total accumulated BTUs, current BTUs, monthly total BTUs, and yearly total BTUs for each location specified or shown.

c. 3P/4W Watt Transducer

(i) Provide transducer as required. Input signal shall be a maximum of 0-480 Volts and 0-1000 Amps with a corresponding output of 4-20 ma. Sensor shall be sized to be mid-scale amperage at normal conditions. Response time shall be a maximum of 250 sec with an accuracy of +/- 0.5% full scale. The unit shall be field calibratable and be as manufactured by Kele or equal.

d. Current Transformer

(i) Provide transducer as required. Input signal shall be a maximum of 0-1000 Amps with a corresponding output of 0-5 Volts. Sensor shall be sized to be mid scale amperage at normal conditions. Response time shall be a maximum of 250 msec with an accuracy of +/- 0.5% full scale. The unit shall be split core and as manufactured by Crompton, or equal.

2. Refrigerant Monitoring System

a. The HVAC Contractor shall furnish the refrigerant monitoring system. The refrigerant monitoring system shall be installed and wired by the BMS contractor.

b. Install a long-term, refrigerant leak detection system to detect A1 and B1 refrigerant leaks furnished this contractor. The leak detection system shall transmit alarms to the BMS via dry contacts. Each refrigeration machine shall be monitored by two sensors, located on either side of the machine and 18 inches above the floor. The system shall utilize a multi-channel scanner to monitor each sensor location and provide a method for setting the zero reference point. The following alarm relay outputs shall be monitored by the BMS:

(i) TLV, start purge ventilation
(ii) STEL, three times TLV

(iii) EEL
(iv) Failure relay.

c. The system shall be provided with a remote reset switch, located outside the plant. The alarm shall be reset only after the refrigerant is cleared.
d. Provide an alarm horn, strobe light and silence switch at each entrance to the plant, above the break glass switch. Alarm to activate when leak occurs. Horn shall be silenceable from switch and strobe shall continue to operate until condition is cleared.
e. Provide emergency power to system.
f. System shall be MSA "Chillgard IR" or equal.
g. The BMS Contractor shall coordinate with the HVAC Contractor and the successful refrigeration machine manufacturer to determine the location of refrigerant sensors and panels.

3. Environmental Monitoring System

a. Provide and install all environmental monitoring system devices sensing lines, filters, terminal panels, etc. as manufactured by Ambient Labs, Inc. (212-463-7812).

4. Fuel Oil Meters

a. Provide fuel oil flow meter on fuel oil supply for duplex fuel oil pump set. Meters shall be contacting head type approved for use in fuel oil systems. Monitor total accumulated flow, current flow, monthly total flow, and yearly total flow for each duplex pump set and jockey pump specified or shown.
b. Meter shall be intrinsically safe, explosion proof with a minimum resolution of 10 gallons with G.P.M. range appropriate for application.

5. Water Leak Detection System

a. General

(i) Furnish and install a complete water detection system for each area specified. The system shall include electronic alarm and locating modules, sensing cable, graphic maps and all auxiliary equipment. The system shall simultaneously detect the presence of water at any point along the cable's length, sound an alarm, and pinpoint the distance to the leak. The sensing cable shall be of such construction that no metallic parts shall be exposed to the environment. The system shall provide pre-connecterized sensing cable and components. The system shall be UL listed and FM approved.
(ii) The water leak detection system shall be installed in the following areas: (Add locations for water leak detection system).
(iii) The system shall be as manufactured by Raychem Corporation or equal.
(iv) Provide two sets of test instrumentation to owner.

b. Locating leak detection panel (TTB-FA)

(i) The alarm and locator module, TTB-FA, shall monitor up to a maximum of 1000 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm, actuating an output relay, sending a proportional 4-20 ma signal to the BMS and displaying the distance from the start of the sensing cable to the start of the first contact with water. The location of the first water contact shall be retained on the display until the cable is dry and the module is updated.

(ii) The alarm module shall be capable of detecting the presence of a 1 inch leak anywhere along the cable with a repeatability of +/- 1%.

(iii) The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a "continuity" LED on the face of the module.

(iv) The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow). The module shall be equipped with exposed test, reset and silence buttons. All other functions shall require key access.

(v) The alarm module shall be powered by emergency power.

(vi) The module enclosure shall be a minimum of 16 gauge steel, flush mounting type.

c. Single point leak detector

(i) The alarm module, TTC, shall monitor up to a maximum of 50 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm and actuating an output relay. The relay shall remain activated until the cable is dry and the module is reset.

(ii) The alarm module shall be capable of detecting the presence of a 1 inch leak anywhere along the cable with a repeatability of +/- 1%.

(iii) The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a "continuity" LED on the face of the module.

(iv) The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow).

(v) The alarm module shall be powered by emergency power.

(vi) The module shall be mounted in a field equipment cabinet.

d. Water sensing cable

(i) The water sensing cable (TT-1000) shall detect the presence of water and pinpoint its location. The cable shall consist of four wires: Two sensor wires, a continuity wire and a return wire. All four wires shall be coated and insulated with a fluoropolymer and wound helically around a flouropolymer core. The cable shall have a breaking strength, including connectors, of at least 70 pounds, per ASTM D-638. The cable shall have an abrasion resistance of >65 cycles, per UL 719.

(ii) The sensing cable shall offer distributed sensing with the ability to detect the location of water at any point along the length of the

cable. The cable shall be flexible, and carry less than 24VDC under normal conditions.

(iii) The system shall not alarm when in contact with any metallic equipment such as drip pans, floor tile supports, conduit, etc.

(iv) The cable shall be available in modular, pre-connectorized lengths of 5, 10, 15, 25 and 50 feet. Field splicing shall not be acceptable.

(v) The cable shall be UL 910 rated and plenum rated per NEC 725-2(b).

e. Jumper cable

(i) Jumper cable shall be used where leak detection cable is not required but continuity is required (in raceways between alarm module and floor surface, etc.). The jumper cable shall be plenum-rated and jacketed with fluoropolymer materials, as per NEC 725-2(b). The jumper cable shall consist of four different color (Y, B, R, G), insulated 18 AWG wires and shall be available in pre-connectorized lengths of 5, 10, 15, 25 and 50 feet.

f. Accessories

(i) Provide all end connectors, leader cables, hold down clips, caution tags, spray adhesive (3M 90M) as required.

g. Graphic display map

(i) Provide a graphic display map for each room served. The map shall be a 1/8 in = 1.0 ft scaled drawing of the area served, indicating actual equipment locations, floor tile and other points of reference. The actual cable routing shall be clearly marked on the map with actual scaled distances every 10 feet.

(ii) A dynamic graphic display, equivalent to the aforementioned map, shall be duplicated on the BMS operator workstation. The area in alarm (within 5 feet) shall blink in red until the alarm is cleared.

h. Performance

(i) A maximum wetted area of 2 inches of cable, at any point along the entire length of cable, shall activate an alarm.

(ii) The system shall be continuously monitored for continuity. The loss of continuity shall cause an alarm within 5 seconds.

(iii) The cable shall be capable of being cleaned with a clean dry cloth, in place.

(iv) The cable shall dry and reset the module immediately upon removal from free water. No shaking, wiping or mechanical action shall be required.

i. Installation

(i) All system components shall be installed in accordance with the manufacturer's recommendations. The manufacturer shall provide necessary installer training and supervision as required.

(ii) The cable shall be installed on clean, dry finished surfaces only (coordinate access and schedule installation as required) after the possibility of physical damage has been eliminated. The cable shall be fastened to the surface it is monitoring every 4 feet with hold down clips and spray mastic adhesive. Hold down clip installation shall be subject to spot checks during commissioning. If any clip fails, all other clips shall be re-attached and re-tested, at no additional cost.

(iii) The system shall be commissioned prior to acceptance. Submit a test procedure for approval.

j. Warranty

(i) All equipment shall be warranted to the same extent as the BMS system, or per the manufacturer's warranty, whichever is greater.

6. Audio/Visual Alarm Units

a. Provide one (1) audio/visual alarm unit(s) that shall be located
b. Each audio/visual alarm unit shall include a 1" x 3" translucent illuminated rectangular alarm light ("BMS Alarm"), a Sonalert horn (hidden), a silence switch with stainless steel cover plate to match mounting surface. When any BMS alarm occurs (as coordinated with facilities personnel), the alarm light shall flash once per second (adjustable) and the horn shall sound. When the silence switch is pushed, the horn will silence and the pilot light shall light continuously until alarm is cleared.
c. The BMS shall monitor the alarm light, horn and silence switch status.
d. Provide 1/8 inch high engraved and painted lettering for operational instructions as required by the owner on the cover plate

2.7 OUTPUT DEVICES

A. General

1. All devices and equipment shall be approved for installation.
2. Provide the following field devices as required by the monitoring, control and optimization functions listed elsewhere in this specification.

B. Actuation

1. **[Electric-Only Actuation**

a. **All valve actuation shall be electric. Pneumatic actuation is not acceptable.]**

2. **[Pneumatic and Electric Actuation**

a. **All valve and damper actuation shall be pneumatic except for terminal equipment valves and dampers which shall be electric. Terminal equipment includes:**

(i) **Cabinet Unit Heaters**
(ii) **Constant Air Volume (CAV) boxes**

(iii) **Duct-mounted reheat coils**
(iv) **Fancoil Units**
(v) **Fan-Powered Variable Air Volume (VAV) Boxes**
(vi) **Radiation**
(vii) **Supplemental AC units**
(viii) **Unit Heaters**
(ix) **Variable Air Volume (VAV) boxes]**

3. Incremental Electronic Actuator for Terminal Equipment Valve and/or Damper Actuation

a. Incremental actuators shall be allowed for terminal equipment only.
b. Actuators shall be proportional, electronic, direct-coupled actuators used for modulating service. Actuators shall be equipped with metal housings and visual stroke indicators.
c. Actuators shall be equipped with a permanent manual adjustment.
d. Minimum Torque: 35 in-lb.
e. Operating Voltage: 24 VAC.
f. Input Signal: 3 wire floating, 0 – 10 VDC, or 4 – 20 ma.
g. Frequency: 50, 60 Hz.
h. Power Consumption: 1.5va maximum.
i. Spring Return Time: 20 seconds maximum.
j. Nominal Force: 90 lb. Minimum.
k. Stroke: 7/32" (5.5 mm) maximum.
l. For use when the maximum media temperature is 230° F.

4. Valve Actuation

a. All valve actuators shall be sized to close against a differential pressure greater than 125% of the design pump head. Where pressure and flow combinations exceed ratings for commercial valves and actuators, industrial class valves and actuators shall be provided.
b. Valve actuators shall provide smooth modulation at design flow and pressure conditions.
c. Valve actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe Positions are as follows:

(i)	Air-Handling Unit Preheat Valves	Normally Open
(ii)	Air-Handling Unit Cooling Valves	Normally Closed
(iii)	Air-Handling Unit Heating Valves	Normally Open
(iv)	Duct-mounted Reheat Coil Valves	Normally Closed
(v)	All Humidification Valves	Normally Closed
(vi)	Radiation Valves	Normally Open
(vii)	Unit Heater Valves	Normally Open
(viii)	Cabinet Unit Heater Valves	Normally Open

d. **[Electronic Modulating Actuator for Valves 2" and Smaller**

(i) **Actuator shall have electronic, proportional control and shall be direct-coupled with spring return.**

(ii) **Actuators shall be equipped with a clutch release for manual override and visual and electronic stroke indicators.**
(iii) **Operating Voltage: 24 VAC.**
(iv) **Input Signal: 4 - 20 ma.**
(v) **Power Consumption: 18 VA maximum.**
(vi) **Spring Return Time: 15 seconds maximum.**
(vii) **Nominal Force: 225 lb. Minimum.**
(viii) **Stroke: 3/4" (20 mm) maximum.**
(ix) **For use when the maximum media temperature is 300 F.]**

e. **[Electronic Modulating Actuator for Valves 2-1/2" and Larger**

(i) **Actuator shall have electronic, proportional control and shall be direct-coupled with spring return.**
(ii) **Actuators shall be equipped with a clutch release for manual override and visual and electronic stroke indicators.**
(iii) **Operating Voltage: 24 VAC.**
(iv) **Input Signal: 4 - 20 ma.**
(v) **Power Consumption: 28va maximum.**
(vi) **Spring Return Time: 20 seconds maximum.**
(vii) **Nominal Force: 610 lb.**
(viii) **Stroke: 1-1/2" (40 mm) maximum.**
(ix) **For use when the maximum media temperature is 300° F.]**

f. **[Pneumatic Valve Actuation**

(i) **Pneumatic actuators shall be diaphragm piston type with easily replaceable, beaded, molded neoprene diaphragm.**
(ii) **Actuator housings may be molded or die-cast zinc or aluminum.**
(iii) **Actuator size and spring ranges selected shall be suitable for intended application.**
(iv) **Rate pneumatic actuators for a minimum 140 kPa (20 psig).**
(v) **Positive positioner to have the following performance characteristics:**

(a) **Linearity: "10% of output signal span.**
(b) **Hysteresis: 3% of the span.**
(c) **Response: 1/4 psig input change.**
(d) **Maximum pilot signal pressure: 140 kPa (20 psig).**
(e) **Maximum control air supply pressure: 420 kPa (60 psig).**

(vi) **Positive positioners shall be provided on all actuators to provide smooth modulation or proper sequencing.**
(vii) **Positive positioners shall be high capacity force balance relay type with suitable mounting provisions and position feedback linkage tailored for particular actuator.**
(viii) **Positive positioners shall use full control air pressure at any point in stem travel to initiate stem movement or to maintain stem position.]**

5. Damper Actuation

a. Damper actuators shall have external adjustable stops to limit the stroke in either direction.
b. All damper actuators shall have sufficient power to overcome friction of damper linkage and air pressure acting on louvers and to operate the damper smoothly throughout the entire damper range.
c. Actuators shall be sized with a torque greater than 150% of the design damper torque.
d. Actuators shall have mounting arrangement for location outside of the air stream. The damper actuators shall be mounted on the damper extension so that it is not burned in the wall construction.
e. Damper actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe Positions are as follows:

(i)	Outside Air Dampers	Normally Closed
(ii)	Return Air Dampers	Normally Opened
(iii)	Exhaust Air Dampers	Normally Closed
(iv)	F/SM, SM Dampers	Normally Closed

f. **[Electric Damper Actuation for Modulating and Two Position Damper Actuation**

(i) **Provide proportional, electronic, direct-coupled spring return actuators for all automatic dampers used for modulating service. Each actuator shall be equipped with a brushless DC motor, self centering shaft coupling, metal housing, permanent manual override, visual stroke indicators, built in adjustable start and span controls, and shall be sized to operate the damper with a torque greater than 150% of the design damper torque. Provide actuators with the following specifications:**

(a)	**Operating Voltage:**	**24 VAC**
(b)	**Input Signal:**	**4-20 ma (modulating),**
	on/off	
	(two position)	
(c)	**Frequency:**	**50, 60 Hz**
(d)	**Power Consumption:**	**9 VA Maximum**
(e)	**Spring Return Time:**	**15 seconds Maximum**
(f)	**Minimum Torque:**	**144 in-LB**
(g)	**Angular Rotation:**	**90 Degrees]**

g. **[Pneumatic Damper Actuation**

(i) **All damper actuators shall be of the neoprene, rubber diaphragm piston type with easily replaceable diaphragm.**
(ii) **Actuator housings may be molded or die-cast zinc or aluminum.**
(iii) **All damper actuators shall be of the neoprene, rubber diaphragm piston type.**
(iv) **Actuators for vortex dampers, variable pitch-bladed dampers, or vane dampers shall be provided with positive positioners.**

(v) **All damper actuators operating in sequence with other instruments shall have positive pilot positioners incorporating positive mechanical feedback.**
(vi) **Actuator size and spring ranges selected shall be suitable for intended application.**
(vii) **Rate pneumatic actuators for a minimum 140 kPa (20 psig).**
(viii) **Positive positioner to have the following performance characteristics:**

(a) **Linearity: "10% of output signal span.**
(b) **Hysteresis: 3% of the span.**
(c) **Response: 1/4 psig input change.**
(d) **Maximum pilot signal pressure: 140 kPa (20 psig).**
(e) **Maximum control air supply pressure: 420 kPa (60 psig).**

(ix) **Positive positioners shall be provided on all actuators to provide smooth modulation or proper sequencing.**
(x) **Positive positioners shall be high capacity force balance relay type with suitable mounting provisions and position feedback linkage tailored for particular actuator.**
(xi) **Positive positioners shall use full control air pressure at any point in stem travel to initiate stem movement or to maintain stem position.]**

h. Fire/Smoke Damper Actuation

(i) Actuator shall be manufactured and factory-installed by the fire/smoke damper manufacturer.
(ii) Acceptable manufacturers: Ruskin, Imperial or approved equal.

2.8 CONTROL VALVES

A. General

1. All automatic control valves controlled by the central control system (/BMS) shall be furnished by the controls contractor unless noted otherwise in these documents.
2. All automatic control valves shall be installed by the mechanical trade.
3. **[The controls contractor shall provide main air to all automatic valves requiring pneumatic air.]**
4. **[The controls contractor shall provide wiring as follows:**

a. **All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.**
b. **All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.**
c. **All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.**
d. **All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.]**

B. Hot Water / Chilled Water / Condenser Water Control Valves

1. Single-seated.
2. Fully proportioning with modulating plug or V-port inner valves.
3. Body pressure rating and connection type construction shall conform to fitting and valve schedules. The ANSI rating of the valve shall match the ANSI rating of the piping in which the valve is installed. Minimum ANSI rating shall be ANSI 125.
4. Stainless steel stems and trim.
5. Spring loaded Teflon packing with replaceable discs.
6. Quiet in operation.
7. Fail-safe in either normally open or normally closed position in the event of power failure.
8. Capable of operating in sequence with other valves and/or dampers when required by the sequence of operation.
9. Capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.
10. Sized by the control manufacturer and guaranteed to meet the heating and cooling loads as scheduled.
11. Shall be suitable for the pressure conditions and shall be sized to close against 125% of the design pump head.
12. No single valve shall be larger than 2-1/2". Whenever the flow rate is such as to require a valve larger than 2-1/2", then two valves in parallel shall be used, with no one larger than 2-1/2". The valves shall operate sequentially.
13. Where pressure and flow combinations exceed ratings for commercial valves and operators, industrial class valves and operators shall be provided. Control valves shall be sized for a 5 PSI pressure drop at full flow.

C. Steam Control Valves

1. Fully proportioning with modulating plug or V-port inner valves.
2. Stainless steel stems.
3. Spring-loaded Teflon packing with replaceable discs.
4. Quiet in operation.
5. Fail-safe in either normally open or normally closed position in the event of power failure.
6. Capable of operating in sequence with other valves and/or dampers when required by the sequence of operation.
7. Capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.
8. Sized by the control manufacturer and guaranteed to meet the heating and cooling loads as scheduled.
9. Shall be suitable for the pressure conditions and shall close against 125% the differential pressures involved.
10. Body pressure rating and connection type construction shall conform to fitting and valve schedules.
11. All steam valves shall have body pressure ratings equal to or greater than that of the piping in which the valve is installed. Valves 2" and smaller, shall have bronze bodies with screwed connections. All steam valves 2-1/2" and larger shall have cast iron bodies with flanged connections.
12. No single steam valve shall be larger than 2" in size. Where the capacity requires a single valve larger than 2", two valves shall be installed in parallel, 1/3 and 2/3 of the total capacity.

D. Differential Pressure Control Valves

1. Provide for all water systems where modulating water flow conditions are required to prevent excessive pump pressure build-up. Provide a valve for each chilled and hot water system. Valve to be globe type. Provide valves 2" and smaller with screwed end bodies and provide valves 2-1/2" and larger with flanged ends.

E. Butterfly Valves

1. Furnish automatic butterfly valves for isolation requirements as shown on the drawings or required herein.
2. Butterfly valves shall be have body ratings in accordance with the piping specifications.
3. Valves shall be high performance, fully lugged with carbon steel body ANSI 300 as required by pipe specifications.
4. Valves shall be bubble tight with 316 stainless steel disc, stainless steel shaft and reinforced Teflon seat.
5. **[If pneumatic actuation is utilized, actuators shall be fail in place, pneumatic with factory mounted 3 wire, 4-way solenoid valves and open and closed position limit switches.][If electric actuation is utilized, actuators shall be fail in place with factory mounted open and closed position limit switches mounted.]**
6. Provide fail in place, electric actuators with waterproof enclosure and crankcase heater for actuator and accessories mounted outside.
7. Provide manual override hand wheels for each valve.
8. Valves shall be Jamesbury 830L or equal.
9. Butterfly valves will only be approved for cooling tower bypass and all two-position (open or close) applications.
10. Valves must have lug type body connections.

2.9 DAMPERS

A. Refer to Section 23 33 10 - Dampers for additional requirements.

B. Automatically Controlled Dampers

1. Temperature control manufacturer shall provide all actuated dampers which do not have either a fire and/or smoke rating and shall comply with the following:

a. Dampers shall be of the louver type with neoprene or vinyl edged blades and end seals.
b. Louver blades shall be #16 gauge galvanized steel, maximum 8" in width.
c. Frames shall be minimum 4" reinforced flat galvanized steel with welded corners and stiffening and provisions for end seals.
d. All rods shall be non-corrosive material with provision for positive interlocking of blades and actuators on the shaft.
e. Where local codes require fire dampers on outside air intakes, rods shall not be of aluminum construction.
f. All bearings shall be nylon or Teflon.
g. All hardware shall be of non-corrosive material.
h. Two position dampers may be of the parallel-blade type. Modulating dampers shall be of the opposed-blade type.

i. Provide solid stops on all sides of the frames against which the louver shall close in order to provide maximum 2% leakage at 5" static pressure.

j. Automatic damper actuators shall be limited to a minimum of one every sixty square feet for two-position type and one every forty square feet for modulating type.

k. Damper actuators shall meet the same requirements as valve actuators with respect to operating at variable rates of speed, etc., and shall have external adjustable stops to limit the stroke in either direction.

l. All damper actuators shall be of the neoprene or rubber diaphragm piston type, with sufficient power to overcome friction of damper linkage and air pressure acting on louvers and with mounting arrangement for location outside of the air stream, wherever possible.

C. Installation

1. General

a. All electric and/or pneumatic operated dampers which have a fire and/or smoke rating shall be furnished by the mechanical contractor. All other electric and/or pneumatic operated dampers shall be furnished by this Contractor. All dampers shall be installed by the mechanical contractor.

b. The BMS contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The controls contractor shall provide a terminal strip alongside the damper for all dampers he furnishes.

c. The Mechanical contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The mechanical contractor shall provide a terminal strip alongside the damper for all dampers he furnishes.

d. Wiring for motor operated dampers that do not have a fire and/or smoke rating shall be provided by the controls contractor from the damper actuator and any associated end switches and sensors to a terminal strip that is wall mounted alongside the damper.

e. The controls contractor shall provide wiring as follows:

(i) Between the central control system BMS and the terminal strip for all dampers monitored and/or controlled by the BMS whether or not the controls contractor has furnished the damper.

(ii) Between the terminal strip for all dampers and their associated thermostats, pressure switches, etc. whether or not the control contractor has furnished the damper.

f. Dampers incorporating multiple sections shall be controlled in unison. Where more than one (1) actuator serves a damper, then the actuators shall be driven in unison and the control wiring shall be provided accordingly.

g. Dampers incorporating multiple sections shall be designed in such a way that the actuators are easily accessible. Under no circumstances shall it be necessary to remove damper sections or structural or other fixtures to facilitate removal of damper motors. Provide access doors wherever necessary to meet this requirement. In particular, insure that where in-air stream actuators are provided, they are readily accessible.

h. The BMS contractor shall provide all power and control wiring for all automatic, fire/smoke or smoke dampers as required to accomplish the HVAC and smoke control sequences of operation. A portion of this work may also be specified in other areas of the specification. It is the responsibility of the BMS contractor to coordinate this work with the other trades. Any work not performed by others will be the ultimate responsibility of the BMS contractor. The fire alarm system shall be able to open or close each damper, regardless of BMS commands.

i. The following table summarizes the trade responsibilities with respect to automatic dampers:

	NON-FIRE OR SMOKE RELATED DAMPERS	FIRE AND/OR SMOKE RATED DAMPERS NOT CONTROLLED BY FIRE ALARM SYSTEM	FIRE AND/OR SMOKE RATED DAMPERS CONTROLLED BY FIRE ALARM SYSTEM
Furnish Damper	Controls Contr.	Mech. Trade	Mech. Trade
Install Damper	Mech. Trade	Mech. Trade	Mech. Trade
Furnish Actuator(s)	Controls Contr.	Mech. Trade	Mech. Trade
Install Actuator(s)	Mech. Trade	Mech. Trade	Mech. Trade
Install and furnish terminal strip complete with all relays, wiring, etc.	Controls Contr.	Mech. Trade	Mech. Trade
Provide wiring between actuator, end switches, heat sensors, and terminal strip	Controls Contr.	Mech. Trade	Mech. Trade
Provide wiring from Central Control System (BMS) to damper terminal strip	Controls Contr.	Controls Contr.	Controls Contr.
Provide wiring from FAS to damper terminal strip			Electrical Trade
Furnish 120V main power to elect. Actuators (See notes below)	Controls Contr.	Controls Contr.	Electrical Trade
Provide wiring from damper terminal strip to terminal strips for interlocked motors, etc.	Controls Contr.	Controls Contr.	Controls Contr.
Provide wiring from damper terminal strip directly to thermostats, etc.	Controls Contr.	Controls Contr.	Controls Contr.

NOTES

1. Controls contractor shall have overall responsibility for the complete coordination of the work and the operation of the damper/actuator installation.

2. In mechanical rooms 120V power circuits will be provided from an emergency distribution board. These circuits will be terminated in a junction box located in each

associated mechanical room and shall be used by the controls contractor to supply local control panels and critical equipment.

3. These circuits will also be used by the electrical trade to supply dampers, etc. requiring control by the Fire Alarm System. Final connection from the terminal strips to the actuators, end switches and sensors shall be by the mechanical trade.

4. For dampers not requiring control by the fire alarm system and for other non-critical equipment, obtain power from either the emergency circuits as detailed above or from the motor starter terminal trip. All wiring shall be by the controls contractor.

5. Damper Terminal Strips

   a. Terminal strip(s) shall be provided alongside all motorized dampers. If the damper has a smoke and/or fire rating, the terminal strip shall be provided by the Mechanical Trade. If the damper does not have a fire and/or smoke rating then the terminal strip shall be provided by the controls contractor.
   b. Where dampers are furnished by the controls contractor then he shall provide relays, interconnect wiring and other components to meet the requirements detailed below. The terminal strip(s), relays, etc. shall be housed in wall mounted enclosures which meet the specifications detailed for local starter enclosures.
   c. The terminal strip shall be wired such that the Central Control System (BMS) can undertake the following control and monitoring functions:

      (i) Open Control - A pair of terminals shall be wired such that when a controls (BMS) relay closes a contact pair across these terminals the damper is driven open. If the damper is two position with an actuator which drives closed and springs open on loss of power then these terminals shall not be used. This signal from the Central Control System (BMS) shall be overridden by a close signal from the Fire Alarm System (FAS) Where dampers are interlocked to motors then the wiring shall be to these terminals.
      (ii) Close Control - A pair of terminals shall be wired such that when a controls (BMS) relay closes a contact pair across these terminals the damper is driven closed. If the damper is two position with an actuator which drives open and springs closed on loss of power then these terminals shall not be used. This signal from the Central Control System (BMS) shall be overridden by an open signal from the FAS.
      (iii) Motor Interlock - A pair of terminals shall be wired to an end switch on the actuator such that the contacts between the terminals shall be closed when the damper is fully open and open when the damper is not fully open. This pair of terminals shall be used for interlocking a damper with a motor such that the motor will not be able to start if the damper is not fully open.

6. Purge Dampers

   a. For each damper which is to be monitored and/or controlled by the Fire Alarm System (FAS), the damper actuator, heat sensor and end switches shall each be wired by the mechanical trade to a terminal strip(s) mounted

adjacent to the damper so that the FAS can undertake the following control and monitoring functions:

(i) FAS "Open/Close" Control - The damper will be driven open in response to closure of an FAS relay contact and will spring closed in response to opening of this relay contact.

(ii) FAS "Override Open" Control (Smoke Purge Dampers Only) - The damper will be re-opened, subsequent to a heat sensor initiated closure, in response to closure of a second FAS relay contact (or re-closure of the first contact for single sensor dampers).

(iii) FAS "Open/Closed" Status Monitoring Control (Smoke Purge Dampers Only) - End Switch closures will cause activation of FAS "opened" and "closed" relays in response to operation of end switches at both ends of travel.

(iv) FAS "Override of (BMS)" Control - For each damper requiring both FAS and ATC (BMS) control, the Controls Contractor shall mount an interface relay within 30 circuiting feet of the damper terminal strip, so wired as to permit FAS override of the ATC (BMS) control.

b. The controls contractor's damper manufacturer shall provide all necessary wiring diagrams to the FAS contractors.

c. Dampers furnished by the mechanical trade shall have similar terminal strips to which the controls contractor shall wire where necessary.

d. Comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

2.10 CONTROL PANELS

A. Field Equipment Cabinets

1. All DDC controllers, transformers, electric relays, static pressure sensors, velocity pressure sensors, manual override switches, etc., shall be mounted in an appropriate NEMA enclosure and factory wired to terminal strips. The enclosure shall be constructed of steel or extruded aluminum and shall be properly rated for the location. Securely mount the enclosures to the wall or floor of the building structure using approved bracing adjacent to each system to be controlled.
2. Cabinets shall allow extra space for installation of future control components.
3. Submit for approval all proposed locations of DDC control and accessory panels.
4. Submit for approval dimensioned shop drawings of the panel equipment layout prior to panel fabrication.
5. Properly label all panel components including wiring and tubing.

2.11 AIR SUPPLY

A. Compressed Air System

1. Provide a duplex type air compressor set complete with air tank, motors, V-belt drives, pressure switches, relief valve, pressure gauge, intake filter silencers, starters, electric alternator, and all other items and accessories. The two compressors shall be mounted on ASME National Board receiving tank. The entire unit shall be factory piped and wired. Compressor shall be sized as necessary to supply all pneumatics associated with the building automation system as well as the

main air for all devices, [refrigeration machines], [Face & Bypass Coils], [domestic water controllers] and all other HVAC equipment, as required.

2. Each air compressor shall be suitable for 70-90 PSI working pressure and shall be capable of supplying compressed air at 80 PSI under maximum CFM and be capable of maintaining 15/20 PSI air pressure (nominal) in the entire system with the compressor in operation less than 1/3rd of the time that is required, and at a speed of 450 rpm. Each compressor shall be single stage, one or two cylinders, air cooled, with drop forged steel crankshaft supported on both ends by means of ball, roller or sleeve main bearings. Lubrication shall be of the constant level splash type, or of the pressure type, to assure adequate supply of oil to all working parts. Compressor shall be provided with oil proof piston rings.
3. The air compressors shall be connected to an ASME air storage vessel of sufficient size to prevent in excess of 6 starts per hour.
4. Each compressor motor shall be provided with a magnetic starter with disconnect, three overload relays, and pressure switch. Provide an electric alternator to alternate automatically the starting sequence of the compressor motors. Electric controls shall be factory installed on the unit. A complete wiring diagram shall be secured to the interior of the cabinet door.
5. Compressor unit shall be painted with a prime and finish coat of paint in accordance with the manufacturers standard practice. Air tank shall be provided with a drain opening at the bottom, which shall be piped near the floor with gate valve and discharge into a floor drain.

B. Air Dryer System

1. Provide in parallel (2) refrigerated air dryers for the compressed air system at each location, one piped as a standby. Each unit shall consist of a hermetically sealed, direct connected refrigerant compressor and motor unit, automatic drain valve, non-toxic refrigerant, automatic expansion valve, condenser, lubrication system insulation, and other items and accessories, contained in a wall mounted cabinet. The air dryers shall be connected in to the high-pressure side of the compressed air line with copper tubing between the air tank and the pressure reducing station. Each unit shall be non-cycling type, with sufficient capacity to chill the compressed air output of one compressor, to a dewpoint of 35 degrees F with an inlet air temperature of 100EF air (based on 110F ambient temperature) required for normal temperature control system operation. Air dryers shall be piped with manual bypass.
2. Provide a compressed air pressure reducing station complete with two (2) air filters, two (2) oil filters, reducing valves, safety valves, isolating valves, gauges, brass piping and fittings. The use of type K copper tubing with brass or copper solder joint fittings is also acceptable for assembling this station. The reducing station shall be wall mounted adjacent to the air compressor and in each MER. Equipment and piping shall be arranged to provide identical parallel paths for the compressed air to be discharged to the temperature control system at the reduced pressure required for the mode of operation.
3. Provide a replaceable media cartridge type particulate and oil filters in the air piping between the refrigerated dryer and the pressure reducing station. Filters shall be so designed that the media can be replaced without removing the entire unit from the piping. A drain, with valve or petcock, shall be provided at the bottom of the filter assembly. Provide, per air pressure reducing station, two (2) pre-filters and two (2) oil filters, each sized for the compressed air requirements. Filters shall provide a dirt and oil free system. Isolation and changeover valves shall permit uninterrupted service during maintenance.

4. Provide 2 pressure reducing valve parallel branches, each branch having a minimum of three, _? pressure reducing valves. These valves shall reduce the air pressure, in stages, from 80 PSI to 30 PSI to 19psi to 15psi. (these pressures are nominal and may differ from manufacturer to manufacturer)
5. Provide high pressure (80 PSI) to each MER.
6. Provide an approved make ASME standard bronze safety valve at the air tank and after each pressure reducing valve. The safety valve at the air tank shall be 3/4?, set at 80 PSI and each safety valve after the primary reducing valve shall be _?, set at 38 PSI. Safety valves after the other pressure reducing valves shall be _?, set approximately 5 PSI higher than the setting of the reducing valve it follows. Safety valves shall be Crosby Valve & Gauge Co., Kunkle Valve Co. or J.E. Lonergan Co.
7. Provide compressed air system sized for system requirements plus 50% spare capacity.

C. Air Gauges

1. Provide air pressure gauges on all main compressed air systems including, main station, air filters, pressure reducing valves, etc. Gauges shall be 2-1/2" in diameter, minimum.
2. Provide air pressure gauges on controlled equipment compressed air signals. Gauges shall be 1-1/2" in diameter, minimum.

D. Pressure Reducing Stations

1. Provide dual pressure reducing stations in each MER. Station shall incorporate air filters, gauges, manual valves and pressure reducing valves to provide low pressure air as required. Station shall be piped to provide 100% standby and be valved to allow maintenance without compressed air shut down.

2.12 NON BMS DEVICES

A. Non-BMS Monitored Devices

1. Electric Thermostats

a. Furnish and install all line voltage thermostats for unit heaters, cabinet unit heaters, and/or radiation. Thermostat contacts shall be rated for maximum heater amperage and shall be snap acting, SPDT.
b. Thermostat shall have a concealed setpoint adjustment.
c. Thermostat shall have concealed thermometer temperature indication.

2. Aquastats

a. Furnish and install strap on aquastats to prevent unit heaters from operating when hot water is not available.

PART 3 - EXECUTION

3.1 DESIGN CRITERIA

A. The Building Management System (BMS) shall be programmed to start and stop the HVAC equipment based on occupancy schedules as coordinated with the owner. The BMS shall also provide equipment interlocks as required.

B. Static pressure safeties shall not be overridden during smoke purge, but other safeties (freezestats) shall be overridden.

C. Each preheat coil section shall be provided with a separate sensor, control loop, output signal, freezestat, and control valve.

D. All control valves that are sequenced shall be provided with dedicated analog outputs or positioning relays, as applicable.

E. All control dampers that are sequenced shall be provided with dedicated analog outputs or positioning relays, as applicable.

F. Fire Alarm Interface for Fans

1. The Fire Alarm System shall provide outputs to notify the BMS of fire alarms.
2. All fan systems shall be stopped from the FAS. When the fan system stops, all associated dampers shall close.
3. All return and exhaust fans shall be stopped from the FAS. When the fan stops, all associated dampers shall close.

G. All safeties shall be capable of being remotely reset from the BMS.

H. All setpoints shall be adjustable from any BMS personal computer operator workstation via single point commands.

I. All reset schedule parameters shall be adjustable from any BMS personal computer operator workstation via single point commands.

J. All inputs and outputs shall be provided with programmable (adjustable) high and low software alarm limits.

3.2 INSTALLATION CRITERIA

A. Space mounted devices are to be identical in appearance. All devices shall be mounted under the same style cover.

B. Room sensors and thermostats shall not be located on outside walls.

C. Provide all relays, switches, sources of electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified.

D. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

E. Mount surface-mounted control devices, tubing and raceways on brackets to clear the final finished surface on insulation.

F. Conceal control conduit and wiring in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

G. Install control valves horizontally with the power unit up. Installation of control valves will be by the mechanical contractor.

H. Unless otherwise noted, install wall-mounted sensors, thermostats and humidistats to meet ADA requirements. Submit device samples, locations, mounting heights and details for approval for all devices.

I. Install outdoor thermostats in perforated tube and sun shield.

J. All relays, electrical wiring, panels, outputs, etc. to make a complete operational system, shall be provided and installed by this section. See sequences of operation for details.

K. Compressed Air Requirements

1. Provide main air, as required by equipment manufacturers, to all HVAC equipment and devices which requires main air, whether or not it interfaces with the BMS, including but not limited to **[refrigeration machines]**, **[face & bypass coils]**, **[domestic hot water controllers]** and all other HVAC equipment as required.

L. Component Tags

1. All automatic and manual valves provided by this contractor, shall be identified with 2" diameter brass tags and brass chains. Lettering shall be ½" high, stamped and painted black. Automatic valve tags shall be stamped with the letters "AV" and sequentially numbered. Provide valve schedule and sample tags for approval.
2. All sensors shall be identified with 1"x 3" black labels with white lettering. Lettering shall be 1/4" high. Provide sensor number, HVAC Unit number, part number and sensor range on tag. Submit tag schedule and sample for approval.
3. All panels, auxiliary component panels, transformer panels, etc. provided by this contractor, shall be identified with 2"x 5" black lamacoid labels with engraved white lettering. Lettering shall be ½" high. Provide panel number, HVAC unit number and service on tag. Submit tag schedule and sample for approval.

3.3 ELECTRICAL WIRING

A. The BMS Contractor shall be responsible for all electrical control work associated with the BMS, HVAC and plumbing systems which is not specified as work of others.

1. Perform all wiring in accordance with all local and national codes including the NEC.
2. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the Division 26 specifications, NEC and local building code.
3. All low voltage electrical control wiring and all Primary Network wiring throughout the building shall be run in conduit. Terminal equipment sensors and the secondary network wiring may be run in plenum rated cable above accessible hung ceilings. Plenum cable shall be run parallel to building lines and supported from the building structure (not from duct, pipe or associated hangers) with bridle rings.
4. Provide extension of 120 volt, 20 amp circuits and circuit breakers from emergency power panels for entire system, except terminal equipment, as required.
5. Surge transient protection shall be incorporated in the design of system to protect electrical components in all DDC control panels and operator workstations.
6. Provide all miscellaneous field device mounting and interconnecting control wiring for all mechanical systems including but not limited to the fuel oil system, emergency generators, chillers, water treatment, AC units, condensing units, PIMs, cooling

towers, expansion tanks, VFDs, unit heaters, filtration systems (air and water), terminal units, fan coil units, electric heaters, house tanks, chiller control system, kitchen equipment, fans, H&V, cabinet heaters, hot water heater, ejectors, sump pits, domestic water system, steam PRV stations, underground pipe leak detection system, and plumbing systems.

7. All systems requiring interconnecting control wiring as specified herein, shall have hardwired interlocks and shall not rely on the BMS to operate (e.g. emergency generator to fuel oil pump interlock, emergency generator to ventilation damper, etc.). Interconnecting wiring shall be run in conduits separate from the BMS associated wiring.
8. All wiring for network communication, sensor signals and interlock wiring shall be permanently labeled at a minimum of 10-foot intervals. Label shall indicate BMS manufacturer's name and cable usage. Labels shall be securely fastened and not be damaged during installation. Cable jackets shall also be color coded to indicate application.
9. Cables shall be tagged or labeled at each termination point and in each intermediate junction box, pull box or cabinet through which they pass.
10. All control and power wiring associated with the control of all automatic, fire/smoke or smoke dampers shall be installed in conduit, regardless of voltage. All control and power wiring for relays associated with the control of any automatic, fire/smoke or smoke damper shall be installed in conduit, regardless of voltage.
11. Data communication between separate buildings or facilities shall be via fiber optic cable only.
12. Provide all line and low voltage wiring for the control of all HVAC, plumbing and fire protection motors (whether individual or as part of packaged equipment) and dampers, including wiring for EP's, PE's, relays, control panels, unit heater and cabinet heater control, etc., except as noted below. Provide wiring to interface devices (relays or others) located within 3 feet of each damper requiring direct smoke and fire control by the Fire Protective Alarm (FPA) System in addition to its automatic temperature control operation.

    a. A separate system of wiring, for smoke and fire control of motors which are to be automatically and/or manually controlled by the fire protective alarm (FPA) system will be run to the motor starters or SCU enclosures by the electrical trade.
    b. Wiring, for smoke and fire control of dampers which are to be automatically and/or manually controlled directly by the FPA system (i.e., not in response to motor operation) will be run by the electrical trade. Wiring will include connections to an adequate 120 volt emergency source, and to interface relays provided as part of the automatic temperature control work within 10 feet of each such damper which is also to be controlled as part of the automatic temperature control work.

13. The BMS contractor shall provide wiring:

    a. Between thermostats, aquastats and unit heater motors.
    b. All control and alarm wiring for all control and alarm devices for all Sections of Specifications.
    c. 120 volt, single phase, 60 hertz emergency power to every BMS panel, VAV box controller, BMS console, PIM, CRT, CPU, valve transmission power supplies, annunciator modules, modems, intercom modules, printers and to other devices as required. It is the intent that the entire building management

system and all peripheral devices, alarms, etc., shall be operative under emergency power conditions in the building. The power supplies are to be extended in conduit and wire from emergency circuit breakers.

d. Provide power supply wiring (as required) to all dampers which do not require "direct" (i.e., not in response to motor operation) smoke and fire control by the fire protective alarm (FPA) system.
e. Provide status function conduit and wiring for equipment covered under this section.
f. Provide conduit and wiring between the BMS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring.
g. Provide conduit and control wiring for devices specified in this Section.
h. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in BMS panels located in the vicinity of motor control centers.
i. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and BMS panels, as shown on the drawings or as specified.
j. Provide electrical wall box and conduit sleeve for all wall mounted devices.
k. Firestopping shall be provided for all penetrations of conduit, etc. through fire rated walls and floors and other fire rated separations.
l. Where conduit is required, it shall be steel electric metallic tubing (EMT), except that it shall be galvanized intermediate steel conduit where located within 8'-0" of the floor in mechanical spaces (or is otherwise exposed to mechanical damage), or is intended for embodiment in concrete.

14. Wires and cables shall have characteristics - in compliance with Articles 725 and/or 800 (as applicable) of the National Electrical Code - as described elsewhere in the specifications or drawings for this project, and shall be UL listed in accordance therewith.
15. Where wires and cables are permitted to be run without conduit, they shall be independently supported from the building structure or ceiling suspension systems at intervals not exceeding four feet on center, utilizing cable supports specifically approved for the purpose. Wires and cables shall not rest on or depend on support from suspended ceiling media (tiles, lath, plaster, as well as splines, runners or bars in the plane of the ceiling), nor shall they be supported from pipes, ducts or conduits. Where cables are bundled together, separate bundles shall be provided separately for each type of cabling and separately for each independent system. Bundling and/or supporting ties shall be of a type suitable for use in a ceiling air handling plenum regardless of whether or not installed in a plenum.
16. Utilize #14 A.W.G. THWN conductors minimum throughout for power wiring (120 VAC or greater) except in conjunction with a manual starter. For a manual starter, utilize conductors equal in size to those in the power circuit.
17. Motor control circuit wires may be run in the same conduit as the wires of motor power circuits; however, abide by the following:

    a. Exclude motor control wires from enclosures (other than motor starter enclosures) which contain power circuit overcurrent protection and switching devices;
    b. Exclude motor control wires from pull boxes and junction boxes containing the wires of main and submain feeders.

c. Utilize auxiliary pull boxes to separate motor control wires from motor power circuit wires at a point before the power circuit wires enter the items from which motor control wires are excluded.
d. Exclude motor control wires from the same conduits as motor power circuit wires larger than 250 MCM.

18. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

a. Wires and Cables:

(i) American Insulated Wire Corporation, Leviton Manufacturing Co.
(ii) Brand-Rex Cable Systems, Brintec Corp.
(iii) Carol Cable Company, Inc.
(iv) Senator Wire & Cable Co.
(v) Southwire Co.
(vi) Belden Division, Cooper Industries
(vii) Cable & Wire Division, A.T.& T.
(viii) American Insulation Wire Company.

b. Connectors for Wires and Cables:

(i) AFC, Monogram Co.
(ii) AMP, Inc.
(iii) Anderson, Square D Co.
(iv) Electrical Products Division, 3M Co.
(v) O-Z/Gedney Unit, General Signal.

c. Connectors and Splices

(i) UL-listed factory-fabricated wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated.

19. Examine raceways and building finishes to receive wires and cables for compliance with installation tolerances and other conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.
20. Utilize copper conductors with THWN, THHN or XHHW insulation. Type THHW and THHW-2 shall not be utilized where excluded by conduit sizing. Type THWN shall not be utilized for connection to 100% rated overcurrent devices.
21. Pull conductors into raceway simultaneously where more than one is being installed in same raceway.
22. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.
23. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
24. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
25. Properly ground all field equipment panels and terminal unit equipment.

3.4 **[PNEUMATIC INSTALLATION**

A. **Control Air Piping**

1. **No air lines are to be hidden within duct insulation. All piping and tubing shall be properly supported using straps, cleats, or hangers as approved. Use of wire will not be permitted. Where this specification permits the use of plastic tubing (inside control panel) virgin polyethylene tubing, with a molecular weight of not less than 25,000 and a melt index of not more than .3 dg./min., shall be supplied. Pressure rating of air tubing: 160 psi/72 degrees F. Ambient temperature rating: 100 to 175 degrees F. Tubing shall be supported with pipe rests or other supporting methods as to prevent the lines from stress conditions.**
2. **Tubing passing through or buried in concrete shall be hard drawn copper in rigid steel conduit.**
3. **Air tubing shall be Type L hard drawn copper.**
4. **Air tubing in finished areas shall be run concealed.**
5. **Air tubing for low and high pressure mains shall be Type L hard drawn copper.**
6. **Polyethylene plastic tubing will be permitted in lieu of copper, except for high pressure mains or smoke control, in the following locations:**

   a. Within control panels only.

7. **Air piping associated with smoke control functions shall be hard drawn Type L copper only (includes main air and damper signals).]**

3.5 COORDINATION

A. Coordination with Other Trades

1. Piping and duct installation requirements are specified in other Division 23 Sections. Coordinate installation of all devices furnished under this section to be installed by other trades with the appropriate trade.
2. It is the responsibility of this contractor to coordinate with all trades the location of installed equipment and routing of all electrical and pneumatic control conduits and lines.
3. Install control system components to allow for proper service and maintenance of equipment.

B. Work Performance Schedule

1. A time-phased schedule for delivery, installation, and acceptance of components for the complete system shall be prepared. Submit this schedule to the Owner within five (5) days after award of contract. Submit updates and changes to this schedule promptly to the Owner.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

B. Commissioning, Testing and Acceptance

1. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets that shall be submitted prior to acceptance testing. Commissioning work that requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.
2. Phase I – Field I/O Calibration and Commissioning

   a. Verify that each control panel has been installed according to plans, specifications and approved shop drawings. Calibrate, test, and have signed off each control sensor and device. Commissioning to include, but not be limited to:

      (i) Sensor accuracy at 10, 50 and 90% of range.
      (ii) Sensor range.
      (iii) Verify analog limit and binary alarm reporting.
      (iv) Point value reporting.
      (v) Binary alarm and switch settings.
      (vi) Actuator and positioner spring ranges if pneumatic actuation is utilized.
      (vii) Fail safe operation on loss of control signal, pneumatic air, electric power, network communications, etc.

3. Phase II – System Commissioning

   a. Each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and re-tested.

4. Phase III - Integrated System Program Commissioning

   a. Tests shall include, but not be limited to:

      (i) Data communication, both normal and failure modes.
      (ii) Fully loaded system response time.
      (iii) Impact of component failures on system performance and system operation.
      (iv) Time/Date changes.
      (v) End of month/ end of year operation.
      (vi) Season changeover.
      (vii) Global application programs and point sharing.
      (viii) System backup and reloading.

(ix) System status displays.
(x) Diagnostic functions.
(xi) Power failure routines.
(xii) Battery backup.
(xiii) Smoke Control, vents, in concert with Fire Alarm System testing.
(xiv) Testing of all electrical and HVAC systems with other division of work.

b. Test procedure and documentation shall be as follows:

(i) Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy and the system performance does not degrade over time.
(ii) Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate 100 percent of the system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.
(iii) The BMS contractor shall supply all instruments for testing. Instruments shall be turned over to the owner after acceptance testing.
(iv) All test instruments shall be submitted for approval prior to their use in commissioning.
(v) Test Instrument Accuracy:

(a) Temperature: 1/4F or 1/2% full scale, whichever is less.
(b) High Pressure (PSI): ½ PSI or 1/2% full scale, whichever is less.
(c) Low Pressure: 1/2% of full scale (in w.c.)
(d) Humidity: 2% RH
(e) Electrical: 1/4% full scale

(vi) After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty-day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

c. Sub Systems shall also be tested and commissioned.

(i) **[Compressed Air System**

(a) **Test all high pressure piping (80 PSI) at 100 PSI sustained for 24 hours. Pressure loss shall not exceed 10 PSI at the end of the 24-hour test period.**

(b) **Test all low-pressure piping (25 PSI and below) at 30 PSI sustained for 24 hours. Pressure loss shall not exceed 3 PSI at the end of the 24-hour period.]**

5. Move In Checkout

   a. Each floor shall be re-tested 24 hours prior to move in. The test shall ensure all corrective work is complete and all systems are 100% operational.

6. Additional testing, debugging and fine tuning

   a. Provide an additional 100 overtime hours of appropriate highest labor cost category to be used at the owner's discretion to test, debug and fine tune the system after occupancy.

C. Owner System Performance Verification (OSPV)

1. The systems and equipment shall be fully functional and operational prior to the OSPV process, or the contract(s) will be back-charged accordingly.
2. OSPV is the process in which the contractor fully demonstrates system operation, system performance, proper operation of the sequence of operations, and system equipment to the Owner's operating staff in the presence of an OSPV agent.
3. After the contractor's obligations are completed, including system testing, equipment testing, calibration, system demonstration, sequence of operation start-up, training, providing of maintenance and operation manuals, and corrective action for all punchlist items, the OSPV process begins. The BMS contractor shall include in their bid 80 hours (two technicians @ 40 Hours for the OSPV process.
4. Complementary to the BMS contractor's responsibility to commission the building systems, an OSPV agent will be retained by the Owner. This OSPV agent will provide independent equipment-systems installation inspection and performance verification. The independent verification will be requested prior to final equipment and systems acceptance by the Owner. It should be emphasized that independent systems verification prior to the OSPV process does not negate the BMS contractor's obligations to full commission the control system.
5. The OSPV agent will verify system installation, operation, performance, and sequences of operation after the BMS contractor provides written notice that the building system is completed, tested, and fully operational. Upon this notification, the OSPV agent will perform the initial verification. The OSPV agent will provide one (1) additional installation and performance verification, upon notification by the BMS contractor that deficiencies identified have been corrected. Any subsequent installation and performance verification will be at the BMS contractor's expense.
6. All building systems shall be verified under actual and simulated full load conditions.
7. The Owner, Architect, Engineer, and OSPV agent will have input to and be part of the approval process for systems performance verification.
8. The Owner's staff shall be informed of all system start-up, shutdown, and verification procedures that involve any utility usage or interruption.
9. The BMS contractor's technicians provided for the OSPV process shall be thoroughly familiar with the OSPV process (start-up, sequence of operation, shutdown, etc.) and the system or equipment required for the OSPV work. The personnel must also be thoroughly familiar with the project specifications and drawings. Convenient technician substitutes for the OSPV process are unacceptable.

10. Under OSPV, the following shall be verified:

    a. Point to point verification of all BMS points.
    b. The sequence of operation for all systems and equipment.
    c. Calibration of all inputs and outputs.
    d. Operation of the compressed air plant.
    e. System programming.
    f. Standard operation procedures (SOP).

11. The OSPV process includes but is not limited to the above items.

3.7 DEMONSTRATION

A. Maintenance Data and Operating Instructions

1. Description - Maintenance and operating manuals in accordance with Section 01 00 00, General Requirements.

    a. Prepare data in the form of an instructional manual.

2. Manual for Equipment and Systems

    a. Each item of equipment and each system: Include description of unit or system, and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and test, and complete nomenclature and model number of replaceable parts.
    b. Panelboard Circuit Directories: provide electrical service characteristics, controls, and communications.
    c. Include wiring diagrams as installed.
    d. Operating Procedures: Includes start-up, break-in and routine normal operating instructions and sequences. Include regulation, control stopping, shutdown and emergency instructions. Include summer, winter, and any other special operating instructions.
    e. Maintenance Requirements: Include routine procedures and guide for preventative maintenance, trouble shooting; disassembly repair, re-assembly instructions including alignment, adjusting, balancing, and checking instructions.
    f. Provide servicing and lubrication schedule for dampers and actuators. Provide a list of lubricants required.
    g. Include manufacturers printed operation and maintenance instructions.
    h. Include sequence of operation by controls manufacturer.
    i. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams.
    j. Provide control diagrams by controls manufacturer as installed.
    k. Provide contractor's coordination drawings with control piping diagrams as installed.
    l. Provide list of original manufacturer's spare parts. Provide a recommendation of quantities to be maintained in storage.
    m. Provide additional requirements as specified in individual product specification sections.

3. Instruction of Facility Personnel

a. Before final inspection, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment, and systems, at agreed upon times.
b. For equipment requiring seasonal operation, perform instruction for other seasons within six months.
c. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.
d. Prepare and insert additional data in Operation and Maintenance manual when need for such data becomes apparent during instruction.

4. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.
5. Instruct Owner on the maintenance instructions for draining and protecting chilled water coils in the winter.

B. Display of Maintenance Instructions

1. One set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

C. Training

1. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays.
2. Provide **[eighty (80)]** hours of training for Owner's operating and maintenance personnel. **[40]** hours shall be off site classroom training and **[40]** hours shall be on-site training. Videotape all sessions and edit each session to 1-hour tapes. Turn over two copies each unedited and edited tape to the Owner. Training shall include:

a. Explanation of drawings, operator's and maintenance manuals.
b. Walk-through of the job to locate all control components.
c. Operator workstation and peripherals.
d. DDC Controller and ASC operation/function.
e. Operator control functions including graphic generation, if design includes color graphics, and field panel programming.
f. Operation of portable operator's terminal, if an operator terminal is provided to the owner as per this specification.
g. Explanation of adjustment, calibration and replacement procedures.

3. Provide 8 hours of additional training quarterly during warranty period.
4. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date.

Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.

3.8 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by the Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

END OF SECTION 23 09 00